

SAP-4.5

Prospectus for

**Effects of Climate Change
on Energy Production and Use
in the United States**

U.S. Climate Change Science Program

Lead Agency
Department of Energy (DOE)

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Department of Energy

For More Information

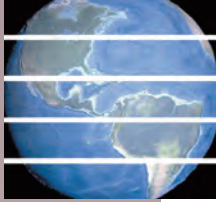
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This prospectus has been prepared according to the *Guidelines for Producing Climate Change Science Program (CCSP) Synthesis and Assessment Products*. The prospectus was reviewed and approved by the CCSP Interagency Committee. The document describes the focus of this synthesis and assessment product, and the process that will be used to prepare it. The document does not express any regulatory policies of the United States or any of its agencies, or make any findings of fact that could serve as predicates for regulatory action.

U.S. CLIMATE CHANGE SCIENCE PROGRAM

Prospectus for Synthesis and Assessment Product 4.5

Effects of Climate Change on Energy Production and Use in the United States



1. OVERVIEW: DESCRIPTION OF TOPIC, AUDIENCE, INTENDED USE, AND QUESTIONS TO BE ADDRESSED

1.1. Introduction

In the *Strategic Plan for the U.S. Climate Change Science Program* (issued in July 2003), 21 Synthesis and Assessment Products (SAPs) were identified to be produced over a 4-year time frame (2004-2007), in line with Climate Change Science Program (CCSP) Decision Support Goal 1: “Prepare scientific syntheses and assessments to support informed discussions of climate variability and change issues by decisionmakers, stakeholders, the media, and the general public.” These products are to be prepared through processes that are open and public, encouraging stakeholder participation in order to promote a consensus about the knowledge base for climate change decision support.

In April 2005, the Government Accountability Office (GAO) issued a report (GAO-05-338R, *Climate Change Assessment*) which suggested that the 21 SAPs do not satisfy the scientific assessment requirement of the Global Change Research Act of 1990 for periodic assessments of implications of global change on various systems and resources in the United States, including effects on energy production and use. On July 15, 2005, CCSP agreed to modify its SAP list to incorporate coverage of all assessment areas listed under Section 106 of the Global Change Research Act. One of these modifications was rescoping Product 4.5 to focus on effects of global change on energy production and use, due in the second quarter of CY 2007 (i.e., June 30, 2007), with the Department of Energy (DOE) as the Lead Agency. Product 4.5 was subsequently titled “Effects of Climate Change on Energy Production and Use in the United States.”

SAP development must follow guidelines issued publicly on December 2, 2004, and employ five general principles:

- Analyses structured around specific questions
- Early and continuing involvement of stakeholders
- Explicit treatment of uncertainties
- Transparent public review of analysis questions, methods, and draft results
- Adoption of a “lessons learned” approach, building on the ongoing CCSP analyses.

Each SAP is assigned to a Lead Agency, working under the auspices of the CCSP Interagency Committee. Lead and contributing authors of SAPs are to be “scientists or individuals with recognized technical expertise appropriate to a product.” Expert reviewers will include individuals with equivalent qualifications. Stakeholders will participate during the scoping process (completed in September 2005 for SAP 4.5), provide comments on the prospectus, and comment on the product during a public comment period.



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1.2. The Topic

This product will summarize the current knowledge base about possible effects of climate change on energy production and use in the United States, as a contributor to further studies of the broader topic of effects of global change on energy production and use.

The process for producing the report will include a survey and assessment of the available literature—which is rather limited and in many cases in the form of reports that were not peer-reviewed—including attention to findings from research about implications of climate variability on energy production and use. It will also include identification and consideration of relevant studies carried out in connection with CCSP, the Climate Change Technology Program (CCTP), and other programs of CCSP agencies (e.g., the Energy Information Administration), and consultation with stakeholders such as the electric utility and energy industries, environmental non-governmental organizations, and the academic research community to determine what analyses have been conducted and reports have been issued.

