U.S. Climate Change Technology Program Strategic Plan – Draft for Public Comment
U.S. Government Draft for Public Comment – September, 2005

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1	General						The Draft Plan Appears To Be Dependent on the Continued Existence over this Century of the CCTP. A review of the companion Vision document shows (pp. 3-6) that in January 2002 "the President reorganized Federal oversight, management and administrative control of climate change-related activities" by establishing a "Cabinet-Level Committee on Climate Change Science and Technology Integration" (CCCSTI), which "makes recommendations to the President on matters concerning climate change science and technology plans, investments, and progress." In addition, the Vision explains that under the CCCSTI "two multi-agency programs were established to coordinate and integrate Federal activities, review progress and make recommendations." These programs are the CCSP and the "technology counterpart to the CCSP," the CCTP, which has as its "principal aim. . . to accelerate the development of new advanced technologies to address climate change." According to the Secretaries (p. iii), the Plan "articulates a vision of the role for advanced technology" in addressing climate change, "defines a supporting mission" for the CCTP, "establishes strategic direction and a framework of guiding principles for Federal R&D agencies in formulating a CCTP research and development portfolio" and "outlines approaches" to "attain CCTP's six strategic goals." The Secretaries add that the Plan "[a]ppropriately. . .takes a century-long look at the nature of the climate change challenge and the potential for technological solutions across a range of uncertainties" (emphasis added). The Foreword explains (p. iv) that "the Plan provides a long-term planning context. . .as well as the opportunities for technology, which will better inform future Federal R&D planning" and, along with the companion "Vision" document, "lays the foundation for setting priorities through its technology strategies and criteria for investment" (emphasis added). Moreover, the Plan "will guide and galvanize the Federal Government's extensive and diverse technical efforts." Id. While there certainly are significant advantages in such long-term planning, we are concerned that the draft Plan appears to be organizationally dependent on the continued existence and inter-relationship over the "long term" of the CCTP and, for that matter, the CCSP and the CCCSTI. In this case, the "long term" is apparently intended to span this century, which, during that time, will encompass numerous Administrations, any number of which could decide to change the "mission" of the CCTP or even dismantle it entirely. While the CCTP can be useful, it is important to us that this planning be "led" by the DOE, which, unlike the CCPT, is a cabinet-level agency. Moreover, DOE has a broadly established RDD&D mission provided by Congress in the Department of Energy Organization Act of 1977 (including related statutes referred to therein), which was greatly enhanced by the Energy Policy Act of 1992 and the recently enacted Energy Policy Act of 2005 (EPAct 2005), 42 U.S.C. § 15801 et seq. This congressional framework provides a more stable organizational basis for such planning. Indeed, nowhere in the draft Plan or the Vision is there any mention or reference to a statutory basis for the CCTP. We trust that that is an oversight and that the final version will include a discussion of statutory authority. Moreover, DOE's overall involvement and lead should be made more prominent in the draft.
2	General						CCTP is in urgent need of organizational strengthening. In the short-run, launching a properly funded exploratory research program would ameliorate the problem. In the longer-term, creating a climate technology ARPA or a climate component of an ARPPA-E will almost certainly be an essential step.
3	General						First of all, congratulations on getting this document out at all. That said, however, now is the chance to really improve the Plan by responding to the public comments and criticisms. You might even want to consider publishing the comments and criticisms along with your response.
4	General						The Plan is not a plan in the budget sense. It does not detail how much is being spent on each RD3 area, nor does it project what is needed to achieve the stated goals. It does not list or explain priorities.
5	General						We) appreciate the establishment by the Administration of the U.S. Climate Change Technology Program (CCTP), which we understand from a "companion document," titled "Vision and Framework for Strategy and Planning" (Vision), is the "technology counterpart" to the U.S. Climate Change Science Program (CCSP) and a "multi-agency planning and coordinating entity, led by the Department of Energy" (DOE).1 We particularly welcome the publication for public "review and comment" of the CCTP's "preliminary. . .Strategic Plan" (Plan), which, according to the draft Plan's cover letter (p. iii) signed by the Secretaries of Commerce and Energy and the Director of the Office of Science and Technology Policy (Secretaries), is intended to provide "strategic direction" to all federal agencies in "formulating a

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							coordinated approach to climate-change-related technology research, development, demonstration, and deployment" (RDD&D). We commend DOE and your federal agency partners for your foresight in preparing this draft Plan, and specifically for the vast majority of very helpful contents. We also take this opportunity to express some general concerns with the draft Plan and CCTP, and urge DOE to make appropriate changes to address these concerns. 1 The Vision document is referred to in the draft Plan's Foreword (p. iv). It is dated August 2005 and was not made available for public comment. We note that much of its contents are restated in the Introduction to the draft Plan.
6	General						We suggest adding language such as "This model does not fully characterize renewables and so underestimates their potential contribution. A more detailed renewable module is under development." [This could be modified depending on what parts of the model are actually used in the update. We know that wind may be included, but solar would not have been added yet.]
7	General						Chapters 4-7 The chapters provide interesting summaries of ongoing and planned federal R&D efforts, but the descriptions of possible effects reflected in the "Technology Strategy" sections are typically overly positive and lack a serious discussion of the probable obstacles to deployment in each individual case. For example, Chapter 5, pg 5-19 outlines a very optimistic growth strategy for a variety of renewable energy technologies. The section discusses only what positive elements would be derived from expanded use of these technologies and that expansion is driven solely by "reduced costs." The assessments of available technologies and programs in Chapters 4-7 give little indication of how the portfolio planning and investment criteria are being applied in practice or will be applied in the future.
8	General						First of all, the Plan is an exceedingly thorough and comprehensive accounting of the RD3 currently being supported by the federal government. It puts the problem of greenhouse gases in the atmosphere in global and national perspective, and it gives a good justification for the government expenditures and involvement. This document will be very important and influential throughout the world.
9	General						We agree with the premise in this plan that a broad range of new energy options will needed to be developed to resolve this Nation's and the world's long term energy needs. We are glad to see fusion included in the portfolio of seriously considered approaches for new energy sources. Although fusion still faces significant technical and scientific challenges there has been significant progress and the potential payoff is immense.
10	General						CCPT should consider the risk that international GHG control regimes may remain narrow in coverage, relatively ineffectual, and slow to evolve. This possibility implies that CCTP should regard it as essential to develop technologies to neutralize harmful climate change and to lower its costs. It also reinforces the point that, while carbon capture and storage remains an important potential tool, CCTP should hedge its bets on this technology.
11	General						The Draft Plan Appears To Be a One-time Document, with No Provision for Further Review and Update of the Plan, the CCTP and their Progress. Chapter 10 of the draft Plan (pp. 10-6 - 10-7) states that the "CCTP's next steps focus on two broad thrusts." One is for the CCTP to "continue to provide support" to the CCCSTI and the other is for the CCTP to "continue to work with and support" the federal agencies "in developing plans and carrying out activities needed to advance the attainment of the CCTP's vision, mission, and strategic goals." It then provides that for each "CCTP strategic goal, to the extent suitable, . . .agency plans and activities will be guided by the seven core approaches" listed, as noted above, in the beginning of the chapter (p. 10-1) in order to ensure progress toward "attainment of the CCTP's vision, mission, and strategic goals." As already noted, it then lists several "activities that follow these seven approaches" under the title "Next Steps." However, as far as we can determine, there is no timetable for the Plan's "vision, mission, goals" and "activities," other than the reference to the 21st century. Nor is there a commitment by the CCTP to report on the progress of the vision, mission, six strategic goals, seven core approaches, etc. annually or at any time in the future. Thus, the draft Plan appears to be a one-time event that provides no opportunity for stakeholders, the public or Congress to learn periodically what has and has not been achieved and to discuss what more needs to be done. In short, there are no real "next steps." The draft plan is seriously lacking in this regard, and we urge that the term "next steps" be expanded at a minimum, with provisions for reporting on progress, achievements and effectiveness, not only of the Plan, but also of the CCTP.

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12	General						While the multi-decadal approach of the Strategic Plan represents an admirable change from recent U.S. energy policy, the levels of R&D spending in your plan are not commensurate with the challenges posed by the increases in greenhouse-gas concentrations that are outlined in Chapter 3. For example, we agree with the recommendations in Chapter 10 that include: "Strengthen Climate Change Technology R&D" and "Strengthen Basic Research Contributions." Yet, the only specific funding levels provided in the Strategic Plan for future years are for 2006, which amount to $3.011b, and which represent a decrease from current levels of climate-related R&D investment. A more serious long-term commitment to research funding [1] will be necessary to commercialize and deploy on a large scale the advanced technologies described in Chapters 3 through 9. We have recently completed work that shows that the investment required will be on the order of 5 to 10 times the levels that you outline in Appendix A [2, 3]. While such an increase would represent a non-incremental change from current trends, we have shown that it is well within the bounds of previous federal efforts to apply science and technology to address national concerns. We append our assessment and documentation of our calculations as attachments to this email. Please refer to the following references: [1] Margolis, R. M. and Kammen, D. M. (1999) "Underinvestment: the science and technology policy challenge", Science , 285, 690-693. [2] Kammen, D. M. and G. F. Nemet (2005). "Reversing the Incredible Shrinking U.S. Energy R&D Budget." Issues in Science and Technology 22: 84-88. see EnergyR&D-IssuesFall2005.pdf) [3] "Appendix: Estimating energy R&D investments required for climate stabilization" http://socrates.berkeley.edu/~rael/RandD_appendix.pdf
13	General						First Overview Comment: I believe the subject report provides little or no predicate demonstrating the concern for controlling Green House Gases (GHG). The authors appear to make the tacit assumption the reader is convinced GHG are a phenomenon of fusil fuel consumption. Early in the history of the Earth, the CO2 concentration was high and in spite of using fusil fuel the CO2 concentrations are lower now. Perhaps the is a natural variation governing the climate.
14	General						The Time Frame of the Plan Is Focused Primarily on the Long Term and on New and Advanced Technologies, with Little Attention Paid to Near- and Mid-Term and Existing and Improved Technologies. As noted above, the draft Plan states that the "CCTP's strategic goals. . .encompass a range of levels under conditions of uncertainty" (p. 2-2). DOE's "Invitation to Review" the draft states that the "purpose of the CCTP is to accelerate the development and reduce the cost of new and advanced technologies that could avoid, reduce, or capture and store" GHG emissions "and contribute to U.S. climate change goals" (emphasis added). The Introduction emphasizes (p. 1-3) that "[t]his Plan takes a century-long look at the nature of this challenge," "explores an array of opportunities for technical solutions," "articulates a vision for new and advanced technology in addressing climate change concerns, defines a supporting planning and coordination mission for the multi-agency CCTP, and provides strategic direction to the Federal agencies in formulating a comprehensive portfolio of related technology" RDD&D (emphasis added). The statement by the Secretaries (p. iii) that the "overwhelming majority of anthropogenic GHG emissions that will occur over the course of the 21st century will arise from equipment and infrastructures not yet built" is even more futuristic.

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							While we support long-term planning, as well as the development of "new and revolutionary technologies," a century is a lengthy time frame to focus upon, and building expectations that new and advanced technologies will successfully address GHGs over that time frame is risky, at best. Moreover, planning over such a long period raises issues of reliability, as well as serious uncertainty. Relying heavily in such planning on the success of one or more such technologies at sometime in this extended period gives the appearance, at least, of the U.S. government "putting all of its eggs in one basket" and, in essence, hoping to hit a "grand slam" or "home runs," when hitting "singles, doubles or triples" might show significant results and consistent progress over the near- and mid-term. Yet, according to the Secretaries (p. iii), the Plan "provides a strategic direction" for the federal agencies "in formulating a coordinated approach to climate change-related technology" RDD&D. They add that the "CCPT activities" are to "form the technology component of a comprehensive U.S. approach to climate change." That approach includes three other components: • "[S]hort-term actions to reduce" GHG "intensity" (emphasis added). • "[Advancing climate science." • "[P]romoting international operations." However, scant attention is paid in the draft Plan to these other components, particularly the first. Indeed, Chapter 10 states (p. 10-2) that six of the 10 chapters of the Plan (i.e., Chapters 4-9) are all devoted to examining "the potential role for advanced technology," leaving the possibility of only Chapters 2 and 3 to address near- or mid-term "actions," since Chapter 1 is the Introduction and Chapter 10 addresses conclusions and next steps (although there is some brief discussion in that chapter of the CCTP's "encouraging integrative system design, with near- and long-term advances in technology"). While Chapter 2 notes that the U.S. "approach" includes such "short-term actions," it emphasizes (p. 2-1) that "this CCTP Strategic Plan articulates a vision of the role of new and advanced technology in addressing climate change concerns" and that the "CCTP aims to inspire broad interest, within and outside of government. . .in an expanded global effort to develop, commercialize and deploy such technology toward attainment of the UNFCCC's ultimate objective." Chapter 3, titled "Synthesis Assessment of Long-Term Climate Change Technology Scenarios," is closely associated with Chapters 4-9 and the relationship of such technology to the FCCC's "ultimate objective."4 Chapter 4.4, titled Electric Grid and Infrastructure," states (p. 4-16) that "[l]arge reductions in CO2. . .may require that a significant amount of electricity be generated from carbon free or carbon neutral sources," such as nuclear and renewables, and that "[s]ome renewable energy resources are concentrated in regions" of the U.S. "that are distant from large urban markets," and thus the "future. . .distribution infrastructure (the 'grid') would need to extend its capacity and evolve to an intelligent and flexible system that enables the use of a wide and varied set of . . .generation technologies." As to the potential role of technology, the chapter notes (p. 4-17) that there are many transmission and distribution "technologies that can improve efficiency and reduce emissions" and refers to several such technologies "[i]n the near term," but then states (p. 4-17) that "[r]ealizing these opportunities requires a research portfolio that focuses on balance of advanced transmission grid and distributed-generation technologies" (emphasis added). However, once again that "portfolio" does not include any real emphasis on the "near term." Chapter 1 includes a summary of some near-term "actions" as follows (p. 1-2) (footnotes omitted): The technological elements of this approach, outlined in this Strategic Plan, build on America's strengths in innovation and technology. These longer-term elements are augmented by near-term policy measures, financial incentives, and voluntary and other Federal programs aimed at slowing the growth of U.S. GHG emissions and reducing GHG intensity. These include the Climate VISION, Climate Leaders, Energy STAR and Smart Way Transport Partnership programs, all of which work with industry to voluntarily reduce emissions. The Department of Agriculture's conservation programs provide incentives for actions that increase carbon sequestration in trees and soils. Energy efficiency, alternatives fuels, renewable and nuclear energy, methane capture and other GHG reduction programs and financial incentives are also underway. Unfortunately, that summary clearly indicates that such "actions" are not a part of the CCTP functions, nor are they even a small part of

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							the Plan itself. However, note that Appendix A (p. A-2) refers to RDD&D "activities" that are "classified as part" of the CCTP for funding purposes. Appendix A includes a footnote 2, which provides a very comprehensive definition of such activities, including a reference to the "near term" as follows: In this context, "research, development, demonstration, and deployment activities" is defined as: applied research; technology development and demonstration, including prototypes, scale-ups, and full-scale plants; technical activities in support of research objectives, including instrumentation, observation and monitoring equipment and systems; research and other activities undertaken in support of technology deployment, including research on codes and standards, safety, regulation, and on understanding factors affecting commercialization and deployment; supporting basic research addressing technical barriers to progress; activities associated with program direction; and related activities such as voluntary partnerships, technical assistance/capacity building, and technology demonstration programs that directly reduce greenhouse gas emissions in the near and long term. (Emphasis added.) It is unclear whether this definition is intended to apply to the Plan itself or just to Appendix A. Moreover, even if it applies to the Plan, the definition alone would not be an adequate substitute for the lack of a serious consideration of near- and mid-term "actions" in the Plan. Unquestionably, new and additional breakthrough and transformational technologies are very important and should be supported and encouraged. However, they should be only a part of the total effort. The other part that is equally, if not more, important is the continued development, demonstration and deployment of existing technologies and practices - together with improvements thereof - in the short and medium time frames. As the Vision document observes (p. 2), "Over the longer term, significant progress would likely require fundamental changes in the way the world provides energy, as well as changes in other processes and infrastructure used in industry, agriculture, forestry, and other human activities that result in GHG emissions." Unfortunately, those "changes" appear to be relatively far off, as there is not now a known "silver bullet" or "magic bullet" for such technologies or fuel changes. In the short and medium terms, we should address global GHG emissions with a portfolio or suite of existing and improved technologies to 1) reduce, avoid and sequester GHGs and 2) adapt to climate change. In addition, in the short, medium and long terms, fuel diversity - particularly in the power sector - and the technologies that underlay such diversity, are imperative. Indeed, we reemphasize that fuel diversity is critical to our sector and our customers. Considering the availability, abundance and reliability of the supply of various fuels and their infrastructure needs, as well as their economics and regulatory and other factors, it is not practicable or reasonable to be overly dependent on a short list of fuels. The Plan needs to include a chapter devoted to the incremental approach in the development, demonstration and deployment of climate change technologies because of the long time frame of climate change and any potential global warming. (Temporal flexibility is recognized in the Wigley-Richels-Edmonds curves.) Such an approach would fit domestic needs and is also sound from an international perspective. Indeed, many developing countries need to incorporate existing technologies and practices now and cannot wait 25, 50 or 100 years or more for new and advanced or revolutionary technologies. See p. 26, infra. While developing countries desire such technologies, the incremental approach is probably more realistic. Indeed, we urge that the Plan include a focus on the short- and medium-term incremental approach to climate change for the U.S. As a start, such a focus should be encapsulated in revised CCTP Vision and mission statements.
15	General						It is the fashion to say ‘portfolio’ but we should consider the potential for truly revolutionary technologies to actually provide the silver bullet. For example, perhaps fortified breeder/burner complexes or solar arrays on the moon. Sometimes ‘portfolio’ is a synonym for ‘pork barrel’ and a chance for everyone to get a little piece of the pie without actually solving the problem
16	General						Climate change is a global problem. R&D that may makes controlling it less expensive should be global in nature. It is wasteful for 10

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							countries to be working simultaneously on the same reactor, for example. The Plan points out numerous examples of collaborative and coordinated R&D. Perhaps new ways should be explored to keep up with the energy R&D expenditures of all of the nations of the world and to enter into agreements for sharing results and encouraging deployment of technologies that reduce GHG emissions. The Plan could be more comprehensive and imaginative in this regard. International R&D strategy could also save a lot of money.
17	General						Future Research Directions sections are generally of poor quality, and they are often so non specific that they are useless. Also, each of these sections begins with a standard paragraph including the sentence: "Within constrained Federal resources, this portfolio addresses the highest priority current investment opportunities." Since the priorities are obscure, how can you make this statement. This is a very self serving sentence. I believe it should be eliminated from all the Future Research Directions sections.
18	General						CCTP is in urgent need of organizational strengthening. In the short-run, launching a properly funded exploratory research program would ameliorate the problem. In the longer-term, creating a climate technology ARPA or a climate component of an ARPPA-E will almost certainly be an essential step.
19	General						It is incorrect and confusing to mention carbon reduction or sequestration when in all your plan you mean reducing or storing carbon as carbon dioxide. Carbon sequestration can be either as carbon or as carbon dioxide. Your decarbonizarion technologies all refer to removal of carbon AS CARBON DIOXIDE not as CARBON as elemental carbon. However, there are technologies for removal, storage and sequestration of carbon as elemental carbon from fossil fuels which are completely ignored in your plan. Look up papers on decabonization of carbon under Meyer Steinberg as author in Journals and in Brookhaven National Laboratory reports and in the book on CO2 Mitigation - the Science and technology.
20	General						RD3 needs to be focused on the needs of developing countries to assure that the poor of the world can choose technologies that are sustainable, i.e. energy systems with low GHG emissions.
21	General						FOR THE LONG RUN, I support the approach that the "United States has placed special emphasis on the fundamental importance of technology investment as a means of achieving climate goals in ways that simultaneously support broader societal goals, and in particular that will meet the world's need for abundant, clean, secure, and affordable energy to provide a continuing engine for global economic advancement in this century." But I could find no specific road map which gives me any hope that we will meet the NECESSARY climate goal. I find the report too broad and lacking a specific road map. I recognize that the solution will not be a simple one; and I am afraid that as with so much done by the government, it will probably be driven by crises. HOWEVER, THERE IS SOMETHING WE CAN DO FOR THE SHORT RUN which can give us time to solve the climate goal in the long run - and I hope consideration will be given to doing this as described below: I find the charge by President Bush "to consider approaches to reduce greenhouse gas emissions" TO BE TOO LIMITING. The issue we are dealing with, per the plan title, is one of climate change. There may be approaches other than limiting greenhouse gas emissions - and in fact the "Plan" does include other approaches such as sequestration of carbon dioxide. IN DEALING WITH THE SHORT RUN, As we look at the possibility that the recent hurricanes, Katrina and Rita, have had their intensity increased by global warming, we may already have started to violate the dictum of the text, to achieve "stabilization of greenhouse gas... within a time-frame sufficient to allow ecosystems to adapt naturally to climate change". And so I make a plea that an approach to "stabilizing or reversing the global warming of our climate" be added to the approaches being studied by this "Climate Change Technology Program". This approach is to look at moving the radiation balance of the Earth back toward the pre-industrial situation by reducing solar flux using such methods as placing long lived benign particles in the upper atmosphere. This approach has been looked at repeatedly and its technical and economic viability has been assessed as valid. The approach has then been put on the shelf - "to be used if we need it". Issues such as whitening of the sky and the effects of increased carbon dioxide on ocean ph and plant growth have been stated as reasons to not look at this approach. I have never seen a trade-off comparing these negative effects with what is happening today recognizing that the world IS NOT REDUCING ITS PRODUCTION OF GREENHOUSE GAS TO ANY SIGNIFICANT DEGREE. It is my contention that the proof of "need" will continue to be creeping - including periodically more severe weather which may or may not be caused by global warming. And so, I propose that we create an international program to study any side effects so that we can trade off whether using this approach of reducing incoming solar flux represents more risk than letting the world slowly see rising sea levels and

