Beyond Technology

Strengthening Energy Policy through Social Science

A Report of the
American Academy
of Arts & Sciences

THE AMERICAN ACADEMY OF ARTS & SCIENCES

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Message from the Under Secretary for Science, U.S. Department of Energy

In November 2010, the President's Council of Advisors on Science and Technology (PCAST) released the *Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy*. Among its recommendations to the Administration and to the Department of Energy (DOE) is a call to integrate the social sciences in energy. Specifically, the report calls for DOE to initiate with the National Science Foundation (NSF) "a multidisciplinary social science research program that will provide critical information and support for policy development that advances diffusion of innovative energy technologies."[1]

In that same report, PCAST also recommended DOE undertake its first Quadrennial Technology Review (QTR) before the government embarks on a multiagency Quadrennial Energy Review (QER) for a national energy policy. Completed in September 2011, the QTR discusses the current energy landscape, the challenges we face, Six Strategies for accelerating energy technology innovation (three in the transport sector and three in the stationary sector), and DOE's three modes of operation (harnessing capability, pushing technology, and serving as a source of information or a convener).

Currently, DOE has inadequate information on how consumers interact with the energy system or how firms decide in which technologies to invest. The social sciences are the most important to the information role, and there is good reason to believe that insights from this area would improve the prospects for success in DOE's efforts to move technologies toward commercialization. As a start on such studies, the Advanced Research Projects Agency-Energy is funding Stanford University's H-STAR Institute and Precourt Energy Efficiency Center to develop an interactive software system to better understand energy efficiency and human behavior.

The QTR asserts that the "aggregated actions of individuals and organizations determine many aspects of the energy system, with demands on the system and the balance of supply and demand affected as much by individual choice, preference, and behavior, as by technical performance."[2] Energy Secretary Steven Chu has affirmed the importance of integrating applied social science into DOE's technology programs in order to better understand how technologies diffuse through a sector and are used in the real world.

The five strategies and the specific actions recommended in this report from the American Academy of Arts and Sciences align with DOE's capacity as a convener and highlight areas in which DOE can draw upon its role as a source of information. A strong partnership between DOE and NSF in creating and supporting an ongoing dialogue among technologists, policy communities, social scientists, federal agencies, local governments, and regulatory communities would be tremendously valuable in this endeavor. NSF's recently released Sustainable Energy Pathways solicitations call for teams of researchers, including social scientists, to address sustainable energy. My

1 President's Council of Advisors on Science and Technology, *Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy* (Washington, D.C.: Executive Office of the President, 2010), ix, http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf.

2 United States Department of Energy, *Report of the First Quadrennial Technology Review* (Washington, D.C.: U.S. Department of Energy, 2011), 125, http://energy.gov/sites/prod/files/ReportOnTheFirstQTR.pdf.

discussions with the NSF leadership show eagerness for DOE and NSF to move ahead together on developing interdisciplinary, systems approaches to energy.

I would like to acknowledge Bob Fri, Leslie Berlowitz, and the American Academy of Arts and Sciences for taking the initiative to answer the PCAST call to action by organizing the Workshop on Social Science and the Alternative Energy Future held on May 19–20, 2011. This workshop is an exemplar of the Academy's role in convening the different parts of the federal government and in stimulating interactions among a variety of actors. The workshop catalyzed discussion among thought leaders in the field who shared ideas on ways energy policy objectives and technology development objectives could benefit from insights produced through social science. In addition, it developed a research agenda intended to give us an improved understanding and to better inform us of energy technology applications through the social science lens. Lastly, I commend the participants for producing such a succinct summary of the many lessons from the workshop.

This report not only makes insights from the workshop discussions available more broadly, but it poses social science questions relevant to the QTR's Six Strategies and provides specific ideas about relevant lines of inquiry to which social scientists could provide direct value. Together with the QTR, this report takes us one step closer to implementing the PCAST recommendation to integrate social science in federal energy research and development.

Steven E. Koonin
Under Secretary for Science
U.S. Department of Energy

Acknowledgments

The American Academy of Arts and Sciences' project on the Alternative Energy Future is examining the legal, social, and economic implications and challenges of transitioning to a greater reliance on cleaner energy technologies. Changing the existing technological infrastructure will require modifications to legal, social, and economic structures as well. However, many of the societal considerations underlying these necessary changes have not been adequately addressed.