SAP 4.5 is not expected to commission new analyses of data, although it is likely to include new syntheses of available knowledge and data. It will not develop climate change scenarios, instead drawing from the current research literature and the report of SAP 2.1 (“Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations and Review of Integrated Scenario Development and Application”), as well as other CCSP sources. Its focus will be on possible energy sector effects of global change, including a characterization of current uncertainties and research priorities for reducing uncertainties (where feasible through research) as a basis for informing decisionmaking. Its intention is to be policy relevant but not policy prescriptive. Although ideally it would report quantitative effects (both positive and negative) under different scenarios for regional climate change and associated uncertainties, given limited data and knowledge it may only be feasible to emphasize vulnerabilities to impacts and general levels of confidence for statements about such concerns. It will also identify where research

could reduce uncertainties about vulnerabilities, possible effects, and possible strategies to reduce negative effects and increase adaptive capacity and consider priorities for strengthening the knowledge base.

The content of SAP 4.5 will include attention to the following issues:

- Possible effects (both positive and negative) of climate change on energy consumption in the United States, for instance:
 - Effects on energy use for space warming, including regional differences
 - Effects on energy use for space cooling and other refrigeration, including regional differences
 - Overall effects on energy use, by delivery form and fuel type (e.g., electricity and natural gas)
 - Other possible effects, including energy demands and uses in key sectors of the economy.
- Possible effects (both positive and negative) on energy production and supply in the United States, for instance:
 - Effects of changed energy requirements on energy institutions (e.g., on electricity system reliability)
 - Effects (positive and negative) on renewable energy resources [e.g., hydropower and biomass (from changes in precipitation patterns) and windpower (from extreme weather events)]
 - Effects on other energy production facilities (e.g., availability of water for cooling, offshore oil production impacts associated with storm behavior)
 - Effects on energy transmission and distribution (e.g., on electricity transmission networks, bridges and rivers that move petroleum products, storm impacts on storage facilities).
- Possible indirect effects on energy consumption and production through:
 - Possible effects on energy planning, nationally and/or regionally, and relationships (positive or negative) with the range of energy resources and technologies
 - Possible effects on energy production and use technologies, including technology research and development investments and technology preferences and choices

- Possible effects on energy production and use institutions (e.g., possible impacts on fossil fuel industries and contexts for policymaking and regulation)
- Possible effects on energy-related dimensions of regional economies (see regional variations above), including changes in regional comparative advantage regarding energy availability and cost
- Possible relationships with other energy-related issues, including energy prices, energy security, environmental emissions, and energy technology and service exports.

1.3. The Audience

The audience for SAP 4.5 includes scientists in related fields, decisionmakers in the public sector (Federal, State, and local governments), the private sector (energy companies, electric utilities, energy equipment providers and vendors, and energy-dependent sectors of the economy), energy and environmental policy interest groups, and the general public. In many cases, it is expected that SAP 4.5 will be unable—based on existing knowledge—to answer all relevant questions that might arise from this diverse array of stakeholders, but it is hoped that the product will inform discussions about the issues raised in Section 1.5 below and clarify priorities for research to reduce uncertainties in answering such questions. The product will be designed to communicate with the informed public as well as with identified decisionmakers.

1.4. Intended Use

A SAP has three end uses: (1) informing the evolution of the research agenda; (2) supporting adaptive management and planning; and (3) supporting policy formulation. This product will inform policymakers, stakeholders, and the general public about issues associated with climate change implications for energy production and use in the United States, increase awareness of what is known and not yet known, and support discussions of technology and policy

options at a stage where the knowledge base is still at an early stage of development.

1.5. Questions To Be Addressed

The central questions to be addressed by SAP 4.5 follow:

- How might climate change affect energy consumption in the United States?
- How might climate change affect energy production and supply in the United States?
- How might climate change affect various contexts that indirectly shape energy production and consumption in the United States, such as energy technologies, energy institutions, regional economic growth, energy prices, energy security, and environmental emissions?

SAP 4.5 may not produce definitive quantitative answers to these questions, beyond broad qualitative generalizations; however, the process of addressing the questions is expected to be informative.