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							more severe weather including hurricanes and drought. For the time constant of such events is sufficiently long - both to create them and to counter then that we cannot wait for irrefutable proof. As to the mechanism for these tests and implementation, it seems to me that the Kyoto treaty could be amended to provide the desired study direction and implementation if study indicates its expected viability; and very reasonably this "geoengineering:" approach can be considered stop-gap while we continue to move toward change of the world's energy base and industrial processes as a long term solution. Below are a few specific comments related to this overview which I found in a non-thorough search of the document
22	General						The Plan Needs To Be Harmonized with DOE Statutes, including EPAct 2005, and with the Climate Vision MOU RDD&D Partnership. The draft Plan does not discuss or even refer to the broad array of statutes that are quite relevant to the implementation of this Plan and that are important to the electric utility industry and other sectors of the economy. Indeed, just recently Congress enacted the Energy Policy Act of 2005 (Pub. L. No. 109-58), which contains a number of new statutory provisions that are be relevant to our industry. Most prominent among these are title XVI, Climate Change; title XVII, Incentives for Innovative Technologies; title IV, Coal; and title VI, Nuclear Matters. In addition, there are provisions in title IX (Research and Development) for the Secretary of Energy to: • Publish annually measurable cost and performance-based goals for electric generation, transmissions and storage. • Fund programs that "address advanced energy technologies and systems and advanced grid reliability technologies." • Establish RD&D programs "to ensure the reliability, efficiency, and environmental integrity of electrical transmission and distribution systems." • Carry out a Nuclear Energy Research Initiative and a Nuclear Energy System Support Program. • Establish an Advanced Power System Technology Incentive Program. • Develop standards and best practices for calculating, monitoring and analyzing GHG intensity. Further, title XVII authorizes a loan guarantee program for advanced nuclear facilities; efficient electrical generation, transmission and distribution technologies; coal gasification; and other purposes. EPAct 2005 also includes several tax incentive provisions in title XIII, Energy Policy Tax Incentives. Similarly, the draft Plan appears to pay little attention to how and to what extent the CCTP will work with, utilize and form public-private partnerships and collaborative activities as a means of leveraging and maximizing the development of climate technologies in the short, medium and long terms. On December 13, 2004, seven power sector groups and DOE signed an umbrella climate VISION Memorandum of Understanding as part of the Climate VISION program that, among other things, features the establishment of an RDD&D partnership with DOE's program offices and the CCTP. Its purpose is for both Parties to "work collectively" to identify: (i) climate technology needs for the electric power sector; (ii) gaps in current power sector climate technology RDD&D; (iii) priority areas for new or supplemental power sector climate technology RDD&D; and (iv) options for potential funding mechanisms for early commercial use of advanced technologies. It includes RDD&D of advanced zero or low-carbon emission electric generation technologies and advanced, high-efficiency electric generation, transmission and end-use technologies. In short, the CCTP Plan must be based on and be consistent with the applicable statutes and take into consideration joint public-private actions. In the case of the latter, Chapter 2 states that the CCTP "will employ seven core approaches to stimulate participation by others" and that Chapter 10 "outlines next steps. . .for each of these core approaches" (p. 2-8) (emphasis added). Approach 3, titled "Enhance Opportunities for Partnerships," notes (p. 2-9) that public-private partnership "can facilitate the transfer of technologies from Federal and

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							national laboratories into commercial application" and "partnering is a common mode of operation in most Federal R&D programs, but the partnering process can be improved" (emphasis added). However, there is no discussion in the draft Plan on how and when to achieve such improvement. As to the "next steps," Chapter 10 merely calls for a "[r]eview" of the "status" of partnerships "and encourage[s] further formation" of them (p. 10-7). The draft Plan is wholly inadequate with respect to this third approach. What is needed is direction from the CCTP that implementation of partnerships, once formulated, is to be pursued aggressively by the CCTP and the federal agencies - including DOE - and that any barriers to that, whether real or imagined, should be addressed promptly by all involved.
23	General						The Plan Should Not Focus on Mitigation, But Should Encompass Technical Advances that Address Various Facets of Climate Change, Including Adaptation. Chapter 2 (p. 2-2 n. 2) states that the Plan "focuses on mitigation. . .consistent with the context of the UNFCCC" and "does not address adaptation." The footnote invites public comment on this "focus" and on the absence of other elements, including adaptation. In the first place, it is wrong to imply that the "context" of the FCCC is on "mitigation." That is clearly not the case. As the "Principles" of Article 3 indicate, the FCCC "context" is to address climate change comprehensively and cost-effectively. That includes research; systematic observation; and the development, application, diffusion and transfer of technologies, practices and processes that control, reduce and prevent man-made GHG emissions, promote sustainable development and provide for adaptation. The FCCC focuses on all of these and more. Moreover, the word "mitigation" has a regulatory connotation that is not helpful in a document on RDD&D. We do not understand why this footnote is included in Chapter 2 or in the Plan. As to adaptation, the absence of any reference to it in the Plan is a serious omission that needs to be corrected. Adaptation and relevant technologies are a matter of great interest and concern to all countries, as evidenced by the "Delhi Ministerial Declaration on Climate Change and Sustainable Development," which was adopted by the FCCC's Conference of the Parties, and which calls adaptation a "high priority for all countries" that "requires urgent attention and action on the part of all countries." Indeed, the Global Environment Facility, the financial mechanism for the FCCC, is developing an Adaptation Fund. In addition, the FCCC recently completed a three-day workshop on the development of the five-year program of work on impacts, vulnerability and adaptation. Moreover, at an October 3, 2005, conference in Vienna, Austria, the European Union Commissioner for Environment called for the development of policies to adapt to climate change. Finally, in preparation for Canada hosting COP-11 later this month, the International Institute for Sustainable Development in August released a paper titled "Climate Change and Adaptation" that provides a "summary of research and policy developments relevant to determining a long-term, integrated approach to addressing adaptation," while noting the "emergence of adaptation as an issue within the UNFCCC." It would be wise for the U.S. and DOE to reinforce these international trends.
24	General						Specific Comment on an Important Omission in the Strategic Plan - Recovery and Reuse of Waste Materials As drafted, the Strategic Plan does not address the issue of recovery and reuse of waste materials. Included could be R&D to address technology improvements in waste recycling such as separation methods, improvements to municipal curbside collection methods, and waste recovery. For example, aluminum production spent potliners (SPL) are a carbonaceous waste material with high BTU content, the potential to improve cement kiln production efficiency, improve clinker formation qualities, and reduce cement kiln emissions due to mineralizing benefits. Efforts to promote the reuse of waste materials and R&D to advance technology in this area would have beneficial impacts on reducing greenhouse gases, improving energy efficiency and lessening the waste stream burdens on society and the environment.
25	General						The draft document does not constitute a strategic plan. The objectives of the Climate Change Technology Program are not adequately specified and the "plan" fails to define the timeframe and scale of technology deployment needed to prevent dangerous global warming. While the document quotes the objective of the United Nations Framework Convention on Climate Change, to which the United States is a party, the full implications of this objective are not reflected in the "plan." There is now compelling evidence that global warming in excess of 2 degrees Celsius (3.6 degrees F.) would be dangerous, which

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							implies that heat-trapping gases should be stabilized at a level no higher than 450 ppm CO2-equivalent. Among other threats, warming in excess of 2ºC is likely to set in motion the disintegration of the Greenland ice sheet, eventually raising sea levels by as much as 20 feet (Alley, et al., 2005). Hurricane intensity would also increase significantly, compounding the danger to millions of citizens in the Southeast and Gulf coasts (Emanuel, 2005). Water resources in the Western United States would also be dangerously depleted due to reductions in winter snow pack (Mote, 2003). Finally, thousands of species would be threatened with extinction (Thomas, et al., 2004), particularly those dependent on highly sensitive habitat, such as polar bears, threatened by the melting of the arctic ice pack; pika, threatened by the desiccation of alpine meadows, and corals threatened by thermal stress and ocean acidification. Despite these clearly documented dangers, the administration asserts that there is not an adequate basis to determine the concentration at which heat-trapping gases need to be stabilized to prevent dangerous global warming. Yet even if the administration is not willing to set a stabilization target, a responsible strategic plan would recognize that near term investments in high-emitting infrastructure, such as conventional pulverized coal power plants, would quickly preclude the option of preventing warming of more than 2ºC. Conversely, the need to keep open the option of stabilizing concentrations at 450 ppm defines the pace and scale of technology deployment that the plan should be designed to achieve. Failing that, the revised plan should at least describe in detail the pace and scale of technology deployment needed to achieve each of the stabilization levels considered in Chapter 3. Well defined objectives for the pace and scale of technology deployment would allow the plan to assess whether the proposed strategies are adequate to the task. Again, if the administration is unwilling to establish a stabilization target, even for planning purposes, the revised plan could at least assess strategies against the pace and scale of technology deployment needed to achieve each option. Without this critical analysis the draft document appears to be largely a post-hoc justification for the existing R&D program, with at best a hint of some need for reprioritization. Lacking an assessment of the adequacy of the strategies in the plan, the draft ignores critical policies that would be needed to deploy low emissions technology in time to prevent dangerous global warming. Historical experience shows clearly that R&D alone is not an adequate driver of the private sector investment needed to commercialize pollution-reducing technology. Rather, emission caps (with trading), efficiency standards, and portfolio requirements have been critical to stimulating innovation, cost reductions, and scale up needed to commercialize new technology and achieve measurable economy-wide results (Burtraw, 2005). Unfortunately, business as usual will quickly preclude the possibility of preventing dangerous global warming as illustrated in our Figures 1 and 2. The International Energy Agency projects that more than 1000 GW of new coal capacity will be built worldwide during the next 25 years. If this capacity is built with conventional technology with no controls on CO2 emissions, each year's new capacity build will carry a lifetime commitment to carbon emissions equal to total annual emissions today. That means that by 2030 we will have locked in additional carbon emissions from coal combustion equal to the total cumulative emissions up to the year 2000 (Figure 1). If we continue with business as usual virtually all of the coal build through 2030 will use conventional steam technology with CO2 vented to the atmosphere. The Future Gen project and other elements of the portfolio described in the draft "plan" are simply too little, too late to bend the curve (Figure 2).
26	General						Budget Implications Must Be Addressed. Appendix A (p. A-1) states that for the CCTP to "carry out its mission, it is necessary to access on a periodic basis the adequacy of Federal investments in the CCTP-relevant research portfolio and make recommendations." The Appendix includes a "budget table" of RD&D "activities classified" as part of the CCTP, with, as noted above, footnote 2 (p. A-2) defining RDD&D activities to include "related activities such as voluntary partnerships, technical assistance/capacity building, and technology demonstration programs that directly reduce" GHG emissions "in the near- and long-term." Table A-1 (pp. A-4 - A-5) indicates that for FY 2005 a total of about $3 billion was available for all the federal agencies in the CCTP. However, the table does not include a breakdown of what portion of that total is for "new and advanced" long-term technologies and what

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							portion is available for near- and mid-term technologies and practices. In addition, the Appendix does not explain how the CCTP will "assess" the "adequacy" of funding for both the long-term and near- and mid-terms. We are concerned that the latter, particularly in the context of the recently enacted EPAct 2005, may not be funded adequately in light of the emphasis in the draft Plan on the long-term and new and advanced technologies, which could result in reduction of funds in real terms for the near- and mid-terms, particularly in times of budget and appropriations constraints. Moreover, the draft Plan does not indicate how budget monies for climate technologies are related to authorizations and appropriations (actual and projected) under EPAct 2005 and other statutes. Without an explanation of such linkages, budget numbers could bear little relationship to implementation of the Plan and the CCTP. We do not understand how DOE can develop an RDD&D budget for existing and advanced technologies without knowing where the money to implement that budget is coming from. In summary, we urge a better discussion in the Plan about 1) the budget implications for both the long-term and the near- and mid-terms, and 2) the relationship of the climate technology budget to authorized and appropriated monies (actual and projected).
27	General						Care should be taken to be even handed with regard to technology policy advocacy. E.g. on p 5-26 under nuclear fission, 2nd paragraph, 4th line seems to encourage Federal Financial Risk Management Tools. I have no problem with such advocacy (see the preceding paragraph), but it must be carefully considered and even handed wrt other technologies that could accomplish the same objectives.
28	General						This plan emphasizes looking at each technology in isolation. I suggest an alternate route: Start by building detailed visions of technically feasible sustainable carbon-emission-free planetary-scale energy systems based on what we know about physics, engineering, economics, social systems, etc. For each of these visions one could examine the technical barriers, resource barriers, etc, and then figure out what research would be needed to achieve that vision. If this is done for several visions, some items will reappear on several lists and others will be specific to an individual vision. Research items that are common to a broad spectrum of visions should be emphasized. You'll never get there unless you keep your eyes on the prize. Present coherent visions of where we would like to be and then decide what we need to do to achieve those visions. Ideally, this would involve geographical specificity (i.e., where exactly would this biomass farm be sited?) and deal with power generation, storage, transmission, etc. This activity should be a major focus of the first phase of CCTP.
29	General						The Plan is not very holistic in its approach.
30	General						The Fact that the U.S. is a Party to the Framework Convention on Climate Change Should Not Suggest that its Ultimate Objective Serves as a U.S. Goal for Plan Purposes. The Introduction refers first to the United Nations' Framework Convention on Climate Change (FCCC), quotes a portion of Article 2 of the FCCC - which sets forth the "ultimate objective" of the FCCC - and then states (pp. 1-2 and 1-3) that "[c]limate change is a serious, long-term issue, requiring sustained action over many generations by both developed and developing countries," that "[d]eveloping innovative technologies and approaches that are cleaner and more efficient is the key to addressing our long-term climate challenge" and that the "U.S. approach to climate change, which is consistent with and supports the UNFCCC's ultimate objective, forms the long-term planning context for the CCPT." In Chapter 2, the draft Plan again refers to the FCCC's "ultimate objective" and asserts (p. 2-2) that it "provides a planning context for CCTP's long-term technology development strategy," while recognizing that the level of "stabilized concentrations" of greenhouse gases (GHGs)2 "in the Earth's atmosphere implied by the ultimate objective is not known and will likely remain for some time a key planning uncertainty." Page 2-2, footnote 2 expressly states that the "CCTP Strategic Plan focuses on mitigation of GHG emissions and atmospheric concentrations, consistent with the context of the UNFCCC."3 Chapter 2 goes on to say (p. 2-2) that "the CCTP strategic goals are not based on any hypothesized level of stabilized GHG concentrations, but rather encompass a range of levels under conditions of uncertainty," and that the "technological challenge is to enable systems that could help achieve" a goal of "net emissions" that would approach levels that are low or near zero" (emphasis in original and emphasis added). In the Introduction (p. 1-1 n. 2), there is a definition/discussion of the term "greenhouse gases," which, among other things, refers to the Kyoto Protocol in a way that suggests that three named gases therein are not also covered by the definition of the term in Article 1 of the FCCC because they are "dealt with under the Montreal Protocol." That reference is misleading and should be avoided because the

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							FCCC Article 1 definition of GHGs covers all gases, while some Articles thereof, such as Article 4, refer to "greenhouse gases not controlled by the Montreal Protocol." However, that phrase is not contained in either Articles 1 or 2. In addition, note that Appendix A (p. A-2 n. 3) appears to be another definition/discussion of the term "greenhouse gases." Both definitions state that gases subject to the Montreal Protocol are "excluded" from the definition of GHGs and, in the case of page 1-1 footnote 2, from the "CCTP purview." While we are not concerned with gases covered by the Montreal Protocol, we do not understand why they should be "excluded" from the CCTP "purview." Furthermore, while the Appendix definition/discussion of GHGs appears to apply only to the Appendix, nevertheless these two differing footnotes on GHGs need to be reconciled. The U.S. is a Party, along with nearly 200 other countries, to the FCCC and Article 2 thereof. Article 2 applies to all Parties to the FCCC, not just the U.S., and sets forth the FCCC's "ultimate objective": The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. The draft Plan even includes a Figure 3.3 that "shows one set of relationships between CO2 emissions and CO2 concentrations over time, across a range of CO2 stabilization levels" derived from "scenario literature" dating back to 1996 and states that they are "illustrative. . .stabilization levels," although they do "not include all possible stabilization levels that might be consistent with the UNFCCC ultimate objective." (p. 3-4). Dr. Harlan L. Watson, Senior Climate Negotiator and Special Representative of the State Department, testified on October 5, 2005, before the Senate Committee on Environment and Public Works that "[a]s a Party to the UNFCCC, the United States shares with many other countries its ultimate objective" and that in 2002 the President "reaffirmed America's commitment" to the entire "Framework Convention" and "its central goal." However, while the Article 2 ultimate objective "provides a planning context" for the CCTP's long-term strategy, that objective is global, not oriented to any one Party, open-ended, uncertain and unknown, and therefore should not be a central basis for CCTP planning purposes. Moreover, the FCCC's supreme body, the Conference of the Parties (COP), which is a governmental policy-making body, not a scientific body, has never considered or adopted any conclusions or decisions regarding a global concentration level, a time frame to achieve that level or any other aspects of the FCCC's Article 2. Furthermore, our review of Article 2 and other Articles does not show any support for the assertions in the first sentences of page 2-2, footnotes 1 and 2 of the draft Plan that the CCTP's focus on "mitigation" of GHG emissions is "consistent with the context of the UNFCCC" or that the FCCC "states" that "additional scientific research is required to determine the level of GHG concentrations that would prevent dangerous anthropogenic interference with the climate system." In short, the draft Plan's references to, and reliance upon, Article 2 regarding the U.S. are inconsistent with the FCCC and are inappropriate. More appropriate for the Plan are the six strategic goals set forth in Chapter 2, which we support: • Reduce emissions from energy end-use and infrastructure. • Reduce emissions from energy supply. • Capture and sequester carbon dioxide (CO2). • Reduce emissions of non-CO2 GHGs. • Improve capabilities to measure and monitor GHGs. • Bolster basic science contributions to technology development.
31	General						The following is in response to your request about previous text that described the assumptions either in the reference case or in specific cases that have been removed in this version. We think that those textual explanations helped the reader understand the assumptions in the reference vs. scenarios.

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							p. 6 In this CCTP Reference Case, by 2100 total energy demand is projected to increase more than three-fold, from about 400 EJ today to 1200 EJ by the end of the century (Figure 3-4). Fossil fuels are projected to remain the backbone of the global energy system. However, as a result of technology improvement and growth in demand for energy, the Reference Case also shows significant global expansion in the use of renewable energy (solar, wind, geothermal, and hydroelectric energy), nuclear energy, and energy derived from biomass (biomass used for production of electricity, gaseous, and liquid fuels). p. 14 (see bolded language): The "story lines" behind the three CCTP advanced technology scenarios are: 1. Closing the Loop on Carbon is an advanced technology future in which the viability of engineered CO2 sequestration enables the continued use of fossil fuels, which in turn is substantially complemented by other energy sources and derivative energy carriers, including hydrogen. In this scenario, engineered sequestration meets key technical, economic, and environmental goals. Coal-based energy-plexes produce electricity, hydrogen, fuels and chemicals, with near-zero emissions. As a result, a large part of the existing fossil-based systems have the ability to become carbon-neutral and remain the backbone of the energy system through the century. There are high efficiency gains in coal combustion. There is also considerably increased use of nuclear, biomass and renewable energy, but these forms of energy do not dominate the energy future as do coal, oil and gas based systems. 2. A New Energy Backbone is an advanced technology future in which nuclear and renewable energy sources become dominant, reducing the proportionate role of fossil fuels and replacing them as the backbone of the energy system. This future would most likely come about as a result of either extraordinary improvements in renewable and nuclear energy technology performance that enable them to capture a larger share of the energy market based purely on their inherent advantages, or limitations that would inhibit sequestration from more significant market penetration. In this scenario, the increase in market share for biomass, renewable energy, and nuclear energy leads to a peak and decline in coal use. While diminished in terms of relative market share, fossil fuel use in 2100 would still be comparable to that of today in absolute terms. 3. Beyond the Standard Suite is an advanced technology future in which novel and advanced technologies grow to play a major role in the energy system, complementing the standard suite of energy technologies (including improved versions of the traditional technologies). This future explores the possibilities of new breakthrough technologies, such as: fusion energy; combinatorial applications of genetic engineering, nano-technology, and biotechnology as new ways to produce fuels or hydrogen and sequester CO2; and technologies for power transmission or beaming that might enable unprecedented expansion of large-scale solar applications. Given the size of the global energy system, it is likely that the standard suite of technologies, including energy efficiency, renewable energy, biomass, and fossil fuels would continue to play a dominant role in this future, as these novel or "exotic" technologies would take decades to mature and penetrate the global energy system to a large extent. However, particularly in the latter half of the 21st century, such technologies could potentially play a major role in the energy system, especially if research is effective. Such technologies would likely compete most directly with higher priced renewable energy, biomass, nuclear, sequestration, and efficiency gains, than with lower cost fossil energy systems. p. 20 The differences seen in technology supply, cost and performance assumed in the three advanced technology scenarios affect the level of penetration of the various technologies that displace unsequestered fossil fuel combustion, across the varying assumptions about carbon constraints, as shown in Figures 3-17and 3-18. For all but the very high emission reduction trajectories, in all of the CCTP advanced technology scenarios, unsequestered use of fossil fuels remains the principal form of energy used during the course of the 21st century, despite considerable substitution in all cases of near net-zero carbon and carbon-neutral energy technologies. Appendix B: in "Table B-1: Assumptions in the CCTP Reference Case and Baseline Scenarios . .: " under "Reference Case and Baseline Scenarios -- Renewables and Nuclear," "Substantial cost decreases in renewables and nuclear bring their costs below today's levels."
32	General						Overview comment on Chapters 1 and 2

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							Overview Comment: We support the goals and objectives of the Climate Change Program Strategic Plan. We are pleased to see an integrated program to address cohesively the goals of energy efficiency, emissions reduction and technology advancement through coordinated research and development efforts. We have been an active participant in the government's efforts to address climate change, energy efficiency and advanced technology initiatives. We are a participant in the EPA Voluntary Aluminum Industrial Program (VAIP) with EPA to reduce perfluorocarbon emissions from primary aluminum production and in the Administration's Climate Vision program to reduce greenhouse gas emissions. Currently the Climate Vision participants at the Association have achieved in 2004 the 2010 goal and reduced GHG CO2 equivalent emissions per ton of production by 53% from 1990 levels, as reported by EPA. The VAIP members also achieved a reduction in perfluorocarbon (PFC) emissions from smelters by 46% between 1990 and 2000. The VAIP has been recognized as one of the most successful voluntary programs the US Environmental Protection Agency has undertaken. Members in the VAIP represent 98% of emissions from primary aluminum production in the U.S. The EPA recognized the aluminum industry's accomplishment with the Climate Leaders award in 2002. The aluminum industry has also actively participated in the DOE-ITP Industries of the Future program to improve existing processes or develop new processes and equipment with greater energy efficiency and also reduced emissions. The draft strategic plan is important since its objectives seek to achieve results that are socially responsible, environmentally beneficial and economically viable in the context of climate protection. In our view, climate change initiatives must maintain a balance in all of these sustainability elements to be successful. The aluminum industry has a key role in climate protection and sustainability. Aluminum is an Environmental Material of choice due to its recycling capability, energy savings potential, sustainable sources, and value to societal objectives. To advance aluminum's potential in mitigating climate change, we see several areas in the Strategic Plan of importance: o Reducing emissions from energy end-use (Chapter 4) o Reducing emissions of high global warming gases (Chapter 7.3) o Enhancing capabilities to measure and monitor greenhouse gases (Chapter 8) In addition, we recommend that the Strategic Plan include some emphasis on the recovery and reuse of waste materials to conserve energy and improve production efficiency.
33	General						Technology Sharing: I would like to see commitment to an aggressive, comprehensive plan for sharing only our cleanest, most efficient technologies with developing countries, and sharing them without placing additional economic burden on those countries. In particular, the two most rapidly growing economies-- that of China and India-must be targeted, with technologies as advanced as carbon capture and sequestration. These technologies should be gifted to them. This truly is in our best interest, given the likely economic consequences of the climate change which will result from allowing China and India to continue development with their current carbon-emitting technologies. Please see my changes in Chapter 1 (Introduction) Page 2 of 8, lines 6 - 10. These are indicative of changes that I would like to see made throughout the document.
34	General						I would like to see research devoted to the proper accounting of carbon credits, i.e., when we ultimately enter a carbon-trading market (which we must), what is the most scientifically accurate way to assign carbon credits to, say, organic farming, planting x-acres of y-species tree, etc, switching to 100% pcw recycled paper - the various ‘soft’ numbers in the carbon balance. I see allusion to that in the