To assess how the social sciences could help address these considerations and inform energy policies and decisions, the Academy convened a diverse group of experts from industry, government, and academia at a workshop in Washington, D.C., on May 19–20, 2011. We are indebted to the workshop participants, who enthusiastically embraced the task at hand to identify many priorities for future social science research and for new collaborations between social scientists and policy makers.

A diverse expert steering group oversaw the design of the workshop and worked diligently to distill the participants' suggestions into the strategies and recommendations presented in this report. This steering group included Steve Ansolabehere, Doug Arent, Ann Carlson, Tom Dietz, Kelly Sims Gallagher, Granger Morgan, Maxine Savitz, Paul Stern, Jim Sweeney, and Mike Vandenbergh. Special thanks go to John Randell, Hellman Fellow and Program Associate for Science Policy at the Academy, who organized the workshop and, with the assistance of the Academy's editorial team, coordinated the drafting and production of this report.

The workshop was funded by the Department of Energy (DOE) and the National Science Foundation (NSF), and we are deeply grateful for the support and guidance of Steve Koonin, Cora Marrett, and Myron Gutmann. We would also like to thank Holmes Hummel, Cynthia Lin, and Linda Blevins at DOE and Rita Teutonico at NSF for their many helpful suggestions. It is our hope that this report will encourage new dialogue between these agencies and others on how to strengthen our energy system through the application of knowledge from the social and behavioral sciences.

We also acknowledge support for the Alternative Energy Future project from two anonymous foundations and from contributors to the American Academy Intellectual Venture Fund, including The Fremont Group, Kleiner Perkins Caufield & Byers, and Novartis.

The Academy's Alternative Energy Future committee will continue to work with government agencies, industry leaders, and nongovernmental organizations to promote multidisciplinary research on energy production and use. A greater appreciation for the contributions and value of the social sciences will be critical for maximizing the return on our nation's investments in new technologies and for securing our energy future.

Robert W. Fri, *Workshop Chair*
Visiting Scholar
Resources for the Future

Leslie C. Berlowitz,
President and William T. Golden Chair
American Academy of Arts and Sciences

Introduction

The American Academy convened representatives from academia, industry, and government in Washington, D.C., on May 19 and 20, 2011, to discuss how social science research and expertise can speed the adoption of new energy technologies. The workshop was chaired by Robert W. Fri, a Fellow of the American Academy, Visiting Scholar and Senior Fellow Emeritus at Resources for the Future, and Project Director for the Academy's Alternative Energy Future project. Fri noted that the workshop was designed to "begin the conversation between the energy policy community and the social science research community," in order to identify steps to help ease the adoption of new energy technologies and to outline a future research agenda.

Steven E. Koonin, a Fellow of the American Academy and Under Secretary for Science at the U.S. Department of Energy (DOE), provided a foundation for the workshop discussion by highlighting six general strategies for transforming the energy system to enhance energy security, improve American competitiveness, and reduce environmental impacts (Figure I-1). Successful