2. CONTACT INFORMATION FOR THE RESPONSIBLE INDIVIDUAL AT THE LEAD AGENCY

Jerry Elwood
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 Office of Biological and Environmental Research
 Office of Science
 Department of Energy
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3. LEAD AUTHORS

Lead and contributing authors of SAPs are to be “scientists or individuals with recognized technical expertise appropriate to a product.” The technical content of SAP 4.5 will require expert knowledge about:

- Economic and engineering aspects of energy demand and supply



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- Available climate change scenarios for the United States and its regions
 - Relationships between weather and climate variables and energy demand and supply
 - Sensitivities of renewable and other energy sources to climate variation
 - Relationships between energy conditions and other economic sectors
 - Regional differences in energy conditions and institutions
 - Institutional structure of the U.S. energy system and recent or current climate-related (or equivalent) stresses on that system (e.g., the experience of the recent California energy crisis, in which one of the causes was climate variability in the Northwest)
 - Climate change technology research and development directions and possible determinants of technology market penetration.

SAP 4.5 will be prepared and authored by staff from the DOE national laboratories, drawing on their own expertise and knowledge bases and also upon other knowledge bases, including those within energy corporations and utilities, consulting firms, non-governmental organizations, state and local governments, and the academic research community. Authorship by DOE national laboratory staff will in no way exclude any relevant research or knowledge, and every effort will be made to identify and utilize all relevant expertise, materials, and other sources.

Authors are expected to include the following leaders and experts from DOE national laboratories, who will interface with appropriate experts from their own and other institutions as appropriate (see Appendix A for brief bios):

- Thomas J. Wilbanks, Oak Ridge National Laboratory, Coordinating Lead Author
- Vatsal Bhatt, Brookhaven National Laboratory
- Marilyn A. Brown, Oak Ridge National Laboratory
- Stan Bull, National Renewable Energy Laboratory
- James Ekmann, National Energy Technology Laboratory
- William Horak, Brookhaven National Laboratory
- Mark D. Levine, Lawrence Berkeley National Laboratory

- Doug Rotman, Lawrence Livermore National Laboratory
- Michael J. Sale, Oak Ridge National Laboratory
- David Schmalzer, Argonne National Laboratory
- Michael Scott, Pacific Northwest National Laboratory.

Further DOE national laboratory staff will also contribute to chapter authorship according to their individual expertise related to topics of the SAP.

4. STAKEHOLDER INTERACTIONS

Stakeholders participated during the scoping process, have provided comments on the prospectus, and will submit comments on the product during a public comment period. Besides the stakeholders workshop on September 27, 2005, to provide input to scoping this draft prospectus, and the review processes described in Section 6, SAP 4.5 will include:

- Active networking by authors with counterparts in other institutions, in part identified through the workshop, to ensure that the process is fully informed about their knowledge bases and viewpoints
- Active outreach to key centers of expertise and stakeholders through site visits and followup interactions
- A web site containing full information about the assessment and the process, including the prospectus, information about the authors and workshop, and as appropriate draft materials under review.

5. DRAFTING PROCESS

According to the *Guidelines for Producing Synthesis and Assessment Products*, the SAP process includes the following steps:

- Summarize the proposed process and product in a draft prospectus, with inputs from users and other stakeholders, including a description of processes for soliciting stakeholder input
- CCSP review and a public comment period of at least 30 days

- Prospectus revision and approval
- Preparation of a first draft by Lead Authors, including a technical section plus a summary for interested non-specialists
- Expert peer review organized by the Lead Agency
- Preparation of a second draft
- Second draft posted for public comment for 45 days
- Preparation of a third draft
- Review by the CCSP Interagency Committee
- National Science and Technology Council approval.

In general, the approach for preparing SAP 4.5 will be consistent with the practices of other SAPs, shaped to some extent by the current scarcity of peer-reviewed research literature that can be cited as a basis for statements about this subject. Author teams will be selected for the major chapters of the product, working under the oversight of an SAP 4.5 Coordinating Team. The Coordinating Team and chapter authors will utilize professional networks, bibliographic information sources, and stakeholder input to identify relevant knowledge bases, direct and indirect; compile all available data in consultation with other experts in the public sector, the private sector, non-governmental organizations, and the academic research community; assess the available knowledge base using established analytic-deliberative practices, also in consultation with other experts; develop a summary of what is known and what is not yet known, along with possible priorities for improving the knowledge base; and produce a summary statement of conclusions as supported by the research evidence, along with an evaluation of levels of confidence represented by each statement.