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							"measuring and monitoring" portion of chapter 10, but there is no mention of application of that research to carbon credit trading. You must begin setting the stage for that step.
35	General						In general, I find the tenor of this document to be insufficiently urgent. It is true that action must be sustained, but it must also be immediate. I realize that this is a document about funding new technologies, but I would like to see policy recommendations, such as for legislative action. Very soon I would like to see your office produce a document that summarizes the amount of GHG's that can be saved with the most, medium, and least ambitious possible technology plans and then actively calls for legislation that forces us to the higher road.
36	General						My focus was primarily on Chapter 6 and especially 6.4, but with implications for other chapters. My general comments are: 1) the current range of technologies emphasized in CCS (chapter 6) is very narrow relative to options that have been proposed or may emerge in the future. CCTP must acknowledge (here, as mentioned in Chapters 2, 9 and 10) that the ultimate, successful technologies and pathways may be very different to what is currently being pursued. CCTP must be open to broad and objective consideration of both new and old ideas. 2) The present and the potential future role of the ocean in mitigating CO2 has been significantly understated. 3) Elevated atmospheric CO2 will not only lead to climate change, but by diffusion into the ocean will lead to significantly increased ocean acidity. This could have a potentially catastrophic impact on ocean ecosystems. Thus, while CCTP's initial charter has been to avoid climate change, it is clear that non-climate impacts such as ocean acidification provide additional, compelling rationale to mitigate CO2.
37	General						The draft strategic plan for the Climate Change Technology Program represents an excellent beginning, but it is still missing some of the components of a complete strategic plan. A strategic plan should present: 1. a vision of success, 2. program priorities and how they are developed, 3. criteria for success, 4. allocation of available resources, 5. responsibilities for execution, and 6. an updating process. Taking each of these requirements in turn: 1.The draft contains a vision statement, but that statement is too narrowly focused on mitigating emissions from the energy sector. The draft plan covers all sectors that contribute to GHG emissions, and the vision statement should reflect that broad coverage. The CCTP should embrace a comprehensive approach to the challenge of climate change. The strategic plan avoids discussion of technological approaches that would facilitate adaptation, for example. As Dr. James Schlesinger noted at the Institute's 2005 Annual Dinner, "if one believes or assumes that it is the release of the greenhouse gases that is the culprit and not some more cyclical phenomenon, there may be no solution - and we need to begin to adjust to an earth that continues to warm. Those who profess to be able to 'fix the problem' may turn out to be like King Canute, commanding the waves of the seas to stand still" (Policy Outlook, "Remarks of Dr. James Schlesinger at the 2005 Annual Dinner and Awards Celebration, June 16, 2005). Whether climate change is driven by natural forces as yet not fully understood or human action or some combination of the two, the technology program designed to help prepare the nation must address those elements of climate change that may be inevitable. 2.The plan indicates four criteria for CCTP portfolio planning and investment, but these criteria cover only the technology development objectives. While technology development is a focus, it is not the only one. How these criteria are applied to the other stated or inferred objectives, such as the development of a viable technology work force for the future and the strategies to commercialize (or otherwise deploy) technologies developed under the plan's activities must be discussed. The plan needs to address how these objectives will be prioritized vis-à-vis the more traditional technology development objectives. More fundamentally, the criteria outlined in the strategic plan for deciding which technologies to support and how long federal support

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							should continue are not explicit enough. The lack of specificity will make it difficult for policy makers and program managers to select among what will be many competing approaches. As written, the plan leaves the impression that each approach is as important or potentially significant as the others. Without criteria that can prioritize investments and the ability to enforce those recommendations, the CCTP may result in supporting a hodge-podge of programs and projects. 3.The plan is commended for including specific targets for individual technology programs that can be used as criteria for success. Success criteria should be enunciated for all program objectives and projects. In particular, a mechanism for establishing criteria for success for the basic science programs outlined in Chapter 9 needs to be developed. Also, criteria for success need to be established for projects that are not part of the traditional technology development process, e.g., the goal of developing a viable technology workforce for the future. The CCTP's discussion of success criteria does not address whether the inability of a particular program or project to meet those criteria will result in its termination. Provisions for ending federal support for any particular program or project must be explicitly included as part of the evaluation process articulated by the strategic plan. The absence of clearly defined and understood standards may allow programs and projects to continue longer than is in the public's interest. These standards should clearly enunciate when a technology project has matured to the point of no longer requiring or deserving public support and they should describe the general conditions that would constitute a failed or unproductive effort. Without these kinds of decision making criteria, projects and programs may continue indefinitely, decisions to continue or terminate federal support will be made on an ad hoc basis and may reflect the predilections and preferences of individual decision makers, and those seeking to evaluate the effectiveness of the programs and projects will lack clear guidelines to assess the programs against.

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38	foreword	iv	iv	6	6		Insert "and Climate" after "Development."

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39	1	General					The plan is commendable for taking a century-long view of the question of climate change. However, figure 3.3 on page 3 - 4 shows that even this is not a long enough perspective. Carbon emissions need to be driven down dramatically after 2100, until about 2200, while energy production is presumably still increasing. Thus the challenge is not only to reduce carbon emissions in the current century, but to position the nation and the world with large-scale technologies to drive carbon emissions to very low levels by 2200.
40	1	General					The report gives the impression that we have a long time - generations - to develop the technologies needed to deal with the climate change problem. There is no sense of urgency, though many scientists, including me, are convinced that we have a relatively small window of opportunity-perhaps only a decade or two--to substantially reduce GHG emissions (especially CO2). Because of positive feedbacks in the Arctic (the reduction in albedo as the ice cap melts and more heat is absorbed by the ocean that replaces it; and the growing emissions of methane and CO2 from Arctic tundra that has been frozen for thousands of years and is now melting at an accelerating pace) the Earth could reach a tipping point where the situation is no longer under our control and global warming runs away-no matter what actions we take at that point. The report also gives the impression that new technologies need to be developed to make any substantial reductions in GHG emissions. Professors Pacala and Socolow at Princeton University published a groundbreaking article in Science in 2004, titled, Stabilization Wedges - Solving the Climate Problem for the Next 50 Years with Current Technologies. The authors suggested 15 existing technologies that can save the planet by improving energy efficiency and moving to renewable energy sources such as wind, solar and biomass. See: http://www.princeton.edu/~cmi/resources/CMI_Resources_new_files/Wedges%20ppr%20in%20Science.pdf
41	1	1-1	1-1	10	33		Delete and substitute: - The United States, as a Party to the United Nations Framework Convention on Climate Change (FCCC), shares with all other Parties to the Convention the ultimate objective of the FCCC, which is set forth in Article 2 as follows: - The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner. - Although the FCCC's Conference of the Parties has not considered or adopted a stabilization level or a related time frame, the United States recognizes that for the Parties to achieve this objective will require long-term international cooperation. As noted in our Overview Comments, the Article 2 ultimate objective of the FCCC is a global goal for all Parties, not just for the U.S. Indeed, because of the global nature of climate change, the U.S. alone could not achieve the "ultimate objective," nor should that be expected. In addition, if the Article is to be quoted, it should be quoted in full, as all its provisions are relevant.
42	1	1-1	1-1	39	39		"sustainable development." The term is not described in this context. The phrase has many meanings and connotations. Suggest rephrasing the sentence to " that countries will undertake." The following sentence defines the U.S.'s objectives and provides sufficient context to interpret the preceding sentence.
43	1	1-2					Climate change is a serious, long-term issue, requiring sustained action over many generations by both developed and developing countries. Solutions will likely require fundamental changes in the way the world produces and uses energy, as well as in many other GHG-emitting activities of industry, agriculture, land use, and land management. Developing innovative technologies and approaches that are cleaner and more efficient is the key to addressing our long-term climate challenge.
44	1	1-2					The strategy outlined on page 1-2 is based on the hope that better technologies achieved through government R&D and strategic collaborations will lower the cost of controlling GHG emissions sufficiently that these better technologies will be widely adopted. In my view this is highly unlikely. Controlling GHG emissions will always be more expensive than not controlling them. The government's

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							strategy should include forcing functions in addition to R&D expenditures. For example, the policies proposed by the National Commission on Energy Policy were modest but with increasing intensity. EIA analyzed this set of policies and found that they involved low cost and were assessed to be generally effective. Also, you should not forget the Sense of the Senate vote as part of EPACT 2005 expressing the view that forcing functions would be necessary in the future. If these policies are not forthcoming the world may be in for a colossal tragedy of the commons.
45	1	1-2	1-2	6	10		"Climate change is a serious, long-term issue, requiring IMMEDIATE AND sustained action over many generations by both developed and developing countries. Solutions MUST require fundamental changes in the way the world produces and uses energy, as well as in many other GHG-emitting activities of industry, agriculture, land use, and land management. Developing innovative technologies and approaches that are cleaner and more efficient AND LEGISLATING STRICT CONTROL ON CARBON EMISSIONS ARE the key to addressing our long-term climate challenge.
46	1	1-2	1-2	7	7		Insert: developed and developing countries. Nor is climate change the only concern with regard to increasing atmospheric CO2. The benefits of technologies like CCS stem from their ability to lower the carbon emissions intensity of conventional fossil-fuel-derived energy resources. As discussed in Chapter 6, roughly one third of excess CO2. The benefits of technologies like CCS stem from their ability to lower the carbon emissions intensity of conventional fossil-fuel-derived energy resources . emissions currently dissolves in the ocean, forming carbonic acid. The resulting ocean acidification is expected to significantly impact marine chemical and biological processes if fossil fuel use and anthropogenic CO2 emissions continue on their present trajectory. Solutions will likely require fundamental changes in the way the...
47	1	1-2	1-2	7	7		"Solutions..." Solutions is an odd word choice as it implies that some set of actions can "solve" a problem. For instance, if climate change is in part a natural phenomenon, then defining what is a "problem" becomes problematic. Suggest replacing "solutions" with "actions" or "steps to address it" which convey the same point, but lack the ambiguity of "solutions."
48	1	1-2	1-2	10	10		Insert: cleaner and more efficient is the key to addressing our long-term climate and environmental challenges.
49	1	1-2	1-2	12	12		Change the sentence that begins on line 12 to read as follows: "It is science- and market-based; and encourages innovation, scientific and technology breakthroughs and global participation.";
50	1	1-2	1-2	17	17		Strike the word "new" and insert "cleaner, more efficient". Both changes bring these sentences in line with page 1, paragraph 2 of the Vision document, which is the source of the paragraph at lines 12-17.
51	1	1-2	1-2	32	32		Insert "and Climate" before the comma after "Development."
52	1	1-7	1-7	8	8		"...meeting climate goals." The use of the word climate is meant to imply something, but what isn't stated. Does it refer to emission level reductions, stabilization of CO2, or some other policy-related objectives? A modifier should be inserted clarifying what is meant by "climate goals."
53	1	1-7	1-7	19	19		Insert: Uncertainties about causes and effects of climate change and other environmental impacts will be better understood and the potential
54	1	1-7	1-7	19	19		Need to injected (somewhere) that ocean acidification is another motivation to stabilize atmospheric CO2. This is not just a climate change issue, it is an environmental and global change issue.

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55	2	General					Once specific targets have been set they must be reiterated in every place possible, even in an overview Chapter like this.
56	2	General					While climate change is again the only reason given for the need for CO2 mitigation, it would be good to point out that there are environmental, non-climate reasons to mitigate CO2, i.e., ocean acidification - see comments on preceding and following chapters esp 6. Finally and gratefully acknowledged by you later in the chapter is the need for broad consideration of potential technology pathways and that the best ultimate solutions may not be the ones presently being pursued.
57	2	General					If research and technology is to have an impact on the future of our climate then it must be directed and managed by specific quantifiable goals. Chapter two is fundamentally void of quantifiable goals. At minimum there should be a specific reduction goal number and a set time when these goals must be achieved. Specific emission reduction numbers are instrumental in identifying the direction research needs to take and the resources necessary to accomplish the desired results. A time frame allows a plan to self-evaluate at appropriate intervals and without self-evaluations there is a high risk for waste, duplication and inefficiencies.
58	2	2-1	2-1				In the Vision Statement on P 2-1 what is meant by "substantial reductions?" Can you be more quantitative?
59	2	2-1	2-1			Vision Box	CCTP Vision text box last line, replace with: climate and environmental change.
60	2	2-1	2-1	13	39		CCTP Mission: While development of new technology is critical, there is a huge pool of existing low-GHG emission technology that is not being used to its full potential. Existing U.S. domestic programs, e.g. Energy STAR, include promoting the use of this technology, as do our partnerships with others (See: Dec. 3, 2004 Department of State Fact Sheet on Bilateral and Regional Partnerships). In the short-term, increased use of existing low-GHG emission technology will provide greater benefits than technology development, which will pay off in the medium- to long-term. The CCTP Mission Statement should include promotion of existing technology. We suggest that the end of the CCTP Mission be rewritten: aimed at accelerating the development of new and advanced technologies, and the utilization of existing technologies, that can attain the CCTP vision.
61	2	2-1	2-1	13	39	Vision Box and Mission Box	CCTP Vision: The CCTP vision statement focuses too narrowly on the provision of energy services. A wide variety of other anthropogenic activities can impact the climate system, and technology development should focus on mitigating the full range of these potential impacts. The CCTP draft strategic plan recognizes this need in Strategic Goal 4, reduce emissions of non-CO2 gases, which includes reducing N2O and methane emissions from agriculture as one of its highlights. Chapter 7 defines other GHGs to include tropospheric ozone and black carbon. In this respect the draft Strategic Plan is comprehensive. Its visions statement should also be comprehensive. We suggest that the CCTP Vision be rewritten: The CCTP vision is to provide the technology needed to ensure that the goods and services required by society, especially abundant, clean, secure, and affordable energy and related services, can be provided while simultaneously achieving substantial reductions in emissions of greenhouse gases and other anthropogenic impacts on the climate system. The Vision statement could be further modified to reflect an endorsement of a comprehensive approach to climate change. The vision avoids discussion of technological approaches that would facilitate adaptation, for example, and indeed adaptation is specifically rejected as a strategic goal on Pg. 2-2, line 32, footnote 2. As Dr. James Schlesinger noted at the Institute's 2005 Annual Dinner, "if one believes or assumes that it is the release of the greenhouse gases that is the culprit and not some more cyclical phenomenon, there may be no solution – and we need to begin to adjust to an earth that continues to warm. Those who profess to be able to 'fix the problem' may turn out to be like King Canute, commanding the waves of the seas to stand still" (*Policy Outlook*, "Remarks of Dr. James Schlesinger at the 2005 Annual Dinner and Awards Celebration," June 16, 2005). Whether climate change is driven by natural forces as yet not fully understood or human action or some combination of the two, the technology program designed to help prepare the nation must address those elements of climate change that may be inevitable.
62	2	2-1	2-1	19	21		"... substantial reductions in emissions..." How is this to be measured? The strategic plan should state what metric (absolute reductions v. intensity reductions - or some other measure) will be used to evaluate the programs.

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63	2	2-1	2-1	23	23		strike word 'potential' It is 'risk of invasion by Martians' not 'risk of potential invasion by Martians'. If the outcome is unlikely, the risk is small. Adding the word 'potential' does not add content.
64	2	2-1	2-1	23	23		Replace with "mitigating the risks of potential climate and environmental change"
65	2	2-1	2-1	37	39		Insert a period after "technology" and delete the words "toward attainment of the UNFCCC's ultimate objective";
66	2	2-2	2-2			footnote 1 and 2	Delete the first sentence of footnote 1 and all of footnote 2. These changes are consistent with our Overview Comments on the Article 2 ultimate objective and adoption.
67	2	2-2	2-2			Footnote 2	Footnote 2 explains that adaptation technology and offset technologies will not be considered. No real explanation of this gap is given. Since the world will experience the consequences of anthropogenic increases in GHG concentrations in the atmosphere global systems will need to adapt. This is true no matter how good we become at mitigating emissions. I can not understand why adaptation technologies are not a part of the CCTP Strategic Plan. You need to explain this much better than is done in footnote 2. Also, offset technologies should at least be explored and tested. They may be needed. They are a kind of insurance policy in case we can't control emissions to avoid dangerous interference with the climate.
68	2	2-2	2-2	2	7		On page 2-2, change lines 2-7 to read as follows: "For the purposes of planning for CCTP's long-term technology development strategy, two considerations arise. First, the level of stabilized concentrations of GHGs in the Earth's atmosphere is not known and will likely remain for some time a key uncertainty.1 Accordingly, CCTP's strategic goals".
69	2	2-2	2-2	4	14		It is unnecessary to raise the issue of the stabilization level needed to avoid dangerous anthropogenic interference with the climate system. As the text points out, stabilizing GHG concentrations at any level requires that net emissions of GHG slow and eventually stop. This is a huge challenge that will require all of the technology discussed in this plan and more. Delete the first consideration and the references to it.
70	2	2-2	2-2	14	14		Amend to read "... achieve this goal affordably." As has been pointed out, the goal could be achieved if we all returned to pre-industrial technologies. The problem is that the costs of doing so are too high. The goal of CCTP is to achieve the goal affordably, with acceptable costs.
71	2	2-2	2-2	17	17		Change the text to "reducing emissions of CO2 from energy end-use and infrastructure, energy supply, and other sectors;". According to the IPCC Third Assessment Report, CO2 emissions from land-use practices accounted for about 20% of total CO2 emissions during the 1990s. Control of some of these CO2 emissions would be enhanced by development of appropriate agricultural technology. Small amounts of CO2, about 2% of the global total, are also emitted as process emissions, e.g. reduction of metal ores, and calcination of carbonates to produce cement and lime. Technology can be developed to reduce some of these emissions. For example, Chapter 4 (Pg. 4-16, lines 7-15) discusses R&D to reduce non-combustion emissions from cement manufacture. To indicate the comprehensive nature of this plan, control of these non-energy related emissions should be part of the strategic goals.
72	2	2-2	2-2	18	18		Replace with: "storing CO2 from various emissions sources or from the air and sequestering it from the atmosphere; and"
73	2	2-2	2-2	19	19		Add "and other contributors to potential climate change from all sectors" after non-CO2 GHGs. The draft's focus on CO2 from the energy sector is too narrow. Other GHG emissions and other anthropogenic emissions contribute to potential climate change. Since a large portion of non-CO2 GHG emissions are not related to energy use, the draft must clarify whether all sectors are included and, if some are excluded, why that is the case. The specifics under CCTP Goal 4 acknowledge the importance of non-CO2 emissions from agriculture and emission of black carbon, but since the strategic goals are likely to appear in many places without the details presented in this plan, it is important that the goal itself include a broader view.
74	2	2-2	2-2	20	20	footnote 2	The CCTP should not limit its focus solely to an interpreted mandate from the UNFCCC. The framework laid out in the strategic plan should help define the scope of all possible technological responses to climate change, particularly in recognition of momentum factors that may be present and uncertainties in the underlying science of climate change.
75	2	2-2	2-2	21	22		Replace with: "any acceleration of technology development is the identification of promising pathways and the use of basic research to illuminate technical opportunities, barriers, and alternatives in solving the CO2 problem."

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76	2	2-3	2-8				Discussion of Goals 1-6 From our electric utility sector perspective, the first three goals are a priority.
77	2	2-3	2-3	1	1		Change to: "Reduce CO2 emissions from energy use and infrastructure and other sectors." According to the IPCC Third Assessment Report, CO2 emissions from land-use practices accounted for about 20% of total CO2 emissions during the 1990s. Control of some of these CO2 emissions would be enhanced by development of appropriate agricultural technology. Small amounts of CO2, about 2.5% of the U.S total, are also emitted as a result of non-combustion industrial processes (e.g., calcination of carbonates to produce cement and lime). Some of these emissions can be reduced by substituting other materials either for the carbonates used in cement or for cement and lime in their end-use applications.
78	2	2-3	2-3	6	6		After Line 6, add "Study mitigation of global warming impacts for possible implementation using geoengineering
79	2	2-3	2-3	20	24		These statements bring the question of how to promote deployment and use of advanced technologies by industry and consumers. Subsequent discussion, either in the strategic plan or related implementation documents, needs to explicitly define how these deployment objectives will be met. The discussion that follows in Chapters 4-7 does an excellent job of summarizing existing federal research and development programs, but offers very little discussion of how the technologies supported (presuming the stated goals are achieved) will be put into service.
80	2	2-4		8			Add another bullet point: Non-energy sources of CO2. While energy supply and use creates the majority of anthropogenic CO2 emissions, significant amounts of CO2 result from land use practices and from some the non-combustion industrial processes, e.g., calcination of carbonates to produce cement and lime. Appropriate agricultural technology can reduce CO2 emissions from land-use, and process changes can reduce non-combustion emissions. For example, using non-carbonate materials (e.g. blast furnace slag, fly ash) to replace part of the carbonate used to make cement will reduce CO2 emissions from cement manufacture.
81	2	2-4	2-4	20	20		Replace with: "electricity generation technologies, deployment of renewable technologies, use of CO2 capture and sequestration (see below), increased use of nuclear"
82	2	2-4	2-4	26	28		There is a logical confusion here. Ethanol and other bio-based fuels are not low carbon energy carriers. If ethanol were made from coal without CCS, we would not think it a great leap forward. Ethanol could be good if it were made from biomass, but gasoline produced by biomass would be good also. Anyway, the point is that carbon-free energy carriers are good (H2 and electricity). Any carbon containing energy carrier is good if the carbon released upon the combustion of the energy carrier is offset by uptake elsewhere in the system (as would occur if the carrier were made from biomass). The point here is that we should be choosing goals: non-carbon energy carriers or carbon-based energy carriers where the carbon (or an equivalent amount) is removed from the atmosphere. Let's specify goals etc and not prejudge which technology would best meet this goal.
83	2	2-4	2-8	29	7		With respect to goal 5, since the enactment of section 821 of Pub. L. No. 101-549 in 1990 (the Clean Air Act Amendments), our industry has reported CO2 emissions annually to the Environmental Protection Agency. That requirement, coupled with voluntary reporting of GHG reductions under section 1605(b) of the Energy Policy Act of 1992, addresses emission measurements for the electric utility industry, and thus the goal should not apply to our sector. Note that goal 5 only refers to R&D regarding GHG emissions monitoring and measuring. The goal should be expanded to cover measuring and monitoring R&D technologies for GHG reductions.
84	2	2-4	2-8	29	7		As to goal 6, we are supportive. However, it is not our highest priority.
85	2	2-4	2-8	29	7		At the beginning of the paragraph, insert: "Fossil fuels will likely remain a mainstay of global energy production well into the 21st century."; and on line 30, after "would," insert "enable the continued use of the world's plentiful coal and other fossil energy resources. Such a transformation would. . ." These inserts are from the p. 15, paragraph one of the "Vision" document from which the paragraph beginning on p. 2-4, line 29 and ending on p. 2-5, line 4 appears to be derived. We presume these inserts were inadvertently dropped from the paragraph. In any event, these inserts are important and should be reinserted.
86	2	2-4	2-8	29	7		In the case of goal 4, CO2 emissions are 99.9 percent or more of electric utility GHGs, and thus we are not particularly concerned with non-CO2 emissions from our sector.
87	2	2-5	2-5	4	4		Replace with: "current focus areas are:"
88	2	2-5	2-5	9	9		Replace with:

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							"saline aquifers, or other deep injection reservoirs. The carbon could also be stored in the ocean as CO2 or other chemical form."
89	2	2-5	2-5	12	13		Reference to ocean sequestration is unclear. Most people who have looked at the issue believe that carbon capture and storage in the ocean is technologically feasible but may pose political and environmental challenges. Most people who have looked at ocean fertilization question its viability and efficacy, and thus it probably should not be highlighted at this level of the report (as this level should focus on things likely to hold some promise). The most promising ocean option in the opinion of this reviewer involves using power plant flue gases in combination with seawater and crushed limestone with effluent release in the surface ocean. Sulfur removal with seawater and limestone are both promoted as clean energy options by the World Bank. These technologies could be combined to remove CO2. This is another case where the report is choosing technologies based on prior DOE funding history and not an objective analysis of engineering and other constraints.
90	2	2-5	2-5	12	13		replace with: low-cost means for long-term carbon storage. Enhancing the ocean's biological CO2 sink could also play a role. An understanding of the efficacy and environmental effects of the preceding approaches is needed.
91	2	2-5	2-5	13	13		Add "and other contributors to potential climate change from all sectors" after non-CO2 GHGs. The focus of the strategic plan is on CO2 from the energy sector. Other GHGs and other anthropogenic emissions, e.g., black carbon, also contribute to potential climate change. Since a large portion of non-CO2 GHG emissions are not related to energy use, the plan’s wording should be clear that all sectors are included. The specifics under this goal acknowledge the importance of non-CO2 emissions from agriculture and emissions of black carbon, but since the strategic goals are likely to appear in many places without the details presented in this plan, it is important that the goal itself include a broader view.
92	2	2-5	2-5	14	15		Not strictly true. The time integrated radiative forcing in Joules per m2 is the instantaneous radiative forcing of CO2 times a time constant that is close to 20,000 years. This is higher than the radiative forcing of these other gases on a mass basis. The IPCC GWP technique ignores the long lifetime of CO2. The statement as written is true only if we are talking about instantaneous radiative forcing and ignoring atmospheric lifetimes. Language should be clarified to indicate this.
93	2	2-6	2-6	1	1		The GWP is a terrible measure as it is non-scientific. It is equivalent to having a zero discount rate for 100 years and an infinite discount rate thereafter which makes no sense. The United States should not be embracing such a measure with no sound basis in science or economics.
94	2	2-7	2-7	5	5		Replace with: "research and development. The dual challenges-addressing global climate/environmental change and providing the"
95	2	2-7	2-7	10	10		Replace with: "better prepared to find solutions and create new opportunities, including fostering new ideas and approaches that may be outside current R&D thrusts. CCTP will focus on several ways to meet"
96	2	2-7	2-7	26	33		The inclusion of provisions for exploratory research is critical to the success of this plan and should be retained. However, there need to be criteria for judging exploratory research and for terminating unsuccessful projects after they have been given a reasonable chance to succeed.
97	2	2-8	2-8	9	9		Missing from the core approaches is learning by doing. If CCTP develops carbon capture and storage and no profit making venture deploys it commercially, a learning opportunity will be missed. A government run demonstration plant will generate a constituency that wants to see the demonstration plant live forever without great incentive to reduce costs. A price on carbon will induce deployment of technologies by enterprises with great incentive to reduce costs.
98	2	2-8	2-8	28	33		As written, the strategic plan perpetuates the antiquated linear framework of innovation (i.e., basic research leads to applied R&D which leads to technology development). Other models of innovation may be more applicable to the climate change issue, but certainly will be less applicable to the traditional federal budgeting and organizational framework.
99	2	2-8	2-8	34	38		The plan should explicitly note that the discoveries mentioned would be more supportive to the general pursuit of the goals of the plan, and likely would not directly contribute to them.
100	2	2-9	2-9	1	17		The CCTP must sharpen the discussion of how public and private sector roles will intersect in the course of the R&D activities defined by the plan. The strategic plan places great emphasis on the need for public-private sector partnerships and enhanced cooperation and collaboration, but its discussions do not provide sufficient details or descriptions to determine how such activities will work in practice. Instead, the plan references a number of ongoing collaborative efforts. These efforts represent multiple ways to organize and execute an R&D. The plan does not discuss which factors produce more successful partnering efforts so that future initiatives

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							(i.e., those guided by this strategic plan) can benefit from the lessons of these prior efforts. The plan also does not discuss the factors that complicate public-private cooperative efforts and does not offer guidance for overcoming those complications. The plan does not discuss what incentives or inducements may be employed to encourage more efficient and effective partnering. The plan appears to promote the view that access to R&D resources/assets and intellectual property is sufficient to encourage private sector involvement. Reviews of prior partnership programs would reveal the limitations of that approach and suggest the need for an additional set of incentives. If it is determined that the range of activities covered by the plan is somehow unique, then the plan must include that discussion. The plan does not discuss other mechanisms by which technologies developed under the auspices of the plan will be transferred to the private sector. If partnerships are the sole instrument for achieving that end, additional exploration of how effective that mechanism will be is strongly recommended. If other actions are foreseen, discussion of them in the strategic plan is clearly warranted.
101	2	2-10	2-10	14	14		Demonstration projects eat up large amounts of money that could be used for more fundamental research and development. Insert a sentence such as "Demonstration projects should be at the smallest scale necessary to demonstrate the technological feasibility of a proposed technology or approach. Demonstration projects should have a limited lifetime." Safeguards are needed to avoid turning demonstration projects into pork. I would like to see a process wherein the funding cycle would continue as if there were no demonstration project and then the proposers of the demonstration project would need to argue that their project is more valuable than all of the projects that would not get funded should the demonstration go forward.
102	2	2-10	2-10	26	35		Ensuring a viable technology workforce for the future is critical to meeting a broad range of U.S. goals, not just to the addressing the risks of climate change. We hope that the CCTP approach is linked to a much larger Federal effort to meet this need. If so, those linkages should be mentioned.
103	2	2-11	2-11	12	12		While the goals and intent of this prioritization process are laudatory, these goals can be undermined if there are conflicts of interests between the prioritizers and those getting the money. I would like to see an open peer review process wherein the panels making funding decisions are composed of people who are not getting any money, or proposing to get money, directly or indirectly, from CCTP. Recusal for specific proposals is not enough. Safeguards must be in place so that CCTP does not turn into a bunch of DOE-managers dividing the money up among themselves. CCTP should look to retirees, uninvolved academics, interested and knowledgeable citizens, etc. to judge the merits of proposed projects, not people who stand to gain or lose personally from CCTP.
104	2	2-12	2-12	1	2		Suggest inserting that "some may fail" after "as hoped." Undoubtedly, some efforts may not produce as expected. The prospect of failure should be recognized so as not to create incentives to underachieve so as to avoid failure. The evaluation regime established for the CCTP as a whole and the individual programs/projects should also be tasked with exploring why failure occurred, so others can learn from those lessons.
105	2	2-12	2-13	28	29	Box 2-1	The criteria for public vs. private investment should be stated more clearly. Public investment should only be made in those areas of R&D which a) require too much capital for individual corporations or consortia of corporations or b) are too long-term for the protection of intellectual property rights. In essence, these investments should meet the "but for" criterion - these major new technologies would not be developed "but for" federal investment. Accelerating the implementation of even much improved technologies which would be developed anyway by private enterprise, but somewhat more slowly, does not in effect meet criterion #3. Large scale should not be measured in GtC per year, but in GtC - meaning that a few-year acceleration of even an attractive large-scale technology should not qualify.
106	2	2-12	2-12	37	37		Who will be applying these criteria? It is all good to state nice principals, but if you get a room full of DOE managers applying these rules, it is likely to conclude that the money should be divided up among DOE labs. There is a need to avoid real or perceived conflicts of interests in the application of these criteria.
107	2	2-13	2-13			Box 2-1	We support these four criteria for CCTP portfolio planning and investments. We are particularly pleased to see the Program's acknowledgement of the role of the private sector in technology R&D. However, we suggest the criteria be enhanced with the following changes. Criteria 1 should include a statement that projects with low risk and quick payout need to be included in the

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							portfolio. Criteria 4, as part of (iii) should include mention of the exploratory research discussed on Pg. 2-7.
108	2	2-13	2-13	1	5	box 2-1	The four criteria are generally acceptable, but sufficiently ambiguous to create important interpretation questions in the future. For instance, Pg 2-13, lines 1-5 concede that the reduction to quantitative analysis is difficult, but yet the first criteria depends on exactly that line of reasoning. Criteria 1 should include a statement that projects with low risk and quick payout need to be included in the portfolio. Criteria 2 requires a discussion of how or who will decide the proper and distinct roles on a case-by-case basis. The plan is commended for recognizing the importance of partnerships, however. Criteria 4, as part of (iii) should include mention of the exploratory research discussed on Pg. 2-7.
109	2	2-14		10	12		An amplifying statement that this process will include shifting resources between goals and between agencies involved in CCTP, as appropriate, would be helpful.
110	2	2-14	2-14	17	18		The plan states that "... by agency deputies, who can adopt ..." in discussing executive direction to federal departments and agencies. The use of the verb "can" implies discretion on the part of the participating agencies. The plan should discuss the instruments that the IWG and the CCCSTI will use to enforce compliance with and fulfillment of CCTP objectives.
111	2	2-15	2-15	7	38	Box 2-2	Section 2.5: Management, Page 2-15, Box 2-2 The Climate Change Technology portfolio includes a section on Carbon Capture. The large point CO2 sources are primarily power plants, oil refineries, and other industrial facilities as stated on page 6-3, line 2-3. It is understandable that the USDA is assigned to lead the working group for CO2 sequestration because of the potential land use issues, however if that is the case, CO2 Capture should not be group under the leadership of the USDA since that technology does not concern land use or agriculture. We suggest that the CO2 Capture should be separated and led by the DOE.
112	2	2-15	2-15	16	18		Pg. 2-15, lines 16-18: The plan must define the term "appropriate priority." The CCTP strategic plan does not articulate how the interagency structure will direct or influence the internal decision making of the constitutive agencies. The plan seemingly relies on the persuasive abilities of the CCTP representatives to direct budgets and policy in the directions identified by the strategic plan. This approach has rarely proven successful.
113	2	2-15	2-16	27	5	section 2.5.4	Suggest clarification of the nature of the external interactions. The CCTP would benefit from the adoption of a formal external review process. A two-prong approach would provide useful insight and perspective on the direction and accomplishments of the research effort. Given the dual emphasis on supporting R&D activities to meet national goals and the strong endorsement of private sector involvement, and by extension their economic goals, the CCTP should be reviewed periodically by (1) a group representing the university and national laboratory stakeholders identified as participating in the CCTP and (2) a group representing the industrial partners. These two external review groups would provide diverse reviews of the program and evaluate it using much different perspectives. Each group would be tasked with providing evaluations of ongoing efforts, summaries of the utility and use of past efforts, and offer recommendations for future research efforts and ways to improve the management and efficiency of the research enterprise supported under the CCTP.
114	2	24	2-4	8	8		Add another bullet point: Non-energy sources of CO2. While energy supply and use creates the majority of anthropogenic CO2 emissions, significant amounts of CO2 result from land use practices and from some the non-combustion industrial processes, e.g., calcination of carbonates to produce cement and lime.

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115	3	Gen eral					The conclusions of this chapter nevertheless are reasonable and appear to follow from the myriad analyses quoted even if the three scenarios above were not included. It remains a challenge therefore to be explicit as to what further insights the PPNL analysis brings to the table beyond their general clarity and expertise.
116	3	Gen eral					Chapter 3 Need a brief summary in this chapter of the range of impacts that could constitute dangerous interference with the climate system, perhaps by borrowing from IPCC second and third assessment reports. This would give the reader an indication why climate change mitigation is important. Chapter 3 does not give a range of primary energy use for the range of carbon emission scenarios. A plot equivalent to Fig 3-4 for primary energy would be useful.
117	3	Gen eral					The aim of the chapter, to aid in formulating a technology agenda by synthesizing scenario results from a variety of models, is highly appropriate. The issues raised here concern some of the choices in structuring the specific scenarios highlighted in support of the CCTP. They are labeled, Closing the Loop on Carbon, A New Energy Backbone, and Beyond the Standard Suite. The current CCTP technology agenda and projects, as detailed in other chapters of the report, largely contains elements that appear either in the Closing the Loop scenario or in the New Energy Backbone scenario. There is therefore no specific scenario that directly relates to the overall CCTP. It would therefore be quite useful and potentially quite instructive to run a scenario using the PPNL MiniCam model that includes the majority of the CCTP technology elements. The extent to which such a scenario approaches the UNFCC goals could be a real test of the CCTP plans.
118	3	Gen eral					While the CCTP primarily focuses on technology as the primary driver for dealing with Climate Change, many hundreds of scenarios have their primary focus on policy formulation. Somewhat in that vein, the recent analysis of the National Commission on Energy Policy combines the two and appears to offer a revenue neutral path toward energy security that also moves toward a lower carbon dependant world. Recent analyses by EIA appear to strongly support the findings of the Commission. If a MiniCam analysis were applied to the NCEP technology formulation and agreement were found, it would suggest that the CCTP agenda could be mounted in a fashion which would lead to a revenue neutral situation at least for some period of time.
119	3	Gen eral					The last scenario, Beyond the Standard Suite, requires rather dramatic breakthroughs in a significant number of technologies. Facetiously, it might be called Far Beyond the Standard Suite. In particular, it calls for reliance on "BIO-X" that is described as a conglomeration of new biological based technologies. The only result from a Google search is a new program at Stanford University with this name whose goal appears to be similar to the description in this chapter. But there is found absolutely no mention of any energy connection. It becomes difficult to understand how BIO-X plays out in this scenario given so little specific information. The inclusion of fusion in the "exotic" category in this scenario appears to be a mischaracterization. A major study by DOE's Fusion Energy Scientific Advisory Committee indicated that a first commercial fusion reactor could be online in 2040. Various studies also show that fusion development could lead to fusion power taking up a significant fraction of the load in the Beyond the Standard Suite scenario. It is recommended that inclusion of such statements relative to fusion be included in the descriptive material for this scenario
120	3	Gen eral					The results of the Pacala and Socolow "wedge" analysis are referred to in this chapter as a technology limiting issue. However, the analysis is brushed aside as not adequately representative from a market, regulatory, etc. etc. perspective. Since CCTP appears to agree that the Pacala-Socolow technology choices are valid ways of achieving gigaton scale reductions and presumably agrees with the Pacala-Socolow statement that these technologies have passed the benchmark state, then what is needed is a more sophisticated scenario analysis. MiniCam calculations should be carried out to see whether the "wedge" concept produces a promising 50-year program as the authors

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							claim. If so, it would allow a redistribution of R&D funding and allow greater support for longer-range technologies such as fusion, hydrogen, etc.
121	3	Gen eral				Fig 3-12	Chapter 3 What is the range of other greenhouse gases on top of CO2. This needs to be exposed. Fig. 3-12 gives a best case scenario where OGG are equal to about 2.5 gtC equivalent in 2100. A plot that shows the combined range of CO2 and OGG is needed to indicate the relative importance of these other gases.
122	3	3-1	3-1	1	36		Overview Comments on Chapter 3 Synthesis Assessment of Long-Term Climate Change 1) Need to at least mention ocean acidification is an addition rationale for CO2 mitigation, i.e. this is truly a global change issue not just a climate change issue. 2) Need to point out that the technologies that are ultimately successful in mitigating CO2 may bare little resemblance to those currently being pursued and rather narrowly discussed here. The national R&D effort must be open to new ideas and approaches and not assume that technologies current research thrusts are the only ones worth considering. The objective is to solve the CO2 problem, and not to assume that the required advances in the specific technologies favored today may be possible or even relevant in the future.
123	3	3-1	3-1	15	21		Delete the sentence beginning on line 15 through line 21. Again, it is not appropriate for the Plan to discuss, in the context of a RDD&D technology strategy for the U.S., a "level" of GHG concentration that "would meet the UNFCCC's ultimate objective," which, as we pointed out repeatedly above, is an unknown global goal for all Parties to the FCCC, not just the U.S. In addition, if Article 2 is quoted, we reiterate that it should be quoted in full.
124	3	3-1		15	21		Delete the discussion of stabilization level. As noted on Pg. 2-2, lines 11-13, stabilization requires net emissions of GHGs to be very low or near zero. From a technology planning standpoint, it makes very little difference what stabilization level is chosen. The challenge for technology is so large that all technologies that will reduce GHGs need to developed. From a practical level, the question of stabilization level has been on the world's political agenda for more than a decade without resolution, or the realistic expectation of resolution. It is unreasonable to assume that there will be a resolution of this issue in a timeframe that would affect the technology development plans in this draft.
125	3	3-1	3-3	38	4	figure 3-1	This discussion is inconsistent. The figure it contains shows global GHG emissions, and the text give information on U.S. emissions from some, but not all GHGs. It would be useful to present a figure in the same format as Figure 3-1 for U.S. GHG emissions.
126	3	Sect ion 3.2				Sectio n 3.2	Section 3.2 makes clear that climate change is a 200 year issue, not just a 100 year issue. While in some scenarios the atmospheric concentrations largely level off in 100 years, even in these same scenarios dramatic further reductions in carbon emissions are needed between 2100 and 2200, while energy production is presumably continuing to increase. Thus the plan must position the nation and the world with large scale technologies that can grow significantly after 2100 to further reduce carbon emissions, while producing more energy.
127	3	3-2	3-2	2	2	Figure 3-1	In figure, break out fuel and cement as two separate wedges. One is an energy producer and the other is a consumer of energy, one is large and one is small. Mixing these together is like mixing apples and golf balls. Communicate that the big target is CO2 emissions from the energy sector, not cement production.
128	3	3-2	3-2	2		footno te 2	Again, if you are to use this odious measure, at least mention that the GWP is equivalent to using a zero discount rate for 100 years and an infinite discount rate thereafter and may not be the best way to compare the climate effect of various greenhouse gases.
129	3	3-2	3-2	2	2	Figure 3-1	This figure is made probably using 100 year GWPs. I would advise against using such a measure as it has no foundation in science or economics. If 100 year GWPs are used, the figure caption should say that these are radiative forcing values integrated out to 100 years and ignores longer-term consequences of CO2 emission. For example, a figure showing the radiative effect of year 2000 emissions in year 2100 would have almost no slice for nitrous oxide and a tiny slice for methane. If this is a century scale problem (which it is) GWPs with a 100 year time horizon overestimate the effect of the importance of non-CO2 greenhouse gases.
130	3	3-2	3-2	10	12		This discussion ignores all of the caveats regarding the use of GWPs. Please do not promulgate a bad measure. Talk about instantaneous radiative forcing and atmospheric lifetimes if you must, but using a zero discount rate for 100 years and an infinite discount rate thereafter is not only misleading but will mislead to bad policy.
131	3	3-4	3-4	3	4		Insert between Line 3 and 4: In addition to the climate implications of increasing atmospheric CO2, there are also concerns about chemical and biological impacts to

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							the ocean. As discussed in Chapter 6, rising atmospheric CO2 concentrations, via equilibrium processes, is leading to greater CO2 concentrations in the ocean. Unfortunately, once in the ocean much of this added carbon does not remain in this molecular form, but rather dissolves to form carbonic acid. Ocean acidity is therefore increasing, and as a parameter with fundamental influence on ocean chemistry and biology, such increases could be potentially catastrophic to ocean ecosystems if our current fossil fuel use and CO2 emissions continue unabated. While the true scope and magnitude of such effects have yet to be fully understood, they in combination with climate effects provide additional motivation to stabilize atmospheric CO2 concentrations.
132	3	3-4	3-4	5	18	3.3-B 3.3-A	It should be mentioned that going from figure 3.3-B to figure 3.3-A involves the use of a carbon cycle model with its own set of uncertainties. If you like you could add that reducing these carbon cycle uncertainties is one of the goals of the CCSP.
133	3	3-4	3-4	9	10		Insert a period after "levels" on line 9 and delete the following words: "that might be consistent with the UNFCCC ultimate objective." This clause injects speculation as to what might be "ultimate objective" levels when in fact the FCCC's supreme body, the COP, has never even considered any such levels.
134	3	3-5	3-5	3	4		Change "mitigate" to "address"; on line 3, delete "anthropogenic"; and on line 4, insert before the period the following: "from natural variation and anthropogenic sources." The word "mitigate" has a narrow regulatory connotation that does not include RDD&D technologies or adaptation. In addition, emission increases are not likely to be solely due to anthropogenic sources. Natural sources and natural variation will likely be contributors.
135	3	3-5	3-5	8	8		"social and economic development (e.g., gross world product and standard of living); increases changes in fossil fuel use; changes in energy efficiency; changes in non CO2-emitting fossil, nuclear, and renewable energy supply; changes in land use; increases changes in other GHG-emitting activities of industry, agriculture and ..." This sentence would work better if it was rewritten along the lines of "...the more significant factors driving increases in future GHG emissions growth include demographic change (e.g., regional population growth); social and economic development (e.g., gross world product and standard of living), increases in fossil fuel use, and changes in land use; and the more significant factors limiting increases in future GHG emissions include improvements in energy efficiency; increases in non-CO2-emitting fossil, nuclear, and renewable energy supply, decreases in GHG-emissions from industry, agriculture, and forestry, and more rapid technological change in energy technology reducing GHG-emissions."
136	3	3-5	3-5	12	12		P.3-5, Line 12: "highest CO2 emissions are those that assume the highest energy demand (including the slowest improvement in energy efficiency) along with the highest proportion..."
137	3	3-6	3-6	15	15	Figure 3-4	p. 3-6, line 15: Figure captions, in general, should say whether the figures refer to the US or the world.
138	3	3-7	3-7	8	12		p 3-7 For the wide range of scenarios can one give the range of temperature increases. One could use Ken Caldeira's plotting approach built around a range of temperature sensitivities.
139	3	3-9	3-9	1	38	box 3-2	This is a good summary of the SRES scenarios, but it lacks one important aspect; the energy intensities of the various scenarios and how they compare with historical reductions in energy intensity. As documented on Chapter 4, Pg 4-1, lines 11-16, over the period 1971-2002, final energy intensity declined about 0.9%/year. The various SRES scenarios have different rates of energy intensity decline, but almost all are larger than the historical average. Global final energy intensity in 1990 was 16.7 x 106 J/US$. Scenario A2 projects the highest global final energy intensity in 2100, 5.9 x 106 J/US$, a decline of 0.95%/year, about the historical average. The next highest value for global final energy intensity in 2100, Scenario B2, projects a rate of 4.0 x 106 J/US$, a decline of 1.3%/year, higher than the historical average. Scenario B1 projects the lowest global final energy intensity in 2100, 1.4 x 106 J/US$, a decline of 2.6%/year, far greater than historical trends.
140	3	3-12	3-12	12	15		Delete the sentence beginning on line 12 and ending on line 15. Again, referring to the "UNFCCC objective" is inappropriate. Incidentally, we have not attempted line-by-line review of the entire draft to determine whether there are any other references to the FCCC objective. We do not believe it belongs anywhere in the Plan.
141	3	3-12	3-12	18	18		This reference case clearly has a lot of energy efficiency improvement and carbon-emission-free energy built into it. Thus the reference case may be considered optimistic. This discussion should include numbers saying how the reference case differs from a "no technological change" case with the same economic growth. What we need to do to get to the stabilization curve includes both what is in the reference case and what is in the "avoided emissions" wedge. Please tell us this number because this number is what we will need to