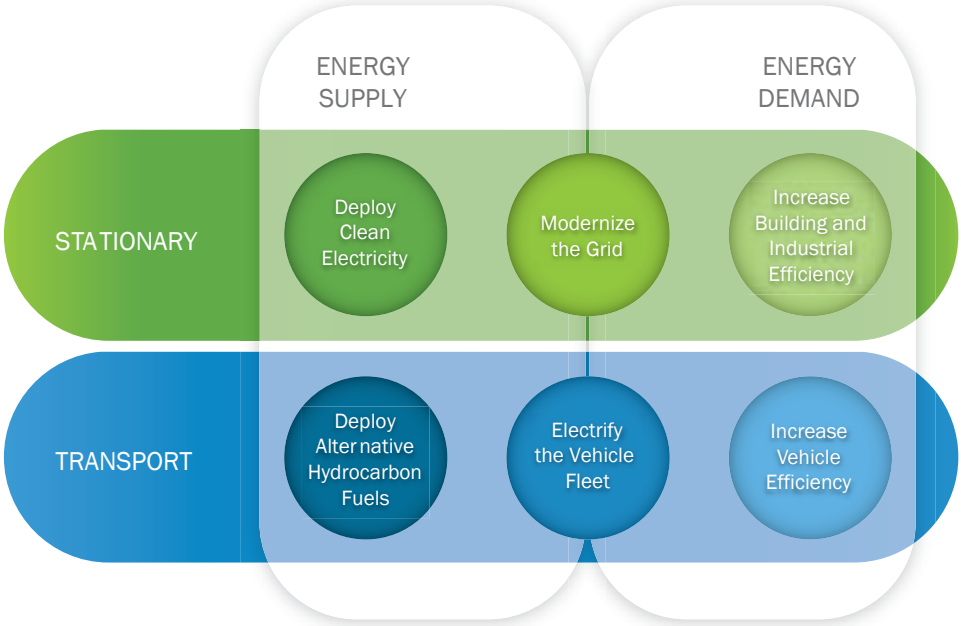

Figure I-1. Six strategies to address national energy challenges. Source: United States Department of Energy. 2011. *Report on the First Quadrennial Technology Review*. Washington, D.C.: U.S. Department of Energy.

transformation of the energy system via these six strategies will require extensive diffusion of innovative technologies and practices throughout the economy. However, individual, household, commercial, and community behavior will affect the acceptance of these technologies, and diffusion of innovations throughout society can also be slowed by institutional rigidity. The American Academy workshop presented solid evidence that the social sciences can help address these challenges and highlighted several existing social science applications that could be applied immediately to make energy policy and programs more effective (see sidebars in chapter 2). In addition, the workshop raised a number of issues on which further social and behavioral research would be

productive and generated ideas for strengthening the linkages between social scientists and energy policy analysts, program managers, and decision makers.

Despite persuasive evidence that social scientific tools can make energy policy and programs more effective, the application of the social sciences to energy policy historically has been limited, especially at the federal government level. Structural and cultural obstacles hinder the integration of social science expertise into policy development. Chapter 1 of this report describes five strategies for enhancing collaboration between energy policy makers and social scientists. Chapter 2 provides a summary of the workshop, including the keynote talks and the panel discussions. Chapter 3 presents a research agenda that addresses several questions that participants identified as being in critical need of attention. Finally, chapter 4 contains a representative sample of many decades of social science research that would be useful to the energy policy community.

Chapter 1: Strategies for Strengthening Energy Policy through the Social Sciences

The question of how to bring policy makers and social scientists into closer collaboration was discussed extensively during the workshop, both in the breakout sessions and informally throughout the two days of panel discussions. Synthesizing these discussions, the workshop steering group identified five broad strategies that can aid in bridging the gap between energy policy makers and the social science research community. These strategies are briefly described in this chapter. Included are examples (drawn from suggestions made in the course of the workshop) of specific policies or programs for executing each strategy.

Although each of these five strategies will be critical for addressing the behavioral and regulatory barriers to the adoption of new technologies, the steering group strongly suggests the immediate adoption of the steps described under strategies 1 and 2. These steps have the potential to yield rapid results and insights that will demonstrate the value of behavioral research and possible applications within existing programs and build a foundation for the other three strategies, which will require longer-term efforts.

Strategy 1: Demonstrate the value of social and behavioral research for enhancing the effectiveness of energy policy and transforming the energy system.

Because energy policy makers are largely unfamiliar with the tools of social science, they are often unaware of the value of those tools for policy development. On the other hand, much excellent social science research has not been translated into practical lessons or "off the shelf" tools. Practical demonstration of how the social sciences can make energy policy more effective is therefore an important first step in creating a demand for further collaboration.

Fortunately, several opportunities exist to create such demonstrations in the near term, either by documenting work already done or by applying well-known social science tools to current energy policy issues. Actors at all levels of government should be enabled to use these tools conveniently. For instance, social scientists understand how to design productive public participation programs, but this knowledge is often not incorporated into such programs or is integrated into the process at too late a stage to be useful.