If quantitative analytic data are limited—as seems possible based on preliminary surveys of the current knowledge base—the author teams will explore the degree to which qualitative statements of possible effects may be valid as outcomes of expert deliberation, utilizing the extensive review processes built into the SAP process to contribute to judgments about the validity of the statements.

SAP 4.5 is subject to provisions of the Information Quality Act, which requires that authors independently verify the

accuracy and reliability of findings, data, results, and conclusions in cited documents that have not been peer-reviewed and published in the open literature.

6. REVIEW

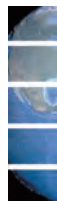
SAP guidelines call for the following steps in reviewing the approach and draft materials associated with SAP 4.5 before its completion (see timeline):

- Opportunities for public comment on the draft SAP 4.5 prospectus (at least 30 days)
- Expert review of first draft materials, organized by DOE with candidate reviewers invited from other CCSP agencies as well
- Opportunities for public comment on second draft materials, posted on the CCSP web site (at least 45 days)
- Final reviews by the CCSP Interagency Committee and NSTC.

7. RELATED ACTIVITIES

Unlike some of the other sectoral assessment areas identified in the Global Change Research Act—such as agriculture, water, and human health—energy was not the subject of a sectoral assessment in the *National Assessment of Possible Consequences of Climate Variability and Change*, completed in 2001. As a result, SAP 4.5 draws upon a less organized knowledge base than these other sectoral impact areas. On the other hand, by addressing an assessment area not covered in the initial national assessment, SAP 4.5 will provide new information and perspectives.

The subject matter associated with SAP 4.5 is incorporated in the Working Group II contribution to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (Impacts, Adaptation, and Vulnerability)—namely Chapter 7, “Industry, Settlement, and Society.” This chapter is summarizing the global knowledge base about possible impacts of climate change on energy production and use in less than 2 pages within a chapter limited to a total of 30 pages, reporting relevant



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research from the United States but not assessing impacts on the United States.

8. COMMUNICATIONS

Communications associated with SAP 4.5 include proposed stakeholder interactions, provisions for reviews of draft materials, and dissemination of SAP results and products.

After completion of the reviews and consequent responses to comments, production and distribution of the final SAP 4.5 report will be arranged by DOE in accordance with established practices for Federal government dissemination. SAP 4.5 will be printed, with hardcopies made available through the CCSP Office. It will also be made available electronically on both the CCSP and SAP 4.5 web sites.

The web site will make a wide variety of information about SAP 4.5 available to stakeholders and the general public, inviting comments and questions about the process, draft materials, and ways to make such a process more useful in the future.

Opportunities for providing information about SAP 4.5 and its results will be sought in various appropriate scientific and other public venues, such as professional conferences and workshops, and one or more summaries of the results may be published in an appropriate professional journal.

9. PROPOSED TIMELINE

The due date for SAP 4.5 is the second quarter of CY 2007 (June 30, 2007). A timeline that meets all of the requirements of the *Guidelines for Producing Synthesis and Assessment Products* follows.

Sept 2005	Stakeholder workshop to help scope the prospectus
Oct - Nov 2005	Drafting of prospectus

Dec 2005 - Feb 2006	CCSP review of prospectus and a public comment period of at least 30 days
Apr 2006	Prospectus revision and approval
Apr - June 2006	Preparation of a first draft by Lead Authors, including a technical section plus a summary for interested non-specialists
July - Aug 2006	Expert peer review organized by the Lead Agency
Sept - Nov 2006	Preparation of a second draft
Dec 2006 - Jan 2007	Second draft posted for public comment for at least 45 days
Feb - Mar 2007	Preparation of a third draft
Apr 2007	Review by the CCSP Interagency Committee
June 2007	NSTC approval

Appendix A. Bios for Potential Lead Authors

Thomas J. Wilbanks, Oak Ridge National Laboratory, Coordinating Lead Author

Thomas J. Wilbanks is a Corporate Research Fellow at the Oak Ridge National Laboratory and leads the Laboratory's Global Change and Developing Country Programs. He conducts research and publishes extensively on such issues as sustainable development, energy and environmental policy, responses to global climate change, and the role of geographical scale in all of these regards. Wilbanks is a past President of the Association of American Geographers (AAG), a member of the Board on Earth Sciences and Resources of the U.S. National Research Council (NRC), Chair of NRC's Committee on Human Dimensions of Global Change, a member of the Panel on Earth Science Applications and Societal Needs of the NRC "decadal study" of Earth Science and Applications from Space: A Community Assessment and Strategy for the Future, and a member of two other current NRC panels related to environmental assessment and decision support. He is also a member of the Scientific Steering Group for the U.S. Carbon Cycle Research Program and serving as Coordinating Lead Author for the IPCC's Fourth Assessment Report, Working Group II, Chapter 7: Industry, Settlement, and Society, which includes energy sector vulnerabilities, impacts, and adaptation potentials.