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							actually do. (We can leave it to the philosophers to decide what would have happened in a counterfactual world.)
142	3	3-13				box 3-3	This is a useful part of the presentation, since most readers have no idea how much technology must be used to control 1 GtC. However, the text either in the box or on Pg. 3-13 needs to make it clear to the reader that the SRES scenarios assume that all of these technologies will be used extensively prior to 2100. Reducing emissions from the SRES scenario baseline requires that more technology than is included in the SRES baseline be implemented.
143	3	3-14	3-14	1	1	box 3-3	For wind and photovoltaics reference to current small installed base is not useful. That would be like writing in the 1950's that a computer infrastructure would involve a zillion-fold increase in the number of transistors. For wind and photovoltaics, tell us in area terms (for example, use the Iowa farmland comparison as per biomass). Why are the coal plants 500 MW but the nuclear 1 GW? Why not make them both the same size to make it easier for the reader?
144	3	3-14	3-14	2	2		Somewhere in this section there should be a paragraph on the impossibility of century-scale technology prediction. If we were going through this exercise a century ago, we would not have predicted jet air travel, computers and the internet, the ubiquity of automobiles, nuclear fission, etc. We can assume there will be great technological innovation in this century and we can assume that we cannot predict what character this innovation will take. Thus, the modeling exercises are presented to help us think of robust strategies that will represent sound investments regardless of what technologies are developed later. If we were in 1905 and wanted to improve our century-scale transportation infrastructure what would we do? Design improved feed stations and manure removal technologies? One of the best things we could have done is invest in science and engineering education. Protect intellectual property rights. State goals (i.e., high speed intercity transport) and not technologies (trains, planes, and automobiles).
145	3	3-14	3-14	3	8		The reference to technology that "would be able to achieve the level of GHG emissions reductions that are likely to be required to stabilize GHG concentrations" fails to put this "level" in a global context, particularly in a Plan that is for the U.S., not for the world.
146	3	3-14	3-14	5	5		Replace Line 5 with: "are likely to be required to stabilize GHG concentrations in the atmosphere, nor at this point do we necessarily know what specific technologies or combinations of technologies will prove to be best for this task. Given the diversity of the"
147	3	3-16	3-16			Footnote 31	We suggest adding the following to the footnote: "The reference case assumes substantial cost decreases in renewables and nuclear [that] bring their costs below today's levels." [Please note that this was the subject of our concerns expressed at the last meeting. See below for direct quotes from the April draft. This sentence was taken from the Appendix that described the assumptions in the reference case -- see the end of the direct quotes).
148	3	3-16	3-16	14	15	also Fig 3-10 and 3-11	It would be more appropriate perhaps to refer to scenario #3 as "major advances in fusion energy and/or novel applications for solar and advanced biotechnology," since fusion alone could provide the 180 EJ/year projected for 2095. The Fusion Energy Sciences Advisory Committee proposed a Plan for the Development of Fusion Energy which would first put electricity on the grid in 2037, with commercial power plants beginning around 2050, consistent with the beginning of energy production shown for "Exotics" in the figure. A reasonable rate of growth would allow 6 TW(th) by 2095. Since fusion is specifically called out in the plan, perhaps rather than referring to it as "Exotics" in figures 3-10 and 3-11, this category could be called fusion, for short.
149	3	3-16	3-16	25	25		Replace line 25 with: "A primary purpose of CCTP is to identify and accelerate the advancement of promising technologies and reduce their"
150	3	3-16	3-16	25	27		The first sentence of the paragraph again raises the issue as to why the CCTP seems to be so focused on "advanced technologies." The purpose of the CCTP should be to "accelerate" advancement and "reduce" the costs of all technologies, not only advanced technologies.
151	3	3-20	3-20	16	16		It is better to divide out carbon capture/storage and sequestration and two separate numbered items. Carbon capture and storage is essentially an energy-industry activity suitable for point sources whereas sequestration approaches capture CO2 from the air and are generally dispersed and involve no changes to energy production and consumption. Lumping these two very different things together is not helpful.
152	3	3-21	3-21			Fig 3-13	Fig 3-13, what is final energy? Is it energy used for end use purposes?
153	3	3-21	3-21	4	7		IPCC (2000), Table SPM-2b, gives the same values for energy intensity in units of million joules/$, not billion joules/$.
154	3	3-21	3-	14	3		Pg. 3-21, line 14 – Pg. 3-22, line 3. The text lacks discussion of the substantial challenges involved in achieving even a 0.25%/year

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			22				improvement over the "middle of the road" scenario.
155	3	3-21	3-22	14	3		While the calculation implied in this text is no doubt correct, it provides no indication of the difficulty involved in achieving even a 0.25%/year improvement over the "middle of the road" scenario. While that scenario is not identified, the median of the SRES illustrative scenarios (IPCC (2000), Table SPM-2b) have a final energy intensity in 2100 about 3 - 3.3 x 106 J/US$, a decline of 1.5-1.6%/year in global final energy intensity over the period 1990-2100, significantly greater than the historical decline in energy, which Chapter 4, Pg 4-1, lines 11-16, indicates was about 0.9%/year over the period 1971-2002.
156	3	3-22	3-22	3	17		The text lacks discussion of the substantial challenges involved in achieving even a 0.25%/year improvement over the "middle of the road" scenario.
157	3	3-23					Ref. 45: We suggest adding language such as "This model does not fully characterize renewables and so underestimates their potential contribution. A more detailed renewable module is under development." [This could be modified depending on what parts of the > > model are actually used in the update. We know that wind may be included, but solar would not have been added yet.]
158	3	3-23	3-23	20	21		Replace line 20-21 with: There are a variety of physical, chemical, geochemical, and biological ways to remove CO2 from the atmosphere or from point sources, and to store or use the resulting CO2 or chemical derivatives thereof (e.g., Halman, 1993; Kojima, 1997; Inui et al., 1998; Lackner, 2002). Currently, the CCTP technology area related to capturing and sequestering CO2 has only two main thrusts: (1) engineered capture and storage of molecular CO2 from power plants and other industrial sources of CO2…
159	3	3-23	3-23	24	29		Replace Lines 24-29 with: Carbon dioxide capture and storage (CCS) here refers to the capture, purification, and concentration of molecular carbon dioxide emitted from combustion or other industrial waste gas streams, and subsequent transport to and storage of CO2 in suitable geologic or ocean reservoirs. The benefits of technologies like CCS stem from their ability to lower the carbon emissions intensity of the conventional, fossil fuel energy base. CCS could also be applied to bio-based electricity-generation systems, or to other non-fossil-fuel waste streams such as in cement production.
160	3	3-25	3-29			references	Citations to add in References: Halmann, H.M. 1993. Chemical fixation of carbon dioxide. CRC Press, Boca Raton. Inui, T., Anpo, M., Izui, K., Yanagida, S., and Yamaguchi, S. 1998. Advances in chemical conversions for mitigating carbon dioxide. Elsevier, Amsterdam. Kojima, T. 1997. The carbon dioxide problem: Integrated energy and environmental policies for the 21rst century. Gordon and Breach, Amsterdam. Lackner, K.S. 2002. Carbonate chemistry for sequestering fossil carbon. Annual Review of Energy and Environment 27: 193-232.
161	3	3-27	3-27	9	9		Replace Line 9 with: "In general, scenario analyses typically indicate that no single technology option as presently envisioned is able to provide"
162	3	3-27	3-27	15	15	Figure 3-15	"Sequestration" is now generally used for capture from atmosphere and storage in forests etc, and "carbon capture and storage" is used for capture from large industrial point sources and storage in geologic formations etc. Better to break these out as two separate items and show bars accordingly.
163	3	3-28	3-28	7	7		Replace Line 7 with: greenhouse gases - on a 100-year scale and across a range of uncertainties. Thus, given the magnitude of the CO2 problem and the uncertainties in cost, efficacy, impacts, and ultimate design of the mitigation technologies considered above, it is important that new advances and alternative approaches be actively solicited and supported. CO2 mitigation R&D is in its infancy, and future successful technologies and strategies within or outside the four cores categories consider here may bare little resemblance to those currently being investigated. At this stage it is therefore important that R&D programs keep an open mind as to what the best approaches might ultimately be. 3

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164	3	3-28	3-28	18	18		Append "in addition to the substantial efficiency improvements and carbon-emission-free energy sources already assumed in the reference scenarios.
165	3	3-28	3-28	25	25		Replace line 25 with: emission reductions. This suggests the importance of a diversified approach to technology R&D, requiring that potential advances in these existing R&D areas as well as consideration of alternative approaches be actively encouraged and supported.

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166	4	General					This chapter does not include the results from industry that meet or exceed many of the goals outlined. For instance, an aluminum producer using technology supplied by Jupiter Oxygen Corporation has reduced its fuel consumption by 70%. Furthermore, goals outlined for industrial boilers have been met. Jupiter Oxygen operated an Industrial boiler in 2002 where the efficiency of the boiler was increased by 12%, resulting in an a 16% fuel reduction, which was accomplished by employing the technology currently being marketed by Jupiter Oxygen (www.jupiteroxygen.com). For clarification towards the goals of the strategic plan, the work mentioned above is useful in several areas. 1) The reduction in fuel usage resultant of the increased efficiency is clearly in line the global issues facing climate change. 2) The reduction in fuel is directly related to a reduction carbon dioxide. 3) The use of oxy-fuel combustion, as patented by Jupiter Oxygen, greatly reduces NOX emission rates to near zero with natural gas and .08 lbs/MMBtu with pulverized coal (Illinois No. 6) [which is expected to fall to .05 lbs/MMBtu with modifications]. 4) The work outlined is available commercially, so that every effort should be made to promote such technologies in the Industrial Sector. This work must be included in Strategic Plan due to inaccuracies in the current text and the need to promote sustainable energy technologies which are commercially available, and our corrections are provided. Under specific comments we have included several corrections that all into two areas. 1) Application - This oxy-fuel combustion has been in every day use for nearly a decade. The corrections will aid in the potential readers understanding as to how oxy-fuel combustion is actually used 2) Update - To inform actual results in recent progress.
167	4	General					We support and are encouraged by the introduction of specific goals in this chapter, but are concerned that they are not tied to an overall objective on greenhouse gas emission reduction. We perceive a true strategy plan to include one overreaching goal, with sub-goals that in the aggregate will help achieve the overall goal. In turn each sub-goal must identify what actions and activities will be undertaken, by whom and when and how much funding is necessary to meet the sub-goal. This structure is especially important when dealing with climate change research that encompasses a vast, almost unmanageable amount of areas and perspectives. Without connecting each research area to the overall goal there is no assurance that that particular research area is of any value or significance to the overall goal of reducing emissions.
168	4	General					Another substantial void, evidenced in this chapter, is the lack of actors that will conduct the research and achieve even the particular goals set out in this chapter. Overall this plan lacks the identification of what entities will be responsible for conducting the research and how they would interact. Just as an evaluation must be made on the contributory value of each research goal, an examination must be made of what entities would be best used to reach the overall goal. We see no discussion in this chapter or any other on that sort of examination or on what entities would be responsible for particular research projects.
169	4	General				Section 4.1	Reducing emissions from energy end-use and infrastructure. Transportation section 4.1 Section 4.1.3 includes in the Current Portfolio under item (c) "material and manufacturing technologies for high volume production vehicles, which enable/support the simultaneous attainment of 50 percent reduction in the weight of vehicle structure and subsystems, affordability, and increased used of recyclable/renewable materials." This is a critical area where aluminum can yield large gains in energy efficiency. Each pound of aluminum in auto/light trucks saves 20 lbs of CO_2 emissions over the life of the vehicle, in current assessments. Advanced use of lightweight materials and improved recycling efficiencies could increase this ratio. Similarly, large energy savings are possible with light weighting of heavy vehicles including truck trailers and train cars.
170	4	Gen				Sectio	Industry section 4.3.4 future research

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		eral				n 4.1	This section notes the importance of research on industrial alternatives to natural gas usage. We believe that the Strategic Plan should include in this section R&D to develop electric plasma arc 'burners' to replace natural gas fired furnaces and improve energy efficiency with reduced emissions.
171	4	Gen eral				Sectio n 4.1	Buildings section 4.2 While the section on buildings has a deserved emphasis on the energy use during the life of a building, the end-of-life aspect of recycling should not be ignored when deciding upon the materials of construction for both the building envelope and the building equipment. The use of aluminum and other highly recyclable materials should be emphasized.
172	4	Gen eral					Research is investment intensive and as such there should be some distinct discussion of how much each project would cost and where that funding should come from, but we see none. There should be some analysis made in which a cost- research benefit analysis is made. There should be some indication of the differential between the cost and potential yield of different research project. In addition, this analysis should be part in the overall selection of research programs to support.
173	4	4-2	4-2	1	1	table 4-2	The agricultural and forestry sector is conspicuous by its absence from this table. Land-use can be either a source or a sink for CO_2, depending on the technology used. To provide a complete summary of U.S. CO_2 emissions, this table should include information on U.S. emissions of CO_2 from agriculture and forestry.
174	4	4-2	4-2	9	20		Reducing Emissions from Energy End Use and Infrastructure - Transportation Omission: (This chapter fails to even mention alternative transportation choices such as bicycling and walking, which consume zero energy and offer practical alternatives to solo auto use in many of America's urban areas. Further, the chapter fails to make important connections between land use patterns and transportation choices and ultimately transportation consumption - namely that sprawling land uses are associated with greater quantities of transportation consumed and are less adept at offering people choices in their mode of transport. One obvious strategy to reduce emissions related to transportation would be to encourage smart growth and denser urban environments that encourage the use of public transit or non-polluting modes such as bicycling and walking. It is a shame the federal government is still so far behind in thinking progressively about transportation and its relationship to the natural environment. Their is also no mention of pricing the externalities associated with single occupancy automobile use. America continues to provide vast subsidies for the use and storage - ie parking - of automobiles, with grave consequences for our environment).
175	4	4-3	4-5	7	19		Chapter 4: Reducing Emissions from Energy End Use and Infrastructure - 4.1 Transportation Page 3, Line 7 - Page 4, Line 21 - Page 5, Line 1 to 19
176	4	4-14	4- 14	20	20		Sentence beginning Several Specific Goals after (1) Rewrite to read ..(1) by 2006 commercially demonstrate the high temperature oxy-fuel technology which resulted in a 12% efficiency gain in industrial boiler trials conducted previously; and by 2007 these package boilers should be made available for wide scale application. Reason re-write The goal for an industrial boiler of the higher efficiency has been met. The technology needs to be used. The text should acknowledge that.
177	4	4-14	4- 14	27	27		Comment 1 to an attachment offered on page 14 line 27 1.4 INDUSTRY 1.4.1 ENERGY CONVERSION AND UTILIZATION Page 2 of the attached .pdf referenced as August 2005 1.4-2 Section Recent Progress Last Bullet point should be re-written as follows A high efficiency, high temperature oxy-fuel combustion system producing near zero NOX levels has been in every day use since 1997. This system uses technology available from Jupiter Oxygen and has resulted in significant efficiency increases in aluminum melting resulting in a 70% reduction in fuel usage. The technology has also been recently transferred to the industrial boiler market. Reason re-write these are actual verifiable results that need to be communicated to decision makers, industrial users an researchers.
178	4	4-14	4- 14	31	32		Discusses R&D on the production of iron without the use of metallurgical coke, while Pg. 4-16, lines 7-15, discusses R&D to reduce non-combustion emissions from cement manufacture. To indicate the comprehensive nature of this plan, control these non-energy related

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							emissions should be part of the strategic goals.
179	4	4-16	4-18				As a regulator of utilities, we are specifically concerned by this section and wish that the plan be more specific in expressing the entities responsible for the research proposed and where funding for that reach would come from.
180	4	4-16	4-16	27	31		Since expansion of the grid to serve remote renewable generation sources (such as wind) will be costly, DOE should substitute "transmission infrastructure (the 'grid')" for "distribution infrastructure (the 'grid')" at line 29 and insert "The cost of expanding the grid to provide transmission from remote areas to load centers is potentially very expensive, and proper allocation of the investment costs would need to be considered, as well as the overall cost-effectiveness of such projects." at the end of line 31.
181	4	4-16	4-17	38	40		Transmission and distribution (T&D) losses are cited as 5.5 percent. The remainder of the section discusses high-technology R&D that could reduce losses, but there are no numerical estimates of such savings. There also is no recognition that long-distance transmission has higher losses than shorter-distance transmission, and that losses would increase as reliance on remote generation (such as wind) increases. Therefore, insert "Notwithstanding these improvements, the extent to which transmission and distribution losses could be reduced is uncertain, and energy losses on the transmission system could even increase as more long-distance transmission lines are brought into service to transmit power from remote generation sources." as a new paragraph after page 4-17, line 29.
182	4	4-17	4-17				Under the section on Electric Grid and Infrastructure there is no mention of wireless power transmission. Also, the possibilities for global power transmission are not mentioned.
183	4	4-19	4-19	9	10	Figure 4-4	Reducing Emissions from Energy End Use and Infrastructure - 4.4 Electric Grid and Infrastructure Page 19, Figure 4-4: A Distributed Energy Future Stephen Gehl (EPRI), in the 2004 presentation "Generation Technology Choices: Near and Long Term" , shows a more comprehensive figure that include also the Vehicle-to-grid power (V2G) that uses electric-drive vehicles (battery, fuel cell, or hybrid) to provide power for specific electric markets. I suggest to include the V2G option in the figure 4-4: A Distributed Energy Future. See: "Generation Technology Choices: Near and Long Term" - U.S. DoE EIA Annual Energy Outlook Conference Washington DC, 2004 http://www.eia.doe.gov/oiaf/archive/aeo04/conf/pdf/gehl.pdf , Page 15.
184	4	4-22	4-22	1	3		Insert "Nevertheless, deployment of these technologies will ultimately depend on the extent that they can compete effectively on economic and market terms with other technologies. As many of the technologies addressed in the preceding section are still in the research and development stage, or in early deployment, their ability to survive in the marketplace is unknown."

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185	5					Section 5.3	Regarding to Chapter 5.3 on renewable energy and fuels, the discussion is generally very good, and we are supportive of RDD&D. The draft Plan (p. 5-13) indicates that while renewables "contributed" in 2003 "8 percent of [energy] supply, or 6 percent of the total [energy consumption]," much of that was from hydropower and burning biomass. It notes that the transition from "today's" reliance on fossil fuels to "to a global energy portfolio that includes significant renewable resources" (p. 5-18) "will require continued improvements in cost and performance of renewable technologies" (emphasis added). While we agree, there should be some effort to define the word "significant" and to provide a time frame for such a transition, noting that for the power sector fossil fuels constitute 71 percent of our energy sources and are likely to continue to do so for some time. In addition, while there is mention that this transition "would also require shifts in energy infrastructure" (p. 5-18), there is no real discussion of this infrastructure shift, the retrofits that would be necessary for renewables to be utilized in existing facilities, the technologies needed for such shifts and retrofits, the time to develop and make operative such infrastructure, or the associated costs. There should be, as energy infrastructure is extremely important.
186	5	General					Critical Research Need for Implementing Nuclear Option Chapter 5 includes a good review of current and forthcoming technology options for nuclear energy. It recognizes a key obstacle to implementation of added capacity - an obstacle that can last to the indefinite future, namely Regulatory Delay. Regulatory delay is founded on the public fears of all things nuclear, and the continued poor progress on waste disposal. Both the waste disposal problem, and the public fears of nuclear energy rest on a basic unverified assumption of Linear - no threshold response to low level radiation. This rests on the snowball assumption. "If a big snowball can kill someone, the same snowball as a million snowflakes falling on a million people will kill someone." While this seems absurd, it is deeply ingrained in regulation - and in public belief. The available research tools could be used to show that the hazard from low levels of radiation - up to several times normal background radiation - are harmless. There is even extensive literature showing beneficial effects from radiation levels a few times higher than natural background radiation. A major effort in laying this unscientific myth would be a major contribution to deploying more of the energy choice that is already preventing the emission of 600,000,000 (six hundred million) tons of CO2 emissions each year.
187	5	General					The Draft Plan's Technology Strategy for Renewable Energy Should Include Promotion of Waste-To-Energy as a Near-Term Technology Option We were pleased to see a discussion of the near and long-term opportunities to promote renewable sources of energy to augment or replace the use of fossil fuels and to reduce greenhouse gases. However, we were disappointed and perplexed by the absence of discussion of municipal solid waste-to-energy facilities as a proven, successful technology option. Waste-to-energy facilities do not appear to be included in the draft plan's list of renewable energy technology options highlighted in Box 5-1. While thermo chemical and biochemical conversion of biomass were included in the list of renewable technology options, the definition of "biomass," on page 5-17 at line 15, did not clearly incorporate the organic or biomass portion of municipal solid waste. This apparent exclusion of waste-to-energy facilities from the draft plan's technology strategy will significantly impair the program's near-term GHG reduction efforts. Waste-to-energy facilities produce clean, renewable energy through the combustion of municipal solid waste in specially designed power plants equipped with the most modern pollution control equipment to clean emissions. Our company operates seventeen waste-to-energy plants - part of a nationwide fleet of 89 facilities, operating in 27 states, managing about 13 percent of America's trash, or about 95,000 tons each day. Waste-to-energy facilities generate about 2,500 megawatts of electricity to meet the power needs of nearly 2.3 million homes. The use of waste-to-energy technology prevents the release of forty million metric tons of greenhouse gases in the form of carbon dioxide equivalents that otherwise would be released into the atmosphere on an annual basis, according to an analysis developed by the U.S. Environmental Protection Agency and the Integrated Waste Services Association (IWSA) using EPA's Decision Support Tool. A recent life-cycle analysis of nine waste management options, using the EPA Decision Support Tool, compared net GHG emissions of each

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							option. The analysis showed that a 30% recycling rate, coupled with use of waste-to-energy for the remaining municipal solid waste was the most attractive option, as GHG emissions were negative, due to energy offsets. The next most attractive option for managing wastes while minimizing GHG emissions was a 30% recycling rate coupled with landfilling waste in a landfill that employs landfill gas-to-energy. The clean energy produced from waste-to-energy plants replaces electricity generated from fossil fuels. Additionally, combustion diverts municipal solid waste from landfills where it would otherwise produce methane as it decomposes. Our activities to control and beneficially use methane production at our landfills are discussed in our comments on Chapter 7. Annual reporting by IWSA to the U.S. Department of Energy's Voluntary Reporting of Greenhouse Gases Program confirms that waste-to-energy also prevents the release each year of nearly 24,000 tons of nitrogen oxides and 2.6 million tons of volatile organic compounds from entering the atmosphere. Given this impressive track record, we recommend that DOE include waste-to-energy in its portfolio of near-term technology options for reducing emissions from energy supply, and work with its partner agencies to promote its expanded use.
188	5	General					Reducing Emissions from Energy Supply First Overview Comment: This CCTP R & D Plan would be strengthened and would be a far more effective policy tool if the problem were defined by the quantity and timing of CO2 emission-free-power and/or efficiency improvements needed to stabilize climate at various levels of atmospheric CO2, or global warming, as the global economy grows at projected rates of 2-3%/yr. The future path is unknowable but emission-free primary power levels needed to attain the WRE stabilization scenarios levels for economic growth and fossil energy assumptions of the IPCC IS92a business-as-usual (BAU) scenario. Primary and emission-free power growth in the previous century is also shown. [Note the emission-free-power growth rate discontinuity in the vicinity of "now," and the subsequently large growth in emission-free energy supply just needed for BAU -- with progressively larger ramp-ups for various stabilization levels.] This is the real problem. The Manhattan Project didn't aim to explore nuclear weapons in general; it's goal was building a Bomb before the end of WW II. The Apollo Program didn't aim at exploring manned spaceflight in general; it's goal was putting a (US) man on the Moon by the end the 60s. So too does the CCTP program need a more concrete goal; specifically, I'm arguing, some combination of terawatts from supply and "negaterawatts" from demand sufficient to stabilize global warming at tolerable levels. One doesn't have to advocate what level. That should be publicly debated, perhaps in Congress. In any case this administration has clearly stated its opposition to specific targets. Avoiding "dangerous anthropogenic interference with the climate system," the stated UN FCCC goal, was undefined in that document -- though melting Arctic sea ice and tundra and increasing hurricane intensity make it more timely than ever to do so. Tony Blair at the recent Exeter conference in the UK set an upper limit of 2 degrees Celsius global warming. This might be cited as an example of thinking by a close US ally. Such a goal implies terawatts of emission-free power in the coming decades (and/or negaterwatts from efficiency improvements) -- as is well documented in peer-reviewed literature. Not to be overly alarmist, but if current GDP growth rates continues, the latter half of the 21st century is a climatic disaster waiting to happen. To address this realistically, a conceptual framework similar to that described above needs to be up front of this Strategic R & D Plan; however challenging the goal may be & however much it requires international cooperation. Otherwise we have is a shopping list, well-motivated & interesting perhaps, but uncoupled from the actual problem.
189	5	General					We believe that the best approach to developing a practical fusion energy source is one that deals simultaneously with the scientific, technical, environmental and economic issues in an integrated effort. While the CTTP strategic plan includes many of the elements needed, e.g. development of fusion materials along with the fusion power sources, the current effort in the United States could be more integrated and focused on the final product of practical fusion energy. For example, the plans should not be too focused on a particular component of the challenge. The two inertial fusion energy programs funded through NNSA, one based on lasers and direct drive targets and the other on Z-pinches, are, in fact, following an integrated path in which the needed science and technologies are developed simultaneously and in concert.
190	5	5-1		6	7		2800 EJ in 2100 seems beyond the range of scenarios 1,2, and 3 and at the extreme end of the SRES scenarios.
191	5	5-6	5-7	36	16		p 5-6 Under hydrogen admit the possibility that biomass fuels could avoid or significantly reduce the need for hydrogen for transportation and the large infrastructure changes to accommodate hydrogen use.