Suggested steps:

- **DOE should commission a set of discrete policy papers that summarize the existing research in the priority areas outlined in chapter 3 of this report and that demonstrate how this knowledge could be applied within specific DOE programs.** This effort could be undertaken in collaboration with an outside agency such as the National Science Foundation (NSF) or the National Research Council.
- **DOE should conduct pilot demonstrations to test the application of social science within existing energy programs.** Rather than trying to change underlying attitudes and motivations, these demonstrations should focus on influencing actions that people are already taking or are willing to take. Many potential social science applications can be found within existing federal energy programs, including:

— the application of behavioral research to smart meter programs and to the effective design of informational labels on energy use by appliances and vehicles;

— the application of established public participation approaches in the design process for new energy supply technologies to identify and address public concerns and human factors;

— the incorporation of behavioral data into the construction of energy-economic models to examine the potential impact of alternative policies; and

— comparative policy analysis to examine the effectiveness of existing policies.

- **Policy makers and program managers should draw on the experience of other governments and agencies.** Particular attention should be paid to scaling up lessons from individual states and municipalities (see the sidebars in chapter 2 for examples). Similarly, other countries have practical experience in applying interdisciplinary social science research to energy policy development that could be useful for this effort. Federal agencies such as the Environmental Protection Agency (EPA) and the Bureau of Land Management have enacted guidelines for using social science expertise in siting decisions, and these guidelines could serve as a model for developing best practices for other agencies.

Strategy 2: Encourage the use of interdisciplinary social science research within energy programs.

DOE has little experience in introducing social sciences into its technology programs or policy development. Even if this capacity existed, individual program managers lack the proper incentives to make use of it. A useful way to encourage the application of social science expertise to energy programs is to evaluate how well those programs are working and to identify how social sciences could contribute to improved effectiveness.

Suggested steps:

- **Government agencies should require periodic studies of adoption potential for each energy technology being developed.** These studies should be undertaken throughout the research, development, demonstration, and adoption process, perhaps in preparation for the Quadrennial Energy Review (QER) proposed in a 2010 report from the President's Council of Advisors on Science and Technology (PCAST).[1] These adoption studies would consider in an integrated way technical and economic barriers, public acceptance, human behavior, and other issues that might constitute obstacles to the adoption of the technology. The studies would also be used to inform design of the technologies with adoption in mind. This strategy would facilitate the integration of social and behavioral science into the technology design process, especially with the hiring of relevant social science expertise.

- **DOE and NSF, along with the American Academy, should create or support a forum for ongoing dialogue among policy makers, the private sector, and social science researchers to share expertise on innovation and on technology adoption at the**

1 President's Council of Advisors on Science and Technology, *Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy* (Washington, D.C.: Executive Office of the President, 2010), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf.

individual and community levels. The private sector is the principal actor in diffusing new technology and practices in the energy sector, and its experience will be crucial for identifying societal obstacles to diffusion and for implementing social science methods to remove them. For example, industry experience in using marketing techniques to promote technology adoption could be readily applied to government programs. Private sector experience with innovation also offers lessons for the creation of regulatory frameworks that are adaptive and encourage innovation. Conversely, existing social science research on innovation and on community-based approaches to technology deployment will be useful to both companies and government agencies. This step is also consistent with the intent of the QER.

- **The design and outcomes of energy programs and policies should be evaluated to determine both their policy and cost effectiveness and the underlying reasons for these results, including the roles of behavioral and regulatory barriers.** To facilitate this effort, DOE should develop a common framework for evaluating pilot programs for technology adoption, including not only experiments sponsored by DOE but experiments sponsored by utilities and other private institutions. Relevant topics for study include the effect of policy framing on the success of outreach efforts and the efficacy of informational, educational, or behavioral interventions as compared to regulatory interventions.

Strategy 3: Build capacity for connecting the energy policy and social science communities.

Despite decades of awareness of the societal issues related to energy, energy policy makers and social scientists do not have a history of close collaboration. Bringing these communities together on substantive issues will build the bridges necessary to make effective use of the social sciences over the long haul. Meeting this objective will involve the previous two strategies because the policy and research and development communities will first need to be persuaded that the social sciences, and especially the behavioral sciences, hold value for policy and technology development.

Needed is both more research that is useful to energy policy and an increased human capacity to conduct and apply social science research. Lines of communication must be developed between researchers and the audience for this research, including industry, private foundations, and state and federal policy makers. A major barrier to academic research on energy issues is the lack of rewards for applied social science research. A widespread perception among the academic social science community is that applied research is not valued in promotion decisions, including tenure decisions.