Vatsal Bhatt, Brookhaven National Laboratory

Vatsal Bhatt is an Energy Analyst, Modeler and Planner with the Energy, Environment and Economic Analysis Group in the Energy Sciences and Technology Department of Brookhaven National Laboratory. He provides technical expertise and analytical support for integrated program assessment, policy analysis, energy and water technology assessment, environmental planning, and economic analysis for various DOE offices, including; the Office of Policy and International Affairs, the Office of Energy Efficiency and Renewable Energy and the Office of Nuclear Energy, Science and Technology. Recently, in support of the U.S. Environmental Protection Agency, he developed an energy system model for New York City to address policies related to peak electricity loads buildings, urban heat island effect and pollution prevention. His ongoing activities include cooperation with the Taiwan Environmental Protection Administration for their national policies and the development of a multi-regional Central American energy systems model for the continuation of Taiwan-Central America regional cooperation in Clean Development Mechanism. Mr. Bhatt has worked extensively on Indian energy and environmental policies, including a study analyzing the impacts of climate change on infrastructure and development. He also contributed to India's National Communication to the United Nation's Framework Convention on Climate Change. He holds degrees in engineering, and in regional and environmental planning. He is a co-founder of a nonprofit organization working for sustainable development in India.

Marilyn A. Brown, Oak Ridge National Laboratory

Dr. Brown is the Interim Director of Oak Ridge National Laboratory's Engineering Science and Technology Division. Dr. Brown is an internationally recognized expert on issues surrounding the commercialization of new energy and environmental technologies and the evaluation of government programs and policies. She is currently working with the multi-agency Climate Change Technology Program, led by the U.S. Department of Energy, to assess its R&D portfolio by identifying any major technology gaps and opportunities. Prior to coming to Oak Ridge, she was a tenured Associate Professor in the Department of Geography at the University of Illinois, Urbana-Champaign. She has authored more than 140 publications and has been an expert witness in hearings before Committees of both the U.S. House of Representatives and the U.S. Senate. Dr. Brown serves on the boards of directors of several nonprofit energy organizations and on the editorial boards of several journals. She is also a member of the National Commission on Energy Policy and is a Certified Energy Manager. Her PhD is in Geography from Ohio State University and her Masters Degree is in Resource Planning from the University of Massachusetts.

Stan Bull, National Renewable Energy Laboratory

Dr. Bull is the Associate Director for Science and Technology at the National Renewable Energy Laboratory (NREL) and Vice President, Midwest Research Institute. Stan has more than 35 years of experience in energy and related applications including renewable energy, energy efficiency, transportation systems, bioenergy, medical systems, and nondestructive testing. He has experience in leading energy research and development, managing and developing programs, and planning and evaluating technical programs. He leads NREL's RD&D, which emphasizes renewable energy and energy efficiency technologies in support of DOE programs. Dr. Bull has also held university faculty and private sector responsibilities. He has authored approximately 85 publications in diverse fields and technical journals, and presented more than 100 papers at international, national, and other meetings. Dr. Bull has a Ph.D. and M.S. from Stanford University and a B.S. from the University of Missouri-Columbia in Chemical Engineering and Mechanical Engineering. Professional recognition and honors include a Senior Fulbright-Hays Professorship in Grenoble, France, the Faculty-Alumni Award from the University of Missouri-Columbia, and the Secretary of Energy Outstanding Program Manager Award.