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192	5	5-6	5-7	36	16	Section 5.2	Section 5.2: Hydrogen In technologies to move forward the concept of hydrogen as a future sustainable fuel, the current and/or future technology portfolios should include carbon capture from conventional SMRs as CO2-free hydrogen production today as a bridging gap until new and innovative production methods are developed and demonstrated.
193	5	5-9	5-9	10	14		Inconsistencies. Cost and durability are the major barriers to Fuel Cell commercialization. The vehicle technologies research programs have a number of specific goals (see: Chapter 4: Reducing Emissions from Energy End Use and Infrastructure - Page 5, Line 5 to 16). For transportation applications, which have the most stringent cost and durability requirements, fuel cell costs need to be decreased by a factor of 5,1 and durability needs to be increased by a factor of 3 to be competitive with current vehicle technologies (see: Technology Options for the Near and Long Term Report: Section 2.2.5 Page 14). Actually the vehicle technologies research programs fixed these goals for the year 2015 (see: Chapter 5: Reducing Emissions from Energy Supply, Page 9, Line 10 to 14) and also the 2005 U.S. Energy Bill decrees that: “the Secretary shall submit to Congress a report describing ...(4) progress, including progress in infrastructure, made toward achieving the goal of producing and deploying not less than — (A) 100,000 hydrogen-fueled vehicles in the United States by 2010; and (B) 2,500,000 hydrogen-fueled vehicles in the United States by 2020”. From my point of view if all actual RD&D, technical and cost barriers are overcame by 2015 and the U.S. Energy Bill goals are achieve by 2020, the H2 Fuel Cell Vehicles will be a “Near Term ” technology and not a “Mid or Long Term ” technology (as indicated in Chapter 10: Conclusions and Next Steps in Figure 10-1: Roadmap for Climate Change Technology Development and Deployment for the 21st Century, Page 3; and Chapter 4: Reducing Emissions from Energy End Use and Infrastructure Page 3, Line 7 and Page 4, Line 21). U.S. Energy Bill, 2005, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf Sec. 811, Page 259. Near Term: “near-term” envisions significant technology adoption by 10 to 20 years from present, “midterm” in a following period of 20-40 years, and “long-term” in a following period of 40-60 years. See: Chapter 10: Conclusions and Next Steps - 10.1 Portfolio Priorities and Current Emphasis Figure 10-1: Roadmap for Climate Change Technology Development and Deployment for the 21st Century, Page 3. Idem Idem
194	5	5-12	5-12	13	26		Hydrogen safety goals are not explicit.
195	5	5-13	5-14				The Section on Renewable Energy and Fuels does not mention way out technologies like solar satellites or high altitude tethered wind turbine kites. These should be carefully evaluated. In fact, the solar satellite idea has been investigated by NASA, and its viability requires significant breakthroughs. See the NRC report "Laying the Foundations for Space Solar Power."
196	5	5-13	5-13	18	18	Section 5.2	Considering the strategic relevance of this Plan, especially in the medium and long term, I underline the importance that great attention is paid to the analysis of innovative solutions regarding the possible use of new products. In particular, I think to the possible use of Fuel Cell Vehicles (FCV) as a new power-generation source, supplying electricity to homes and to the grid like a new different type of Distributed Generation , especially at peak times (Vehicle-to-Grid - V2G). This innovative use of FCV could be able to reduce the costs related to the introduction of the new products , and will represent a huge amount of new installed peak power generation capacity . As above mentioned, based on U.S. Energy Bill data, on 2,5 million FCV (little more than 1% of the U.S. vehicle stock), in 2020, will be installed (based on 80 Kw stack) 200 GW of V2G power generation capacity (i.e. 21% of the U.S. total power generation installed capacity in 2003). Based on these considerations, and assuming the CCTP Portfolio Planning and Investment Criteria (as indicated in Chapter 2, Page 12,

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							Line 30 - the CCTP focuses on technologies with potential for large-scale application- and in Chapter 2, Page 13, Box 2-1: CCTP Portfolio Planning and Investment Criteria, -Criterion #3- Focusing on Technology with Large Scale Potential), I suggest to add a new paragraph (on Page 13, Line 18): "Develop Fundamental Understanding of the Vehicle-to-Grid (V2G) impact on global energy sector and climate change". I think it's time to take into consideration the new scenarios regarding the future FCVs' total installed peak power generation capacity and include them in the analysis of the global energy sector and of the climate change for two reasons. First, because the hydrogen carrier has the potential to play a major role in the United States' future energy system. Second, for the huge dimension of the FCV total future installed peak power generation capacity. Also, as Ms Loyola de Palacio at the IPHE Ministerial meeting (2003) note that: "The introduction of hydrogen in the energy market cuts across many policy areas. Energy, industrial, environmental, research, transport, and even taxation or education policies are in the hydrogen loop. The need to align all these policies to enhance each other is a must. The leaders (CCCSTI) should bear this in mind and favour holistic approaches that will take into account all the dimension of developing an hydrogen economy. " Finally, I think that a lot of work regarding V2G, including research and analysis, must be concerned, coordinated and finally completed under the auspices of the U.S. Climate Change Technology Program. See: "Vehicle-to-Grid Power: Battery, Hybrid, and Fuel Cell Vehicles as Resources for Distributed Electric Power in California" 2001. California Air Resources Board, California Environmental Protection Agency http://www.udel.edu/V2G/V2G-Cal-2001.pdf . See: "Vehicle-to-grid power fundamentals: Calculating capacity and net revenue" http://www.udel.edu/V2G/KempTom-V2G-Fundamentals05.PDF . See: "Hydrogen: a new possible bridge between mobility and distributed generation (CHP)" 19th World Energy Congress, Sydney, 2004 http://www.worldenergy.org/wec-geis/congress/papers/romeriv0904.pdf ; for U.S. Data only, see also: "Vehicles as a New Power-Generation Source. Hydrogen a Possible Bridge Between Mobility & Distributed Generation (CHP)", World Renewable Energy Congress VIII (WREC 2004), Denver CO. EIA Annual Energy Outlook 2005, http://www.eia.doe.gov/oiaf/aeo/pdf/0383(2005).pdf . See: "Hydrogen, a universal energy carrier – a crossroad for global Energy policies" - IPHE Ministerial Meeting, Washington DC, 2003 http://www.iphe.net/IPHE%20Presentations/European%20Union.pdf .
197	5	5-18	5-18			Figure 5-11	Fig. 5-11 shows biomass as feedstock potential as ~30 EJ from the U.S. It would be helpful to have the same estimates for the world. Are they available?
198	5	5-18	5-18				Develop methods to use biomass residues efficiently in the rural developing world.
199	5	5-18	5-19	1	39		Chapter 5, pg 5-19 outlines a very optimistic growth strategy for a variety of renewable energy technologies. The section discusses only what positive elements would be derived from expanded use of these technologies and that expansion is driven solely by "reduced costs."
200	5	5-20	5-20				What is the impact of wind turbines on avian populations? How bad are the noise and aesthetics impacts? These should be at least mentioned as R&D needs.
201	5	5-28	5-28	10	39		Goals for GEN IV are very vague. How much is safety to be improved? How much is proliferation resistance to be improved? How much is cost to be reduced?
202	5	5-30	5-30				No mention is given to a large scale global nuclear system. There is no mention of breeders or extracting low grade U and Th resources, etc.
203	5	5-30	5-35	10	13	Section 5.5	The Fusion Energy section uses a great deal of technical language. It might be clarifying to base this section on the Fusion Energy Sciences Advisory Committee's 2003 "Plan for the Development of Fusion Energy," which would provide a clear and consistent framework of explanation, and allow some of the specific technical references to be eliminated.

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							Lines 10-13: The last paragraph of Section 5.5 clearly belongs in Section 5.6.
204	5	5-34	5-34				No mention is made of the need for a 14 Mev neutron materials research facility. How else can the fusion reactor materials be designed and tested?
205	5	5-35	5-35				Where is the notion of a fusion-fission hybrid discussed? The concept could be evaluated in ITER experiments.
206	5	5-35	5-35	1	1		Suggest adding the following sentence at the beginning of the paragraph to explain the concept of inertial fusion: A very different approach is through inertial fusion, in which an array of intense x-rays, lasers, or heavy ion beams are used to compress and heat a pellet to fusion conditions.
207	5	5-35	5-35	6	6		Suggest adding the following line: The inertial fusion energy programs based on lasers and Z-pinches are funded by NNSA, and are following an integrated path in which the needed science and technologies are developed simultaneously and in concert.
208	5	5-35	5-35	8	9		Over $100M has been invested in the Z and laser-based inertial-fusion-energy programs in NNSA. . There has consequently already been significant progress in the S&T, and significant additional advances can be reasonably expected. We believe that the current statement in the Draft Strategic Plan that: "any additional investment in the inertial fusion energy approach awaits successful demonstration of ignition and gain in the NIF" does not account for this progress, and is at variance with the concept of a coherent integrated approach to fusion energy. We suggest replacing this sentence with: There have been significant advances in key inertial fusion energy technologies including: high-repetition drivers, target fabrication and reactor chamber concepts. Successful ignition and gain on the NIF could stimulate an intensified investment in this approach to fusion energy.

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209	6	General					The potential role of technology in terrestrial carbon sequestration is presented in a balanced fashion. The theoretical or technical potential is clearly indicated as different from what is likely to be achieved based on effectiveness, permanence, competing uses for land, expense, and social willingness. It would be good if this standard were applied to the geological and ocean sections of this Chapter. Nevertheless, additional context would enhance the potential section. In particular, the notion of full carbon accounting should be introduced. This is different from accounting for all GHGs as is mentioned in various bullets in section 6.3.2. Accounting for the amount of CO2 released or kept from being released while performing carbon sequestration technologies is also required. For example, no-till crop management may result in additional reductions in CO2 released because no-till requires a smaller number of less energy intensive tillage operations than does conventional tillage. Another example where full carbon accounting may be important is fertilizer applications that increase the amount of soil C. The CO2 released during the production of the fertilizer production could be greater than the additional CO2 fixed in the soil.
210	6	General				6.6 References	To add to 6.6 References: Caldeira K, Rau, GH. 2000. Accelerating carbonate dissolution to sequester carbon dioxide in the ocean: Geochemical implications. GEOPHYSICAL RESEARCH LETTERS 27 (2): 225-228. Caldeira K, Wickett ME. 2003. Anthropogenic carbon and ocean pH. NATURE 425 (6956): 365-365. Feely RA, Sabine CL, Lee K, Berelson W, Kleypas J, Fabry VJ, Millero FJ. 2004. Impact of anthropogenic CO2 on the CaCO3 system in the oceans. SCIENCE 305 (5682): 362-366. Golomb, D., Angelopoulos, A. 2001. A Benign Form of CO2 Sequestration in the Ocean. Greenhouse Gas Control Technologies, Proceedings of the 5th International Conference on Greenhouse Gas Control Technologies; CSIRO Publishing: Collingwood, Victoria, Australia, 2001; pp 463-467. GOLOMB, D, E. BARRY, D. RYAN, C. LAWTON, AND P. SWETT. 2004. Limestone-Particle-Stabilized Macroemulsion of Liquid and Supercritical Carbon Dioxide in Water for Ocean Sequestration. Environ.Sci.Technol. 38: 4445-4450 KHESHGI HS. 1995. SEQUESTERING ATMOSPHERIC CARBON-DIOXIDE BY INCREASING OCEAN ALKALINITY. ENERGY 20 (9): 915-922. Metzger RA, Benford G. 2001. Sequestering of atmospheric carbon through permanent disposal of crop residue. CLIMATIC CHANGE 49 (1-2): 11-19. Orr JC, Fabry VJ, Aumont O, Bopp L, Doney SC, Feely RA, Gnanadesikan A, Gruber N, Ishida A, Joos F, Key RM, Lindsay K, Maier-Reimer E, Matear R, Monfray P, Mouchet A, Najjar RG, Plattner GK, Rodgers KB, Sabine CL, Sarmiento JL, Schlitzer R, Slater RD, Totterdell IJ, Weirig MF, Yamanaka Y, Yool A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. NATURE 437 (7059): 681-686. Portner, H.O., Langenbuch, M., & Reipschlager, A. 2004. Biological impact of elevated ocean CO2 concentrations: Lessons from animal physiology and earth history. Journal of Oceanography 60: 705-718. Rau GH, Caldeira K. 1999. Enhanced carbonate dissolution: a means of sequestering waste CO2 as ocean bicarbonate. ENERGY CONVERSION AND MANAGEMENT 40 (17): 1803-1813. Rau GH, Caldeira K. 2002. Minimizing effects of CO2 storage in oceans. SCIENCE 295 (5553): 275-276. Rau GH , KG Knauss, WH Langer, K.Caldeira. 2004. CO2 MITIGATION VIA ACCELERATED LIMESTONE WEATHERING. American Chemical Society, Division of Fuel Chemistry Preprints 49 (1): 376. Sabine CL, Feely RA, Gruber N, Key RM, Lee K, Bullister JL, Wanninkhof R, Wong CS, Wallace DWR, Tilbrook B, Millero FJ, Peng TH, Kozyr A, Ono T, Rios AF. 2004. The oceanic sink for anthropogenic CO2. SCIENCE 305 (5682): 367-371. Sarv H, Downs W. 2002. CO2 capture and sequestration using a novel limestone lagoon scrubber - A white paper. McDermott Technology, Inc, Alliance, OH. TRS. 2005. Ocean acidification due to increasing carbon dioxide. The Royal Society, London. http://www.pml.ac.uk/pml/news/050630.htm
211	6	General					In summary the ocean is currently playing an important role in mitigating significant amounts of anthropogenic CO2 via passive air-to-sea transfer. This natural CO2 uptake, however, is obviously not keeping pace with anthropogenic emissions, and the chemical impact

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							accompanying this flux will have undesirable environmental consequences if allowed to continue. Any scheme that introduces additional molecular, uncombined CO2 to the ocean will contribute to this problem. As reviewed above there are alternative, potentially promising ways for ocean carbon addition that lessen or avoid these impacts. However, all of these approaches have unresolved issues of their own, and the true economic and environmental cost/benefit of all of these schemes is in need of further research. Given the magnitude and urgency of the global CO2 problem, and given the likely inadequacy of any single approach to mitigating this problem, all options for safely using the ocean's vast potential for carbon uptake and storage need to be seriously and carefully considered.
212	6	General					Chapter 6 on Capturing and Sequestering Carbon Dioxide does not mention the possibility of direct extraction of CO2 from the atmosphere except by plants. It might be done more efficiently by inorganic chemical absorption. This extraction might be combined with solar bio or photo reduction water to produce hydrogen to react with CO2 to produce fuels in a closed cycle, what Bob Williams calls artificial photosynthesis.
213	6	General					The draft does not reference the IPCC Special Report on Carbon Dioxide Capture and Storage. The report was approved in September, 2005, and its information should be included in the next draft of the CCTP Strategic Plan. It is a more up-to-date reference than those cited in the draft.
214	6	General					The chapter fails to include the very significant work in the field, which was completed in November of 2004 and referred to in Section 1407 of the Energy Policy Act of 2005. Carbon Dioxide from the combustion of coal has been captured as part of Proof of concept testing performed by the USDOE/NETL and Jupiter Oxygen under a CRADA agreement, with important results and advantages. Please see the link to the press release on the results. (http://www.jupiteroxygen.com/spotlight/news.php?id=6). The core of any effort to optimally mitigate Carbon Dioxide must be the point source. It has been shown that boilers can greatly reduce their potential emissions by using oxyfuel combustion systems. When optimally done with undiluted high flame temperature, the increased thermal efficiency results in significantly less fuel being used. Moreover, optimal oxyfuel combustion acts as an enabling technology for the Integrated Pollutant Removal technology, and this combination of technologies has shown the practical ability to remove or capture virtually all pollutants including CO2. This work must be included in Strategic Plan, especially since it shows how coordination between industry and the USDOE/NETL can demonstrate the best results in pollution abatement for sustainable energy. The work is important and needs to be included. Under specific comments, we have included several corrections that fall into two areas. 3) Application - Oxyfuel combustion has been in every day use for nearly a decade. The corrections will aid in the potential readers understanding as to how oxy-fuel combustion is actually used as well as how it is best used. 4) Update - Corrections made to bring current work into focus; not repeating work that was completed years ago.
215	6	General					Carbon Capture Future Research Directions The great majority of the more than 300 GW of existing US coal fired generation is provided through combustion of coal, in conventional pulverized coal and cyclone boilers. Retrofitting oxy-combustion modifications to a portion of these plants would provide a means to produce concentrated streams of carbon dioxide. This would enable sequestration, to affect substantial reductions in total greenhouse gas emissions to the atmosphere from the existing fleet of power plants. Additionally, there are plans to build new pulverized coal plants; and some of these plants should be candidates for oxy-combustion systems. Similar comments apply for generation outside the US. Overall system optimization opportunities include integration of facilities for oxygen supply, coal combustion, power generation, compression of carbon dioxide, etc. Reductions in overall system costs can thus be anticipated with integration of cryogenic oxygen supply with the entire power generation complex. Ocean Sequestration Future Research Directions The reaction of combustion-generated flue gas from fossil-fired power plants with limestone and seawater is an innovative research

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							opportunity. The creation of bicarbonate provides an avenue to indirect injection that should have minimal impact on the ocean environment.
216	6	6-1	6-1	5	6		Replace line 5-6 with: "growth in atmospheric CO_2 concentrations. Currently the main focus areas for research and development"
217	6	6-1	6-1	33	33		Replace line 33 with: share), even under high carbon management requirements. In summing up the imperative for CO_2 capture and storage as part of future use of fossil fuels, Lord Oxburgh, Chairman of Shell Oil stated, "[CO_2] sequestration is difficult, but if we don't have sequestration then I see very little hope for the world." (The Guardian, June 17, 2004).
218	6	6-2	6-2	23	25		Replace Lines 23-5 with: other types of geologic storage and terrestrial sequestration options, as well as consideration of ocean carbon storage.
219	6	6-2	6-2	25	25		Replace line 25 with: anthropogenic CO_2, and is playing a critical in lessening the impact of current anthropogenic CO_2 emissions by passively absorbing some 7.3 Gt of excess atmospheric CO_2 per yr (Sabine et al., 2004). The potential storage capacity of the ocean is largely unknown, although some
220	6	6-3	6-3	18	18	Section 6.1.2	Sentence beginning Larger Re-write sentence to read. Promising technologies have been identified and targeted for large scale development in the next several years. This would include the high temperature oxy-fuel technology as identified under Section 1407 of the Energy Policy Act of 2005. Reason re-write: update to recent news that authorizing language for oxyfuel is funded.
221	6	6-3	6-3	32	32		Comment 1: to an attachment offered on page 3 line 32 3.0 CAPTURING AND SEQUESTERING CARBON DIOXIDE 3.1 GEOLOGICAL SEQUESTRATION 3.1.1 CO_2 CAPTURE AND SEPARATION 1) Graphic at top of page does not reflect an accurate description of CO_2 capture, the provided document does. Picture here [see other attachment] 2) Under System Concepts, the definition of Oxy-fuel combustion should be rewritten as the technology has been applied in industry for nearly a decade and as the technology has been tested for power plants with the best results under DOE CRADA programs. The description is both misleading an inaccurate. Please change. 2nd bullet point Oxy-fuel combustion. Pure oxygen rather than air charged to the combustion chamber, producing greater radiant heat transfer and reduced flue gas volume consisting of CO_2 and water. A portion of the CO_2 is recycled to propel the fuel (for example coal) without air, and to balance the heat transfer between the radiative and convective sections of the boiler. The resultant high temperature flame, of the patented process, increases efficiency because the flame is not diluted and heat loss is minimized due to the exclusion of nitrogen from the air thereby creating significant fuel and other savings. While the lower flue gas volumes (because there is no nitrogen from the air) enables other pollution control technologies (like Integrated Pollutant Removal or even mercury control alone) to be significantly less costly and more highly efficient. Under Technology Status/Applications Oxy-fuel combustion systems have been used on Industrial boilers using both coal and natural gas. Trials, by Jupiter Oxygen working under a USDOE/NETL CRADA, have shown that boiler material changes are not required. Integration of Oxy-fuel combustion and Integrated Pollutant Removal was successfully operated under a separate CRADA agreement between the Albany Research Center and Jupiter Oxygen using coal as the fossil fuel. 95% of the CO_2 was captured while removing more the 99% of the SOX, 99% of the PM including 80% of the PM 2.5. NOX results post combustion before other control, were recorded at .088 lbs/MMBtu (.05 lbs./MMBtu is expected). The tests also showed that up to 90% of the mercury was captured, making 90% mercury capture practical. Cost estimates for the combined process system are on the order of 5.1 cents (U.S.A.)/kWh with amortized capital expenses, including a production cost of 1.7 cents (U.S.A.)/kWh (costs which are lower that those for alternative technologies to achieve the same results).