Suggested steps:

- **DOE should enhance its organizational capacity to adopt social science knowledge within energy programs.** Although creation of a dedicated "office of social science" within DOE might be possible, such an office is unlikely to be politically sustainable, and thus other avenues should be explored. A critical step will be to employ behavioral scientists who are familiar with the research literature and best practices and can thus identify the most productive research directions and policy and program applications.
- **DOE and NSF should establish a collaborative research program based on the priority research questions described in chapter 3.** Priority research areas should include effective design of labels and standards, the effects of social networks on shaping social

norms, dynamic pricing and adoption of smart grid technologies, policy evaluation, and understanding the bases for individual and household decisions as they relate to energy use. Also needed is more research on how to create durable energy policies and effective polycentric governance mechanisms and more research on the role of government in the U.S. energy innovation system.

- **Agencies should sponsor pre- and/or postdoctoral fellowships to examine the societal obstacles to new energy technologies.** For instance, DOE might fund postdoctoral researchers to work with social scientists from NSF on energy issues. Establishment of an interdisciplinary research and training program, as recommended by PCAST in 2010, would be an excellent step forward. DOE could also provide funding for social scientists from NSF to work with energy researchers from DOE or for DOE staff to work with university researchers on social science questions.
- **Interdisciplinary teams of technical and behavioral experts should be organized to work on high-payoff issues.** These include facility siting, the design of consumer-oriented labels, and smart meter deployment programs.
- **DOE should sponsor annual conferences or summer sessions for researchers, perhaps in collaboration with other agencies such as NSF.** These meetings would be primarily for the research community rather than for practitioners and would facilitate communication among social science disciplines. They would also provide an opportunity for policy makers to learn about the most current social science research.

Strategy 4: Incorporate social science into federal energy policy analysis.

Workshop participants emphasized the need to incorporate behavioral considerations into energy economic modeling efforts and offered suggestions for modeling the human dimensions of energy use. Because of the expense and time required to develop new models, participants generally agreed that modelers should focus on modifying existing models to account for incomplete policy compliance and the nonrationality of individual actors.

Suggested steps:

- **The energy modeling communities in government, academia, and industry should rethink the role of economic models in policy development.** First, the energy modeling communities should develop capabilities to gain insights from complementary models that more accurately reflect behavioral considerations. Second, more attention should be paid to incorporating behavioral considerations other than price- and income-driven behavior into economic models, while avoiding making models overly complex.
- **The Energy Information Administration (EIA) should collect and organize data useful for social science.** This effort would be facilitated by the creation of a social science advisory group to advise EIA on how to include behavioral data in its energy surveys and how to format technical data on energy so they are useful to social scientist researchers. Because the available information on the technical potential of behavioral interventions is often scattered across many sources, particular attention should be paid to increasing the availability of these data.

Strategy 5: Engage state and local governments and regulatory communities.

Many efforts to promote the spread of innovative policies and technologies take place at the regional, state, and local levels. Not only does each level of government have considerable experience on which to build, but engaging each level will be essential to any mechanism for scaling social science tools to design more-effective energy policies. Regulatory commissions can direct the entire electric utility sector to undertake certain actions, but traditional forms of oversight and the makeup of commissions (e.g., the rapid turnover of public utility commission chairs) inhibit commissions from taking a proactive approach to energy policy. Commission staffs are generally stable, however. Staff training should thus include training on behavioral issues.

A particularly relevant social science research question for the state and local sectors, and one needing further research, is how to guide consumer choices. What motivates consumers, and how can policies and regulations reinforce these motivations? When researching consumer motivations, attitudes, and behavior, an important consideration is the impact of regional, socioeconomic, and educational differences.

Suggested steps:

- **State public utility commissioners should require utilities to use social science research when deploying new technologies, such as smart meters, whose success depends on public acceptance or active effort on the part of individuals.** The National Association of Regulatory Utility Commissioners could work with social scientists to identify lessons that could be applied to technology deployment programs. Other communities that should be approached include developers, builders, planning commissioners, and real estate appraisers.
- **Public utility commissions should perform evaluations of the behavioral and regulatory barriers to technology deployment programs.** These evaluations would be similar to those recommended for federal agencies under strategy 2.
- **Utilities should work with state regulators and behavioral experts to conduct field experiments on how to most effectively engage consumers on dynamic pricing.**
- **DOE should work with the National Governors Association (NGA) and others to analyze model programs and adapt their lessons to the circumstances of individual states.** NGA has performed pilot studies that could be a useful starting point for examining regional and socioeconomic differences in consumer behavior and how policies and regulations can affect consumer decision making.