James Ekmann, National Energy Technology Laboratory

Mr. Ekmann currently serves as Director of the Office of Systems, Analyses and Planning at the National Energy Technology Laboratory of the United States Department of Energy. His Office focuses on studies of the benefits of accelerated technology deployment and system analysis of energy technologies. Technology benefits studies are focused on assessing the impact of technology options for reducing greenhouse gas emissions from both mobile and stationary sources; and, costs and benefits of deploying advanced, ultra-low emission energy systems. He has extensive research experience in combustion and holds several patents for emission control technologies and diagnostic devices applicable to boilers. Mr. Ekmann is the U.S. coordinator for collaboration on environmental control technologies (Annex IV) under the U.S. – China Protocol

between the Office of Fossil Energy within USDOE and the Ministry of Science and Technology of the People's Republic of China. He and his staff have worked under USAID funding in India on the Greenhouse Gas Pollution Prevention (GEP) Project with tasks focused on the utility sector, distributed generation and, in partnership with the DOE Clean Cities International program, on clean transportation. He has participated in negotiating research collaborations focused on new technologies under bilateral agreements between the United States and India, China, Italy, Norway, and the European Commission. Mr. Ekmann represented NETL in the development of two Department of Energy studies dealing with climate change mitigation technologies: *Technology Options to Reduce U.S. Greenhouse Gas Emissions* and *Carbon Sequestration: State of the Science*. He is author or co-author of numerous papers and presentations in the areas of combustion, multiphase flow, complex systems and climate change mitigation technologies. He has organized numerous technical meetings dealing with greenhouse gas mitigation technologies and with issues reshaping the power industry including organizing a special session at the American Association for the Advancement of Science annual meeting in 2003 and at the Electric Power 2004 and 2005 conferences. He organized the first meeting in China, in August of 2001, focused exclusively on greenhouse gas mitigation technologies. He was Co-chairman of the International Program for the Power India 2005 conference.

William Horak, Brookhaven National Laboratory

William Horak was appointed Chair of Brookhaven National Laboratory's Energy Sciences & Technology Department (EST), on September 15, 2000. He has a B.S. in Aeronautical and Astronautical Engineering, and a M.S. and Ph.D. in Nuclear Nuclear Engineering from the University of Illinois. He is an internationally recognized expert on energy issues and has served on numerous boards, committees and panels, both in the United States and for international organizations, such as the European Bank for Reconstruction and Development. Since coming to Brookhaven he has had a lead role in DOE's activities responding to the Chernobyl accident, including evaluations of Soviet designed facilities. He has implemented and managed numerous programs in nuclear safety, international safeguards, and energy system development. He has received numerous commendations including the American Nuclear Society's Mark Mills Award and the Nuclear Regulatory Commission's Special Achievement Certificate.

Mark D. Levine, Lawrence Berkeley National Laboratory

Mark Levine is Director of the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory. He received a bachelor's degree *summa cum laude* in chemistry from Princeton University and his doctorate in chemistry from UC Berkeley. Before joining LBNL in 1978 he was a staff scientist for the Ford Foundation Energy Project and a senior energy policy analyst at SRI International. From 1983 until his appointment as Division Director in 1997, Dr. Levine served as Head of LBNL's Energy Analysis Program, which analyzes domestic and international energy demand and efficiency issues. He is a co-founder of the Beijing Energy Efficiency Center and has expertise in energy modeling, appliance energy efficiency policy, and other aspects of energy efficiency and climate change policy analysis. Dr. Levine sits on the boards of several energy policy organizations and coo-lead the report

“Scenarios for a Clean Energy Future,” which analyzed U.S. energy efficiency and renewable energy technologies and policies. He has authored several reports for international bodies, including the Intergovernmental Panel on Climate Change (IPCC) and the World Energy Council.

Doug Rotman, Lawrence Livermore National Laboratory

Doug Rotman is Program Leader for Earth Systems Science and Engineering at Lawrence Livermore National Laboratory, where he manages programs in carbon management, climate and carbon cycle, water and environment, and energy systems. He began his career at LLNL in 1985 and holds a Ph.D. in Mechanical Engineering from the University of California at Berkeley. Doug’s research interests include the dynamical formulation of chemical species transport, atmospheric physics, and links between the distribution of atmospheric species and climate change. He has held several management positions, including Group Leader for Atmospheric Chemistry and Deputy Division Leader in the Atmospheric Science Division. Doug has been the PI on a DOE-NSF-NASA collaborative effort to enable advanced chemistry-climate simulations and also served as program manager and PI of a multi-institution NASA project to develop a framework for community wide use in chemical transport modeling. He has served on various advisory panels for NSF and NASA, including serving as Chair of the DOE User group committee developing input to a DOE Office of Science 5-year computing plan and Subcommittee Chair of a NASA committee laying out future NASA Earth System Science activities. He is a member of the NASA/NSF/NOAA Earth System Modeling Framework Advisory Panel, and a member of the Bay Area air quality management district Modeling Advisory Committee.