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222	6	6-4	6-4	3	8	Section 6.1.3	Line 3 to Line 8 Should be re-written to accurately reflect Current research Insert the following: High temperature oxygen fired combustion has completed proof of concept testing under a patented process and DOE CRADA projects. CO2 from the combustion process was recovered at rates of up to 95% using coal as the fossil fuel. In oxygen fired combustion, oxygen, instead of air, is used in combustion of petroleum coke, coal or biomass fuels. Recycled flue gas has been identified to balance heat transfer between the radiative and convective sections of existing boilers, but should not be used to dilute the flame temperature which would decrease thermal efficiency. This technology is applicable to the economical retrofit of the large existing fleet of power generating equipment using existing materials while decreasing the use of chemicals for pollution removal. Furthermore modification to high temperature oxy-fuel combustion will result in fuel savings and reduced cost for capture or removal of all pollutants. Future power plant may require greatly reduced flue gas recycle rates which will add flexibility to design allowing for a reduction in boiler size and costs in the range of 60%.
223	6	6-4	6-5	3	45		Section 6.1: Carbon Capture, Page 6-4, lines 3-8 & Page 6-5, lines 42-45 Oxygen-fired combustion research and demonstration is important as stated in the above sections in order to determine the ease of CO2 capture from the combustion process. R&D investment in oxygen transport membranes is a good step in providing effective and low-cost separation technologies. However, in addition to the focus on new plants, steps should be taken to evaluate technologies to retrofit the numerous existing power plants and other large CO2 point emitters. A great example would be a 2-step retrofit of existing PC plants. (1) Convert to supercritical PC for efficiency comparable to new IGCC; the conversion is close to economically justifiable due to the efficiency gains (2) Use oxyfuel for easier carbon capture from supercritical PC plants when sequestration is viable.
224	6	6-4	6-4	6	6		"Oxygen-fired combustion may also be implemented in power systems in which gaseous fuels are combusted with oxygen in the presence of recycled water to produce a steam/CO2 turbine drive gas. Water is condensed from the steam/CO2 exiting the turbine, leaving sequesterable CO2." Note: Clean Energy Systems, Inc. is demonstrating this concept at their 20MWth plant near Bakersfield, CA, with supporting funding provided by DOE.
225	6	6-5	6-6	10	25		6.1.4 Carbon Capture Future Research Directions Add in: Continue R&D efforts on the oxy-combustion technology at pilot-scale, leading to commercial scale-up for applications to existing and new pulverized coal and cyclone boilers. The R&D will focus on the overall cost reduction of oxy-combustion by improving oxygen production, boiler operation and steam conditions optimization along with flue gas purification, and CO2 compression and storage.
226	6	6-5	6-5	45	45		"Develop oxy-combustors and high-temperature turbines for oxy-fuel Rankine cycle power systems. Using pure oxygen and recycled water in a turbine's combustion chamber can enable 100% CO2 capture and long-term power generation efficiencies of 50-60 percent" Note that Siemens Power Generation and Clean Energy Systems were awarded $19 million by DOE to develop these technologies under awards DE-FC26-05NT42645&6.
227	6	6-6	6-11				We strongly support this chapter, particularly the sections on Geologic Storage (6.2) and Terrestrial Sequestration (6.3). Carbon capture and storage (CCS) is a perfect candidate for further climate technology RDD&D, as currently there are only three "industrial-scale" (i.e., 1 million tons of CO2 annually) storage projects in operation, in Norway, Canada and Algeria.8 Because commercialization of large-scale CCS integrated into major power plants is probably a decade or so away, We believe this to be a medium-term energy supply technology (see subsection III.H.2 below). It is ideally suited for government and private RDDD money, needing assistance in achieving demonstration and deployment in large power plant systems. Moreover, over time the costs of this technology will decrease, obviating the cost-benefit objection that some of its detractors have raised.
228	6	6-6	6-6	7	7		insert after Line 7: Solicit and foster concepts that either build on current approaches or that offer entirely new pathways. Given the magnitude and urgency of the CO2 problem and the infancy of large-scale CO2 capture/storage, it is important to recognize that technologies may emerge that offer distinct advantages over present concepts. As an example, the point-source capture and storage SO2, another acid gas from fossil fuel combustion, is now commonly achieved by a process quite different from those emphasized above and from those initially considered.
229	6	6-11	6-	33	11		Biomass (cellulosic waste or energy crops) could be used to produce a char based fertilizer for sequestering carbon in soil. Biomass is

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			12				pyrolyzed to produce a porous char and producer gas. The producer gas is shifted to produce hydrogen for ammonia production and energy. The char can absorb CO2 and NH3 to produce ammonium bicarbonate resulting in a long release nitrogen fertilizer. The fertilizer production process can be used to scrub CO2, NOx, and SO2 from flue gases. The net sequestration of carbon can offset the emissions from transportation, for example. The fertilizer can be used to improve the productivity of marginal land, and hence increase biomass productivity, and this can further contribute to the net extraction and sequestration of atmospheric carbon.
230	6	6-13	6-13	18	18		"good" should be "goods"
231	6	6-13	6-13	20	21		the phrase "time and space" could be made more specific. For example this bullet could be "determine how terrestrial systems" capacities can be manipulated to enhance carbon sequestration by increasing pool sizes, rates of increase, areal extent, or longevity.
232	6	6-13	6-13	22	24		this bullet should also include relationships with "energy policy" to capture the carbon benefits of biofuels of several types.
233	6	6-13	6-13	27	27		practices and techniques have climate impacts in addition to altering GHGs, in particular albedo and roughness changes that have been shown to be dramatic.
234	6	6-14	6-14	16	28		this section on precision agriculture is fairly narrowly defined. First it only mentions C sequestration and not full carbon accounting or other GHGs. Secondly it should consider fallow reduction, including use of winter cover crops.
235	6	6-14	6-14	29	29		"conserve" should be "conservation". This section should also consider GHGs in addition to CO2.
236	6	6-15	6-15	21	26		it is interesting that there is work on natural and restored wetlands. The sequestration potential of created wetlands should also be a research topic.
237	6	6-16	6-19			Section 6.4	This important section must first point out that the ocean, as part of the natural carbon cycle, is currently playing a critical CO2 mitigation role by passively absorbing significant amounts of the anthropogenic CO2 via air-to-sea diffusion. Without this uptake the planet would be at considerably great risk than it currently is. I have added or changed wording that summarizes this concept. Secondly, while direct CO2 injection and ocean fertilization may be the approaches that have receive the most attention, they are by no means the only possible ocean strategies, nor should they be assumed to be the only ones worth considering. As an important strategic planning document for a national research effort that is still in its infancy, an effort to acknowledge and briefly consider other published ideas needs to be made. This should include the possibility that the best strategies or combination of strategies may have yet to be proposed. I have added words and sections that provide a broader sense of these possibilities as well as their uncertainties. I have added a list of references that document the preceding ideas. Finally, I have offered some rewordings that may help clarify certain topics. Details are as follows:
238	6	6-18	6-18				Power-plant flue gases could be used to dissolve limestone and the resulting solution could be placed in the ocean without harming ocean biota or causing ocean acidification.
239	6	6-18	6-18	5	14		Line 5 through Line14 replace with: Because of the large CO2 storage capacity of the ocean, increasing the carbon uptake and storage of carbon in the oceans cannot be ignored. Indeed, the ocean is currently playing an important role in consuming significant amounts of anthropogenic CO2 via passive air-sea exchange, biological uptake, and ocean mixing (e.g., Sabine et al., 2004). Unfortunately, this natural CO2 uptake (about 7.3Gt CO2/yr) is not keeping pace with current anthropogenic emissions, and the ocean acidification that is accompanying the air-sea flux will have undesirable environmental consequences if allowed to continue (e.g., Caldeira and Wickett, 2003; Feely et al., 2004; Orr et al., 2005). To understand the additional role the ocean could play in mitigating CO2, several issues must be addressed, including the capacity of the ocean to sequester CO2, its effectiveness at reducing atmospheric CO2 levels, the depth and form (e.g., molecular or chemically bound, gas, liquid or solid) for introduction of the carbon, and the potential for adverse environmental consequences. Ocean storage has not yet been deployed or thoroughly tested, but there have been small-scale field experiments and 25 years of theoretical, laboratory, and modeling studies of intentional ocean storage of CO2. Nevertheless, much more needs to be learned about the potential environmental consequences to ocean ecosystems and natural biogeochemical cycles. While there are a variety of potential ocean carbon sequestration options (see "Future Research Directions"), two strategies have

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							received the most attention: (1) direct injection of a relatively.....
240	6	6-18	6-18	22	36		Line 22 through Line 36 replace with: Over the period of centuries, the oceans will passively take up about 70 percent of global fossil carbon emissions as CO2 diffuses into the ocean, is transported across the ocean thermocline, and mixed into deep ocean waters (IPCC 2001a). Intentional direct injection of captured CO2 would seek to augment to this natural CO2 flux to the deep sea and thus more rapidly slow or reverse the atmospheric CO2 increase. The potential for the ocean to absorb CO2 over the long term is large relative to that which would be generated by fossil-fuel resources. But several factors may affect the capacity and desirability of direct injection. Unless consumed by biological or chemical processes, excess CO2 placed in the deep sea will eventually via diffusion and ocean circulation interact with the atmosphere, adding some part of the injected CO2 to the atmospheric burden. For example, injection of about 8000 Gt CO2 to the deep ocean will eventually produce atmospheric CO2 concentrations of about 750 ppm, even in the absence of additional CO2 release to the atmosphere (citation?). It has been shown in experiments and models that high concentrations of CO2 depress ocean pH, and thus harm marine organisms and biogeochemical processes (e.g. Portner et al. 2004; TRS, 2005), but the true scope and magnitude of such effects need further study. Alternatives to direct injection and fertilization have been proposed for CO2 mitigation strategies, and while they can avoid the preceding concerns, they may have environmental , capacity, and cost limitations of their own (see "Future Research Directions").
241	6	6-18	6-18	38	38		Line 38 Replace with: Ocean carbon sequestration offers the potential to significantly reduce CO2 concentrations in the atmosphere.
242	6	6-18	6-19	38	10	Section 6.4	In Section 6.4, Ocean Sequestration, ocean pH effects are not mentioned.
243	6	6-19	6-19	3	10		Line 3 through Line 10 replace with: Fertilization of the oceans with iron, a nutrient whose low concentrations in the open ocean frequently limit phytoplankton growth, is another strategy being considered. Here fertilization enhances marine photosynthetic draw-down of ocean and hence atmospheric CO2 and thus potentially accelerates the transfer of carbon to the deep ocean via sedimentation of some of the biomass formed (collectively - the "biological carbon pump"). Such fertilization will therefore manipulate and affect surface ocean ecosystems and will in turn expose the deep-sea to increases in sedimentary organic loading coupled with elevated CO2 concentrations and depressed oxygen levels as at least some of the sedimented biomass is oxidized back to CO2. Thus, while direct injection is likely to produce acute chemical and biological effects in the local region of injection, iron fertilization could produce ecosystem shifts over large areas of the surface and deep ocean. Alternative ocean carbon storage methods can lessen or avoid these impacts (section 6.4.4).
244	6	6-19	6-19	28	28		After sentence in Line 28 Insert: Alternative ocean CO2 mitigation strategies (see "Future Research Directions") pose a different set of environmental and efficacy concerns that need to be evaluated should those of direct injection and fertilization prove to be unacceptable.
245	6	6-20	6-21	22	4	Section 6.4.4	6.4.4 Ocean Sequestration Future Research Directions. Add in: Indirect Injection - A potentially more permanent and environmentally safer carbon sequestration alternative to direct injection involves contacting combustion-generated flue gas of fossil-fuel power plants with limestone and seawater. CO2 contained in the exhaust gases dissolves in water and reacts with limestone to form bicarbonate for release and sequestration in the ocean. This approach significantly reduces the acidification of the local environment compared with that of direct injection. Upon mixing and dilution with additional seawater in the ocean, the pH and the concentrations of dissolved calcium and CO2 will return nearly to background levels. Pilot-scale CO2 capture and sequestration performance testing as well as safety and environmental assessments must be conducted prior to large-scale implementation. Biological responses of selected marine organisms to the aqueous effluents should be evaluated.
246	6	6-20	6-20	39	49		after Line 39: Insert: • Enhancement of Chemical CO2 Uptake. The uptake of CO2 by an aqueous solution can be enhanced by the addition of OH- and/or CO3- ions. Thus, Kheshgi (1995) pointed out that this could be done on a large scale by adding lime (CaO or CaOH) to the ocean to facilitate its abiotic CO2 uptake from the atmosphere via the reaction: CaOH + CO2 □Ca2+ + HCO3-. Importantly, this form of CO2 mitigation would; 1) avoid the need for point-source CO2 capture, separation, and purification (unlike direct injection, but similar to ocean fertilization), 2) prevent increased ocean acidity because the added CO2 is neutralized to calcium bicarbonate dissolved in seawater, and 3) permanently store the added carbon in an ionic from that is already abundant in the ocean and not easily degassed back to the

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							atmosphere. The concerns with this approach include the cost and carbon intensity of producing lime from the calcination of limestone, its transport to and dispersal in the ocean, and the environmental consequences of doing so. All of these issues require further study. • Enhanced Carbonate Weathering. Rau and Caldeira (1999; 2002) suggested employing the spontaneous geochemical reaction CO2 + H2O + CaCO3 -□ Ca2+ + 2(HCO3-) to directly react CO2 out of waste gas streams and to place the resulting dissolved calcium bicarbonate ions in the ocean. Again this would avoid the need for molecular CO2 capture and purification and would convert most of the CO2 to relatively benign, ionic species. Modeling studies showed that such carbon storage would be effective for thousands of years and with far less impact to ocean pH than directly injecting a comparable quantity of carbon as molecular CO2 in the ocean (Caldeira and Rau, 2000). Initial cost estimates have shown that for treatment of coastal CO2 point sources this form of CO2 mitigation would be less expensive than more conventional molecular CO2 capture and geologic storage (Sarv and Downs, 2002; Rau et al., 2004). However, the true cost, capacity, effectiveness, and environmental impact of this approach need further evaluation. • Ocean Burial of Crop Residue. It has been suggested that organic waste from agriculture be actively buried on the ocean floor, thus enhancing the natural air-to-land-to-ocean carbon sink represented by plant production, soil formation, soil erosion and river transport to the sea (Metzger and Benford, 2001). This approach would prevent some if not most of the oxidation of residue biomass on land and thus eliminate the resulting flux of CO2 back to the atmosphere. Ocean sites with existing permanent anoxia (e.g. offshore from major river deltas) could be used to slow or avoid oxidation of the biomass once on the ocean floor prior to its permanent burial by natural sedimentation. Concerns to be more thoroughly addressed include: 1) the cost of collecting, bundling, transporting, and sinking the residue, 2) the consequences to the fertility of the remaining cropland, and 3) the ultimate impacts to the marine environment. • Ocean Disposal of CO2 Emulsions. Golomb et al. (2001; 2004) has shown that CO2 can form a dense emulsion when combined CaCO3 (e.g., limestone) particles under pressure. Such emulsions could be formed prior to or during ocean CO2 injection, with the resulting CO2-rich mass sinking to and stored on the ocean floor. Studies suggest that at deep ocean temperatures and pressures the CO2 might be sequestered indefinitely by this approach. The method and cost of: 1) initial CO2 capture and purification, 2) limestone/carbonate preparation, 3) transporting reactants to ocean sites, as well as the marine environmental consequences of this approach are among the issues that remain to be addressed in detail. • Other Methods. The preceding list of CO2 mitigation options involving the ocean may not be exhaustive, and any future research portfolio must be open to the possibility of new approaches or mix of approaches.
247	6	6-21	6-21	9	17		Replace Lines 9-17 with: of sequestration could provide many options for a future of reduced or near-net-zero GHG emissions. Carbon sequestration will hopefully be able to contribute to safe, cost-effective stabilization of GHG concentrations in the atmosphere, thus further supporting domestic and global economic growth based on fossil fuels. Although an energy
248	6	6-21	6-21	22	22		Replace Line 22 with: non-fossil energy sources is required. For the preceding reasons CO2 capture and storage must be viewed as an essential part of a global, low-carbon-intensity energy future.

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249	7						Specific Comments on Chapter 7.3 Emissions of high global-warming potential gases The Current Portfolio section 7.3.2.3 and Future Research Direction section 7.3.2.4 includes research on the 'aluminum industry - perfluorocarbon emissions' that addresses anode effect research and R&D for an inert anode. These efforts should continue due to their high potential to improve energy efficiency and reduce PFC emissions. Much progress has been made on reducing anode effects reducing PFC emissions in the U.S. primary aluminum industry by over 46 percent. Production of an inert anode can eliminate associated PFC emissions and increase energy efficiency by up to 25 percent.
250	7	General					We were pleased to see that the draft plan recognizes the waste management sector as presenting some of the most promising and cost-effective opportunities for reducing GHGs. However, the draft plan fails to recognize the significant GHG reductions already achieved by the industry. Since the mid-1970s, technological advancements, environmental regulations, and emphasis on recycling, composting and energy recovery have significantly reduced the environmental impacts of municipal solid waste management, including GHG emissions, even as the amount of solid waste managed has grown nearly two-fold. Changes in waste management practices over the past 50 years that have resulted in decreased GHG emissions include: • Increased recycling and composting rates. • Increased combustion of municipal solid waste and waste biomass to produce energy. • Increased collection and control of landfill gas. • Transitioning of refuse collection fleets to alternative fuel vehicles. Various studies have estimated that changes in solid waste management practices have resulted in a 50 to over 80 percent reduction in GHG emission compared to what would have occurred without implementation of these improved waste management practices. Despite the range of estimated reductions, it is clear that improvements in solid waste management practices have already resulted in some of the largest percentage reductions in GHG emissions accomplished by any sector of the US economy. EPA's most recent study, the 2005 U.S. Inventory of Greenhouse Gas Emissions, estimated that between 1990 and 2003, methane emissions from landfills had been reduced by 40 percent. (Note: the % Change in methane emissions figure for landfills in Table 7-3 is incorrectly shown as -24%.) The Draft Plan Should Incorporate Development of Streamlined Permitting Approaches to Foster New Renewable Energy Projects We are at the forefront of producing clean renewable energy from landfill gas-to-energy (LFGTE) projects, which minimize emissions of greenhouse gases, as well as generate either electricity or fuel for beneficial uses. We operate 58 landfill gas-to-electricity projects that generate 264 megawatts of electricity – enough to power 238,000 households. We also operate 34 landfill gas-to-fuel projects that generate nearly 16 million MMBTU of fuel or the equivalent of nearly 3 million barrels of oil. We believe that market forces that increase the value of landfill-gas will drive increasing numbers of gas collection and beneficial use projects, as well as increased gas collection efficiency. Nonetheless, significant environmental regulatory barriers exist to siting new landfill-gas projects. These barriers are neither acknowledged, nor addressed in the draft plan. We recommend that DOE work with its partner agencies and make the development of streamlined permitting options for LFGTE projects a priority in the draft plan. Obtaining the necessary federal, state and local air quality permits can pose major obstacles to developing viable LFGTE projects. A complex array of standards can potentially affect LFGTE projects including: New Source Performance Standards for municipal solid waste landfills and stationary turbines, as well as National Emission Standards for Hazardous Pollutants, which affect LFG collection and control equipment; New Source Review or Prevention of Significant Deterioration, which may entail air quality impact analyses, obtaining offsets for emission increases, implementing the most stringent and expensive controls (LAER/BACT) on project equipment, and alternate site analyses; and Title V, which could subject LFGTE facilities to an extensive permitting process that includes a

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							comprehensive emissions inventory, regulatory applicability review, compliance certification and substantial public involvement. State and local authorities may also impose provisions for construction and operating permits, source-specific requirements, and various other regulatory elements. Complying with this dizzying array of regulatory requirements can be very expensive, making an otherwise viable LFGTE project uneconomical. The draft plan's technology strategy for promoting LFGTE projects should incorporate the development of streamlined permitting approaches that allow federal, state and local regulators to balance air quality goals with the other environmental benefits offered by these projects. The Draft Plan Should Delineate Specific Research for Promoting Bioreactor Technology As a leader in the research, development and demonstration of bioreactor landfill technology, We strongly support the CCTP draft plan's focus on bioreactors. We are committed to the development and adoption of bioreactor landfills as demonstrated by our joint work with EPA. We have engaged in a Cooperative Research and Development Agreement (CRADA) with EPA to determine which practices best promote the safe operation of large-scale bioreactor landfills, and we are participating in EPA's Project XL, an initiative that involves pilot projects to demonstrate superior environmental performance from using bioreactor landfill technology. We are also very supportive of bioreactor development work DOE has engaged in with Yolo County and the Environmental Research & Education Foundation to develop and demonstrate bioreactor technology at the Yolo County and Northern Oaks landfills. We recommend the draft plan highlight specific work to demonstrate the potential of bioreactor landfill technology for reducing non-CO2 greenhouse gas emissions by focusing on the following areas: concentration and capture of methane; improved gas collection and control systems; and use of alternative cover materials to control fugitive emissions. Bioreactors landfills are expected to concentrate methane generation to a shorter time frame and facilitate the capture of more methane than conventional landfills, assuming the total methane generating potential of the solid waste is constant. Providing funding to demonstrate that these benefits are actually being achieved in the RD& D projects that are underway or planned would provide important validation of this technology and promote its more widespread use. Improved landfill gas collection and control systems can provide significant non-CO2 emissions reductions for both conventional and bioreactor landfills. DOE's funding to demonstrate the Intelligent Bioreactor Management Information System (IBM-IS) for the control of fugitive landfill gas emissions from an anaerobic bioreactor landfill at Yolo County is an important first step. We recommend that the draft plan include in its research agenda the installation of improved gas collection and control systems in new bioreactor landfill construction. Bioreactor landfills are required to install gas collection systems prior to adding liquids and this provides an opportunity to improve gas collection efficiency by designing systems that can be installed as the landfill is constructed rather than the traditional approach of drilling vertical wells after the landfill is completed. Research on the design, construction and operational effectiveness of horizontal wells, permeable layers and other new gas collection systems would be very beneficial. Another fruitful area of research that should be identified in the plan is the reduction of methane emissions from old or small landfills, by using catalysts, aeration or optimization of oxidation in landfill cover systems. Funding for demonstration projects on optimizing methane oxidation by cover soils or materials impregnated with methanotrophic bacteria has been useful in promoting these near-term technologies. Finally, the draft plan should address an important barrier to promoting the widespread use of bioreactor technology, which is the regulatory barrier posed by the Resource Conservation and Recovery Act (RCRA) regulations for municipal solid waste landfills. RCRA regulations preclude a number of practices inherent to creating a bioreactor landfill, and it is only through EPA's development of an RD&D Rule, that bioreactor landfill technology can be tested in states that adopt the rule. However, the regulatory flexibilities granted by the RD&D Rule are only available for a twelve-year period. Since the life of a landfill extends well beyond twelve years, this creates a great

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							deal of uncertainty for companies or municipalities that would like to take advantage of the potential benefits of the technology, and is a serious barrier to the technology's widespread use. Preliminary discussions have been held among leading landfill academics, consultants, owner/operators and trade groups to organize a specialty symposium in 2008 with the objective of providing a forum for high quality peer-reviewed research on bioreactor landfills that will support EPA's final rule making process to revise the RCRA standards to accommodate bioreactor technology. The DOE's support of such a symposium through the CCTP would be very helpful.
251	7	General					Landfills are brushed over in this chapter and mostly discussed in the context of methane emission containment. The use and management should be afforded a much deeper and comprehensive investigation. Research must be invested into reversing the practice of deposing biodegradable materials in landfills, so that they can be turned into energy either in the form of a gas that can produce electricity or biofuels.
252	7	7-2	7-2	1	6		A reference is needed for the scenarios discussed in this sentence. Also, the potential reduction in non-CO2 gas emissions should be put in the context of the projected CO2 emissions, which range from 983-2189 GtC for 1990-2100 in the SRES illustrative scenarios (IPCC (2000), Table SPM-2b).
253	7	7-7	7-7	9	16	Section 7.1.1.2	Collection and destruction of methane from landfills at a scale of 2.5 million metric tons of waste in place is required under USEPA regulations in order to achieve incidental control of non-methane organic compounds typically found in landfill gas. Landfills of this size and larger typically produce over 500 cubic feet per minute (CFM) of methane, which is capable of producing more than 1 MW of power with commercially available equipment. Economically attractive technology is available and commonly in use for conversion of methane to energy at landfills in this size range, both in the US and globally. Marketplace drivers to improve technology at this scale are already operating. However, most landfill sites in the US and globally are smaller than this, yet contribute significantly to methane emissions. These smaller sites have neither regulatory nor economic drivers in place to motivate the landfill owners to capture and destroy the methane. Existing energy conversion technologies do not allow breakeven economics for conversion of methane to useful energy products at this scale, with very few exceptions. An effective technology strategy for government intervention to increase capture and conversion of landfill methane therefore should include a component that focuses on small scale landfills that are currently below the regulatory and economic breakeven thresholds for methane capture and energy conversion. This would generally be for landfills designed to hold less than 2.5 million metric tons of waste, that would produce less than 500 CFM of methane. Furthermore, focus on the methane energy conversion technologies in this range (less than one MW) would also provide incentives for alternative waste processing technologies that produce methane, including bioreactor landfills and anaerobic digestion.
254	7	7-7	7-7	18	34	Section 7.1.1.3	There are two categories in the current portfolio: bioreactor landfills and emerging technologies for the conversion of landfill methane. In the bioreactor landfill category, a significant number of the current full-scale demonstration projects are at landfills that were not designed as bioreactor landfills, i.e. where bioreactor technologies are retrofit in existing landfill sites. While these projects are valuable, the data has only tentative applicability to future bioreactor landfills that are designed "from scratch" as bioreactor landfills. The latter will have monitoring systems, drainage systems, and gas collection systems designed from the beginning, rather than retrofitted, to be used in bioreactor landfill operations, and will not have partly decomposed wastes in place from a time before bioreactor operations were implemented. Funding should be focused on new landfills (or new, separate, landfill cells at existing sites) that will produce data that can be used in design of future facilities. In the energy conversion category, there is a focus on LNG production. There are many other technologies that may be developed to convert methane to energy, including small scale engines and turbines such as Rankine cycle, Stirling engines, and microturbines and associated generators that could benefit from technology development. This category of the portfolio should be broadened to not focus narrowly on LNG.
255	7	7-8	7-8	3	12		With regard to landfill methane, why not concentrate some RD3 on separating the components of waste and gasifying the hydrocarbon

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							fraction to produce hydrogen and/or electricity and sequestering the resulting CO2. The other components of the waste could be recycled or reused. Only a small fraction would need to be landfilled. This is an old idea, but it could do with some dusting off and reinvigoration.