Chapter 2: Workshop Summary

Leslie Berlowitz, President of the American Academy, opened the workshop with the observation that interdisciplinary study is critically needed in the areas of energy production and use, saying, "This project is trying to apply social science expertise to better understand how public attitudes, economic trends, and government regulations affect the development and adoption of clean energy." Steven Knapp, a Fellow of the American Academy and President of The George Washington University, welcomed participants, and the program featured keynote speeches by Steven Koonin, Under Secretary for Science at DOE, and Myron Gutmann, Assistant Director for Social, Behavioral, and Economic Sciences at NSF.

Koonin spoke on the realities and challenges of the energy system, laying out the administration's clean energy goals, which include reductions in oil imports and greenhouse gas emissions and increases in energy efficiency and electric vehicles. Noting that "the challenges of policy and human behavior have become even more critical," he urged participants to look at how social science research can further the transition to a clean energy future, citing specific areas that need more study, including incentives, discount rates, energy awareness, and the acceptance and adoption of new technologies. Regarding discount rates, he said, "Consumers have a two- or three-year discount rate in their head when they buy automobiles. How do we get people to think more long term and understand the difference between capital and operating expenses?" On energy awareness, he noted, "One of the great triumphs of modern society is that we've hidden the infrastructure. Nobody really understands where electricity, gas, or water come from." Because 95 percent of this energy system is constructed, owned, and operated by the private sector, Koonin said, "nothing is going to happen in energy of any consequence unless the private sector is engaged."

Gutmann explained that while NSF is investing significantly and thinking seriously about energy issues, "It's very much up to people like you in the research and broader scientific community to help us define the research problems and to help us make clear what are the best strategies to getting the critical answers in this area. What is clear is that every approach we take will cross traditional disciplinary boundaries." Citing the need for more research, he said, "We don't want to just know whether people will adopt a new technology; we need to understand fundamental questions; for example, about how markets work. This is what engages the economic community and the decision community, and we're not going to advance the science unless we do that."

Gutmann emphasized that "the critical questions are fundamental questions about behavior: how are people thinking about and reacting to new energy sources? So instead of figuring out where to put the outlets for plug-in hybrid cars, we should be theorizing about where to look for the next innovation behaviorally beyond the plug-in, or how to think about optimizing commuting and residential patterns to enhance conservation, but also to enhance how the technology community thinks about their innovations."

Nicholas M. Donofrio, a Fellow of the American Academy, Senior Fellow at the Ewing and Marion Kauffman Foundation, and former Executive Vice President of Innovation and Technology at IBM, tied the workshop presentations to the need for both technological and policy innovation, saying that at IBM innovation is "all about creating value by understanding the problem." He advised participants to strive to understand the problem and then "apply your technology,

your knowledge, your invention, your creation, and your discovery in a unique and facile way to unlock that hidden value." Donofrio described innovation cultures as being collaborative, open, multidisciplinary, and global.

Workshop attendees brought a diverse range of experience and expertise to the meeting. The workshop included representatives from DOE, NSF, and the National Renewable Energy Laboratory, as well as senior staff from public utility commissions, universities, industry, and nongovernmental organizations. A series of six panel discussions focused on institutional and consumer behavior, policy analysis, and energy regulation.

Session A: Behavior and decision making related to energy efficiency

Chair:

Thomas Dietz, *Professor of Sociology and Environmental Science and Policy; and Assistant Vice President for Environmental Research, Michigan State University*

Panelists:

Paul C. Stern, *Study Director, National Research Council*
Charlie Wilson, *Lecturer, Tyndall Centre for Climate Change Research*
Marsha L. Walton, *Senior Project Manager, New York State Energy Research and Development Authority*

Although the first panel discussion centered on lessons from the behavioral sciences related to energy efficiency, participants noted at the outset that much of the behavioral research on energy efficiency also applies to other energy technologies. The panel focused on three agents that can contribute to greater energy efficiency in residential buildings: households, regulators, and third-party intermediaries.