Michael J. Sale, Oak Ridge National Laboratory, Oak Ridge, TN

Dr. Michael J. Sale is a Distinguished Staff Member in the Environmental Sciences Division of Oak Ridge National Laboratory, where he serves as Group Leader for Water Resources and Aquatic Sciences. He is an expert in a wide range of water resources issues, particularly those related to energy development and aquatic ecosystems. Dr. Sale’s academic background includes a B.S. in Zoology from the University of Michigan, a M.S. in Aquatic Ecology from the University of Illinois, and a Ph.D. in Environmental Engineering and Science from the University of Illinois. He was a member of the Water Sector Assessment Team for the first National Assessment of Climate Variability and Change and was on the writing team for the recent report from the NCST/CENR Subcommittee on Water Availability and Quality on “Science and technology to support fresh water availability in the United States.” Dr. Sale serves on a number of other national advisory panels and technical working groups related to water resources, such as the Science Advisory Board for the Trinity River Restoration Program in California, and the Governing Board for the Low Impact Hydro Institute. He is a Fellow Member of the American Water Resources Association.

David Schmalzer, Argonne National Laboratory

Dr. Schmalzer is Manager of Fossil Energy Research at Argonne National Laboratory and acting manager for carbon management and sequestration research. Active studies relevant to the SAP 4.5 include engineering studies of carbon dioxide capture in conventional PC power plants, Oxyfuel plants and IGCC plants of varying configurations, studies of transport options for captured carbon dioxide, and studies of geologic and mineral sequestration options. Additionally, technical/econometric modeling studies are being performed in collaboration with NETL looking at the interactions of transportation technology, alternate fuels technologies, and electrical generation technologies in a carbon-constrained economy. Prior to joining Argonne, Dr. Schmalzer worked for Gulf Oil Corporation and affiliates for some years and served as Manager of Alternate Fuels Research and as Vice President and Managing Director of Solvent Refined Coal International, Inc., a joint venture of Gulf, Mitsui, and Ruhrkohle. Dr. Schmalzer received a PhD in Chemical Engineering from the University of Pittsburgh and BES and MS degrees in Chemical Engineering from the Johns Hopkins University. He is a licensed professional engineer in Pennsylvania, the author of three US patents and several publications.

Michael Scott, Pacific Northwest National Laboratory

Dr. Scott received his Ph.D. in economics from the University of Washington in 1975. He is currently a Staff Scientist in the Energy Science and Technology Directorate at the Pacific Northwest National Laboratory (PNNL). Over the last 20 years, Dr. Scott has specialized in studying the effects of global environmental change on natural resources and the economy, particularly impacts on human systems and the effects of uncertainty. He has managed a series of projects analyzing the effects of global warming on water supply and utilization of the Columbia River system by hydropower, irrigation, and fisheries interests, the impact of climate change on energy use in buildings, and policies for limiting greenhouse gas emissions. He has also contributed to PNNL's Second Generation Model, used to estimate the effects of economic development and policy on greenhouse gas emissions. He was a convening lead author for the Intergovernmental Panel on Climate Change (IPCC) Second Assessment Report *Climate Change 1995* in the topic area of Human Settlements; was a contributing author to the IPCC Special Report *The Regional Impacts of Climate Change*; and was a coordinating lead author for the IPCC's Third Assessment Report *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. He is a lead author on the North American Chapter in IPCC's Fourth Assessment Report, currently in preparation. He has published in the journals *Climatic Change*, *Journal of the American Water Resources Association*, *Global Environmental Change*, *Environmental Management*, and *Energy Policy*, among others. His current research is on the impacts of climate change and variability, emissions trading, and uncertainty in integrated assessment models.