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256	8					Section 8.4	Specific Comments on Chapter 8.4 Enhancing capabilities to measure and monitor greenhouse gases The Aluminum industry is currently participating with EPA in advancing the measurement of PFC emissions from aluminum primary production faculties. These efforts have lead to improved monitoring and measurement methods, as well as advancements in the accuracy of emission factors. These efforts should be continued and added to the Strategic Plan.
257	8	General					In support of Implementation Next Steps, Core Approach #3: Enhance Opportunities for Partnerships, we recommend two additional activities: - Establish an information sharing program that will provide basic guidance to the private sector on modeling, analyzing, measuring/monitoring, and reporting of emissions data. This would enhance the Integrated Measurement and Monitoring System Architecture (Figure 8-2), enable faster and more accurate benchmarking and assessment of GHG reduction actions, and reduce overall implementation costs to the U.S. economy through various commonalities of R&D software and hardware technology and processes. - Utilize Participant Indicative Data Obfuscation (data masking) software technology to allow private sector companies to provide data anonymously into the Program if they wish to do so. Privacy of data and information must be considered as a crucial factor in convincing early adopters of climate change technologies to provide corporate data. In support of Implementation Next Steps, Core Approach #7: Provide Supporting Technology Policy, we recommend three additional activities: - Establish criteria for use of robust and scalable analytical data management and decision support systems that can transition across different climate change technology development platforms as they are developed over the near term timeline (to 10 years from present). This would help Federal agencies 1) leverage their R&D investment in analytical data management and decision support systems across different climate change technology development platforms and timelines 2) allocate more federal budget dollars for emissions reduction and emissions monitoring technology work and 3) maximize their R&D information technology return on investment (ROI). - From the outset of the Program, establish criteria for software and systems development that effectively integrates measurement and management of emissions data with the modeling and mining of emissions data. This would include systems development for national and local emissions inventories, carbon budget estimates, emissions reduction modeling and estimates, emissions measurements, and so on. - Identify those data modeling, data management and decision support systems that are immediately required. These R&D software and hardware systems would include: * Large scale aggregated data warehouses and a supporting data framework that would provide a common access platform to researchers and hold baseline data on CO2 sequestration, energy efficiency technological developments, etc. * Databases to hold an inventory of the monitoring equipment utilized in R&D and data models to analyze this equipment information. We believe that data mining and modeling on this monitoring equipment data could reveal critical device related trends that can negatively or positively impact GHG measurements. All readings must be traceable to their originating measurement device or proxy.
258	8	8-2	8-2	22	34		The Measurements and Monitoring Framework for the Climate Change Technology Program Strategy as mapped appears to be one-directional, from supply to demand only, with no looping back of information from demand side actors. This would not support a more granular breakdown of field data required for voluntary benchmarking assessment of private sector results.
259	8	8-3	8-3	2	2	Figure 8-1	We recommend that Figure 8-1 show the demand side actors providing data to contribute to the integrated information required for benchmarking of results against expectations.

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260	8	8-3	8-11	19	19		Data exchange protocols must be defined and agreed to well before deployment to ensure required information is captured or calculated at each source. We recommend the use of service oriented architectures that will 1) decouple requestors from databases and permit users in any area of R&D to utilize common calls to access data from any source and 2) seamlessly merge content from multiple R&D sources irrespective of the specific source's content.
261	8	8-12	8-12	21	33		Of the three methods of CO2 sequestration presented, geologic, terrestrial, and oceanic, we've assessed that oceanic sequestration presents the highest levels of risk and risk management requirements to both public and private sector participants. This is due to the lack of supporting demonstrable scientific experiments and environmental impact studies as mentioned. We would like to add a third level of risk, which is the lack of clear ownership of location. The lack of clear ownership of location, for example in the case of international waters, presents an additional risk management challenge that does not exist in geologic and terrestrial sequestration since these occur within national borders. This lack of clear ownership of location and subsequent lack of oversight could present future data traceability and data monitoring challenges, unless clear restrictions are put on location of oceanic sequestration activities and special procedures are developed to prevent leakages beyond these locations. We therefore recommend that the Program make note of the higher level of risk associated with oceanic sequestration along with possible risk mitigation strategies, which could include scientific, technology, legal, and insurance-based risk mitigation actions and hedges.
262	8	8-14	8-14	34	35	Sections 8.2 & 8.3	We believe that the statement :software development that allows further integration of measurement data with emission modeling processes can lead to improved estimates" should be seen as an overall goal of the U.S. Climate Change Technology Program in all areas of climate change technology development. This goal should also be applied to Section 8.2 Energy Production and Efficiency Technologies, Section 8.3 CO2 Capture and Sequestration, and Section 8.5 Integrated Measurement and Monitoring System Architecture. All of these areas would benefit significantly from a tighter integration of data measurement and modeling processes and software systems.
263	8	8-16	8-16				Geographic distribution of SO2 and carbon black is important, yet the measurement and monitoring of these is not mentioned.
264	8	8-18	8-18	9	24	8-2	The Integrated Measurement and Monitoring System Architecture would benefit from an identification of actors, for example, who makes the predictions and observations, who implements and manages the decision support systems and management systems, and who takes GHG reduction actions. Currently the only actor inferred is the public sector utilizing the federal observations systems and models. However given the expectation of adoption of climate change technologies by the private sector and the requirement for benchmarking of planned improvements against current capabilities, then field data will be required from companies for calibration. We recommend that participation from public sector and private sector actors be more clearly noted in the System Architecture Figure 8-2.

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265	9	General					Basic research is an important component of the technology development process, and CCTP is to be commended for including it as one of the program's strategic goals. However, basic research needs to be subjected to the same management criteria as technology development. Appropriate criteria for success need to be established for basic research projects. These should be articulated in the strategic plan as should the manage-ment process for ensuring that basic research will be a productive component of the CCTP.
266	9	General					Chapter 9 discusses the science of estimating future climates. Great strides have been made in computational skills. However, the promise of estimating future earth temperatures is questionable, since today we can not take yesterday's climate data and hind cast yesterday's weather conditions. Thus, projecting the future is not possible.
267	9	General					Good overview of how to broadly and effectively select and focus R&D.
268	9	General					While modeling is acknowledged to play a key role in the necessary technology development to reduce greenhouse gas emissions in the United States, the draft could be much more specific in the necessary modeling capabilities that are required.
269	9	General					Chapter 9 discusses lighter automobiles, and fission energy, but is silent on the use of nuclear power plants. Nuclear power is available now. It is clean, low cost and affordable. However, with all the years of nuclear power, government has not been able to solve the waste problem. Government has studied the burial of the waste, but the problem is still sitting in pools of water: waiting. If we cannot solve the nuclear waste problem, how will we develop new energy generating system without creating more problems to solve? Chapter 9 falls back on wind and solar power, but no one has made a life cycle economic analysis of either of these forms of power. The low voltage generated means batteries and transformers must be involved. Base on the life of my car battery, I can envision high maintenance and replacement cost. Also, the energy required to fabricate structures, batteries, blades, transmission lines appear staggering. We are having difficulty maintaining our current grids, without adding to the burden by spreading the generating sources to windy or sunny places.
270	9	9-6	9-6	4	6		The following key areas of modeling are mentioned: * Improved models of the aerodynamics of wind turbines and other fluid dynamics processes * Computer-assisted simulations of proposed advanced components and energy systems * Predictive modeling of physical systems. I believe these are too vague and the following specific areas need to be included: -Three dimensional Computational Fluid Dynamics modeling for Generation III and Generation IV nuclear reactors. This should include coupling of neutronics physics to heat transfer and fluid dynamics, as well as three dimensional models for critical heat flux or dry-out prediction (the latter being relevant for Generation III reactors). Significant validation is also required for these powerful models to be used in a regulatory environment. -Development of Computational Fluid Dynamic modeling capabilities related to the Advanced Fuel Cycle Initiative (AFCI) The UREX+, PYROX, and SANEX/DIAMEX processes all involve fluid mixing coupled to chemical reaction, precipitation and/or electrochemical processes in the liquid or gaseous phase. Spallation of liquid metals is an additional complex fluid dynamic process that is key to accelerator driven transmutation. Coupling these physical models to the fluid dynamics will be important for scaling up these processes. -Further development of tools to model gasification accurately and reliably This should include multiphase model development. Existing models need to be further developed to improve computational efficiency

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							for the unsteady flows found in gasification combustion systems. Ash, slagging, and fouling are some of the most important technical challenges facing gasification systems, and the relevant CFD models need to be developed and validated. Mercury absorption models for CFD have been developed for sorbent injection within traditional coal-fired power plants, but the mechanism will be different for gasification plants, and these models need to be further developed. -Further development of CFD combustion models for NOx, SOx formation While the focus of the program is greenhouse gas reduction, any fossil fuel combustion process will need to address NOx and SOx formation. Current CFD models for the formation of these species are empirical, and detailed chemical mechanisms are too inefficient to use for practical problems. New efficient models need to be developed. This will assist in improving emissions from processes in all industries using fossil fuels or bio-fuels.
271	9	9-6	9-7	14	10		Strategic Research is at the heart of Pasteur Quadrant basic research needed by applied technologies. However, not many explicit examples are given. Instead paragraphs contain italics phrases that are not elaborated. For example, under transportation on p 9-7 the first paragraph italicizes "materials science" and "joining and welding science." What are the particulars that go with these phrases?
272	9	9-11	9-11	17	33		Not all under "carbon capture and geologic repositories" seem to fit that heading. For example the basic biological research paragraph and the genomics research paragraph don't seem to fit.
273	9	9-11	9-11	19	19		Replace line 19 with: transforming it to another form of carbon that may be more useful, or more safely or permanently stored.
274	9	9-12	9-12	18	19		Insert between Line 18 and 19: Research on methods of enhancing the abiotic uptake of CO2 by the ocean, and/or storing carbon in the ocean in forms other than acid-producing, easily degassible CO2 will also be considered.
275	9	9-13	9-14	26	30		Exploratory Research is an important key to innovation. I applaud you for identifying and highlighting it. No idea is presented about how Exploratory Research will be organized, managed or even initiated, however. I suggest consideration of the paper called Climate Change Technology Exploratory Research (CCTER) as a seed money approach to organizing Exploratory Research. This seed money activity could be carried out within or outside DOE. I prefer the option of a not for profit corporation funded by DOE, other agencies and the private sector to administer the seed money endeavor. It would be part of CCTP, but not part of DOE. This paper is on the web at www.cpc-inc.org.
276	9	9-14	9-14	9	9		Replace Line 9 with: genomics, chemistry, biotechnology and bioengineering. Also, relevant to CO2 capture and sequestration, the natural chemical reactivity of CO2 could be exploited to remove CO2 from the air or from waste streams, while forming stable, storable carbon compounds or useful products.
277	9	9-14	9-14	10	15	Section 9.3	Integrative concepts. Integrative concepts cut across R&D program lines and attempt to combine technologies and/or disciplines. An example might be a scheme that combines sequestration of carbon in soils with the development of a novel form of bio-energy. My suggestion is: "Another example might be the development of fundamental understanding of the Vehicle-to-Grid (V2G) impact on global energy sector and climate change". Integrative concepts might be difficult to coordinate across agencies or across traditional R&D program or mission areas; hence more concerted effort might be required to explore such concepts and manage research in these multi-mission areas.
278	9	9-15	9-15	1	14		Scientific breakthroughs need to be pushed toward energy technology applications. This is being done more and more effectively by BES and BER, but something like the old ECUT program might be worth reconstructing to pursue science push more systematically.

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279	10	General					Chapter 10 seems to take the place of an Executive Summary. That is OK, but perhaps it should be acknowledged up front. Chapter 10 is not really an executive summary, however. I think one is needed.
280	10	General					Chapter 10, Conclusions and Next Steps, seems to underplay the role of renewables. For example, the central role of biomass for carbon neutral fuels and to offset the carbon emissions from transportation should be more explicitly highlighted. Chapter 10, The importance of terrestrial storage is underplayed.
281	10	10-1	10-1	2	6		Under Presidential leadership, and in partnership with others, the United States is now embarked on an ambitious undertaking to develop new and advanced climate change technologies. These technologies have the potential to facilitate a global shift toward significantly lower greenhouse gas (GHG) emissions, and do so at substantially lower cost, while continuing to provide the energy-related and other services needed to spur and sustain economic growth. - I don't see much leadership from the President in pushing for legislation that could substantially reduce GHG emissions within the next few decades. Far from being an ambitions undertaking, I see the plan as an effort to appear to be doing something significant while delaying any real action until the costs to human societies and natural ecosystems are obvious to everyone. By then it may be too late.
282	10	10-2	10-3	9	8	Figure 10-1	Inconsistencies. Cost and durability are the major barriers to Fuel Cell commercialization. The vehicle technologies research programs have a number of specific goals (see: Chapter 4: Reducing Emissions from Energy End Use and Infrastructure - Page 5, Line 5 to 16). For transportation applications, which have the most stringent cost and durability requirements, fuel cell costs need to be decreased by a factor of 5,1 and durability needs to be increased by a factor of 3 to be competitive with current vehicle technologies (see: Technology Options for the Near and Long Term Report: Section 2.2.5 Page 14). Actually the vehicle technologies research programs fixed these goals for the year 2015 (see: Chapter 5: Reducing Emissions from Energy Supply, Page 9, Line 10 to 14) and also the 2005 U.S. Energy Bill decrees that: "the Secretary shall submit to Congress a report describing ...(4) progress, including progress in infrastructure, made toward achieving the goal of producing and deploying not less than — (A) 100,000 hydrogen-fueled vehicles in the United States by 2010; and (B) 2,500,000 hydrogen-fueled vehicles in the United States by 2020". From my point of view if all actual RD&D, technical and cost barriers are overcame by 2015 and the U.S. Energy Bill goals are achieve by 2020, the H2 Fuel Cell Vehicles will be a "Near Term " technology and not a "Mid or Long Term " technology (as indicated in Chapter 10: Conclusions and Next Steps in Figure 10-1: Roadmap for Climate Change Technology Development and Deployment for the 21st Century, Page 3; and Chapter 4: Reducing Emissions from Energy End Use and Infrastructure Page 3, Line 7 and Page 4, Line 21). U.S. Energy Bill, 2005, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_bills&docid=f:h6enr.txt.pdf Sec. 811, Page 259. Near Term: "near-term" envisions significant technology adoption by 10 to 20 years from present, "midterm" in a following period of 20-40 years, and "long-term" in a following period of 40-60 years. See: Chapter 10: Conclusions and Next Steps - 10.1 Portfolio Priorities and Current Emphasis Figure 10-1: Roadmap for Climate Change Technology Development and Deployment for the 21st Century, Page 3. Idem Idem
283	10	10-3	10-3			Figure : 10-1	The timelines established give no opportunity for hydrogen internal combustion engine (ICE) vehicles. Those vehicles could easily be on the road today if there was a refueling infrastructure. ICE vehicles require only minimum modification in order to run on hydrogen and would greatly reduce not only greenhouse gas emissions, but the 100% known danger of air borne pollutants. If a hydrogen fueling infrastructure existed...even a minimal one... it would pave the wave for even more efficient fuel cell vehicles. BMW and Ford among

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							others have plans to produce hydrogen ICE vehicles. Energy Conversion Devices has modified a Toyota Prius to run on hydrogen. Hydrogen ICE vehicles can deliver almost zero emissions and they can do it today. Offering hydrogen as fuel choice is imperative for America's energy independence, for the reduction of air borne pollutants, and for reducing green house gas emissions. America was founded on the concept of free markets and competition. Our reliance on foreign oil has stifled that competition and freedom and is sending the money of Americans to foreign lands...and often lands that are hostile to us. Establishing hydrogen as a fuel choice would spark a new flow of competition amongst native coal, ethanol, nuclear, wind, solar, and hydro companies to produce hydrogen at a low cost using new methods. The industry needs government support to establish rules and regulations that allow hydrogen to be a transport fuel. According to Air Products, the hydrogen already produced to day would be sufficient to fuel 250 million fuel cell vehicles (http://www.airproducts.com/Products/LiquidBulkGases/HydrogenEnergyFuelCells/FrequentlyAskedQuestions.htm). The United States knows how to produce hydrogen and we know how to ship it and transport it to industries. We need to take that the extra mile now and make it available at the pump to US consumers. Additionally, representatives of both Ballard Power and General Motors testified before the US Senate on July, 27 2005 that they expect to have fuel cells for vehicles that would be competitive on price and performance with traditional gasoline internal combustion engines by 2010 if produced in volumes of 500,000 or more. Without a fueling infrastructure, it will obviously be impossible for them to achieve that goal. The timeline established in figure 10-1 has fuel cell vehicles coming into play in 2025 at the earliest, while in the July 27, 2005 testimony of Larry Burns and Dennis Campbell you have the key players in America's big 3 automotive companies stating fuel cells could be ready in 2010. I believe that time line needs to be adjusted. The testimony that Larry Burns (VP of Research & Development at GM) gave before the US Senate can be found here: http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1490&Witness_ID=4233 The testimony that Dennis Campbell (CEO at Ballard Power) gave before the US Senate can be found here: http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1490&Witness_ID=4234
284	10	10-3	10-3			Figure 10-1	Initial deployment of fusion energy is planned for the "mid-term" as defined here, and large-scale fusion deployment is planned for the "long term" as defined here. The figure should be so modified.
285	10	10-3	10-3	1	3	Figure 10-1	The "Roadmap" in Figure 10-1 (p. 10-3) appears to be a reasonable delineation of the short-, mid-, and long-term objectives of technologies, but the three proposed 20-year time frames extend too far out in the future, recognizing that not each and every one of the technologies listed in the columns may be realized when expected. The more realistic time frames that we have proposed above correspond to reasonable time frames for the energy supply technologies grouped in subsection III.H.2 below. As to anything beyond 45 to 50 years, that is far too speculative for meaningful analysis. 8 Intergovernmental Panel on Climate Change Special Report on Carbon dioxide Capture and Storage, Summary for Policymakers at 8 & n. 12 (Sept. 25, 2005).
286	10	10-3	10-3	5	7	10-1	Change the sentence beginning on line 5 to read as follows: "With some overlap, 'near-term' envisions significant adoption of at least some of the technologies in the column by 0-10 years from present, 'mid-term' in a following period of 10-20 years, and 'long-term' in a following period of 20-45 years."
287	10	10-3	10-4	16	11		We believe that energy supply technologies for electric utilities should be included as follows: − Short-term: advanced clean coal technologies (e.g., IGCC, supercritical pulverized coal), Regional Carbon Sequestration Partnerships, Carbon Sequestration Leadership Forum, Nuclear Power 2010, Advanced Fuel Cycle Initiative, hydro and non-hydro renewables. − Medium-term: carbon capture and storage, FutureGen, Gen IV nuclear, advanced renewables. − Long-term: fuel cells and hydrogen-linked generation, international magnetic fusion experiment (ITER), widespread renewables enabled by advanced electricity storage and enhanced transmission infrastructure.
288	10	10-4	10-8	1	25		Biological/terrestrial sequestration, pages 10-4 and 10-8: We support "R&D programs in advanced forest. . .systems" (p. 10-4)

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							and the concept that the government should "evaluate various technology policy options for stimulating land-use and land management practices that promote carbon sequestration and GHG emissions reductions" (p. 10-8, lines 24-25).
289	10	10-4	10-4	15	15		Replace line 15 with: regarding the technical, economic, and environmental acceptability will need to be explored and critically evaluated.
290	10	10-4	10-4	19	19		Replace line 19 with: Important research activities currently include: (1) the international Carbon Sequestration Leadership Forum ...
291	10	10-7	10-7	5	6		The beginning of this section correctly observes that not all of the activities listed in the section will (or can) be pursued at once. The four Portfolio Planning and Investment Criteria listed in Box 2-1 will be useful in prioritizing actions under some but not all of the seven approaches listed in the section. CCTP needs to develop and make public its criteria for the approaches that are not part of the technology development cycle, specifically for ensuring a viable technology workforce of the future and for providing supporting technology policy.
292	10	10-7	10-7	5	6		The beginning of this section correctly observes that not all of the activities listed in the section will (or can) be pursued at once.
293	10	10-7	10-8	28	11		Increase International Cooperation, pages 10-7 - 10-8: We are very supportive of the international cooperation areas listed here and elsewhere and, in particular, the Carbon Sequestration Leadership Forum and the developing Asia-Pacific Partnership for Clean Development and Climate. In this regard, Dr. Watson in his Senate testimony (noted previously) said that "[a]ny effective international response to climate change requires developing country participation, which includes" - as we have urged in these comments - "both near-term efforts to slow the growth in emissions and longer-term efforts to build capacity for future cooperation" (emphasis added).
294	10	10-8	10-8	8	9	also Footnote 2	Change "Asia Pacific Partnership for Clean Development" to "Asia-Pacific Partnership for Clean Development and Climate," which is the correct title.

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295	Appendix A	Mid-page				A.1	This offers a lead to study geoengineering approaches to mitigation. Technologies that mitigate the effects of climate change, enhance adaptation or resilience to climate change impacts, or potentially counterbalance the likelihood of human-induced climate change;"