Households account for 30–40 percent of the energy use in the United States, which points to the potential benefits of greater energy efficiency in the household sector. By focusing only on available no-or-low-cost behavioral interventions that do not require a major lifestyle change, such as weatherizing houses or properly maintaining vehicles and HVAC equipment, energy consumption in the residential sector could be reduced by 20 percent, which equates to 7.5 percent of total U.S. energy consumption.[2] However, achieving these savings will require combining behavioral interventions with policies aimed at facilitating their adoption. Such policies are not common in the United States but could be implemented at either the state or the national level.

The reduction estimates associated with available no-or-low-cost interventions exclude the savings that could be achieved through federally mandated high-efficiency lighting technologies, and in fact an equal reduction in energy use is achievable through more-efficient household technologies. Up-front cost is a major barrier to the adoption of more-efficient technologies, and this consideration often outweighs the potential for long-term savings. Other barriers to household actions include existing regulations, infrastructure issues, limited consumer choice, and a lack of information about energy savings.

The most productive strategy will be to identify and promote the behaviors and technologies that can have the greatest impact on energy consumption and simultaneously to address the many

2 Dietz, T., G. T. Gardner, J. Gilligan, P. C. Stern, and M. P. Vandenbergh, "Household Actions Can Provide a Behavioral Wedge to Rapidly Reduce U.S. Carbon Emissions," *Proceedings of the National Academy of Sciences* 106 (2009): 18452–18456. doi:10.1073/pnas.0908738106.

barriers to these choices through major outreach campaigns. The failure to address even a single barrier can block progress. Energy policies often address only individual barriers and thus do not gain much headway at the consumer level. Similarly, simply providing consumers with pertinent information on energy savings, while important, is not sufficient to effect change.

How should energy efficiency programs be designed? First, outreach programs should focus on those actions and technologies that are likely to have the greatest impact; that is, those with the most technical potential and the greatest potential to change behaviors and attitudes among the largest number of individuals. Second, where applicable the available financial incentives must be sufficient to get people's attention. Third, an effective marketing campaign must be put into action. Fourth, credible and accessible information must be made available to the consumer. Fifth, participation in the program must be simple and easy. Finally, a trustworthy quality control mechanism must be in place to ensure that products and services meet expectations. The 2009 "Cash for Clunkers" program met these criteria, whereas existing home retrofit programs often violate these principles with poor marketing, delayed incentives, burdensome paperwork, and uncertain product quality.

A major regulatory effort is now under way in the United Kingdom to substantially increase the energy efficiency of the residential sector. Introduced in Parliament in December 2010 with an anticipated launch in 2012, the "Green Deal" would allow the up-front costs of energy efficiency retrofits to be paid by third parties, who would then share the long-term savings in energy costs with the property owners. This incentive program would complement existing regulations requiring the use of certain energy efficiency technologies. With a long lead time, such regulations can have a major effect on technology adoption with relatively little resistance from industry: a U.K. regulation requiring the use of high-efficiency boilers resulted in the market share of these boilers increasing from 20–30 percent to around 90 percent in approximately one year.

European regulators have been especially proactive in requiring efficient building technologies: all houses being sold or rented must now have an energy performance certificate, and this information must be provided to prospective buyers and tenants. In Germany this requirement has already been extended to encompass existing houses.

A developing area of research is the potential role of third-party intermediaries in promoting energy efficiency technologies at the household level. Third parties such as realtors, mortgage providers, and service engineers are well positioned to deliver information about potential energy efficiency upgrades to current and prospective property owners. A particularly promising opportunity to educate households about energy efficiency arises when those households undertake non-energy-related home renovations. Research is needed on the potential effectiveness of this approach and possible negative consequences.

Ultimately, effective policy design requires a combination of applied behavioral research and learning through experience. Behavioral barriers that need to be addressed include loss aversion, status quo bias, and entrenched social norms. The New York State Energy Research and Development Authority (NYSERDA) behavior research program is one initiative that is performing field experiments and employing community-based social marketing to increase participation in energy conservation programs. Program evaluation is a critical aspect of these approaches, and NYSERDA is actively involved in designing more-effective evaluation protocols.

How can successes at the local level be scaled up to the state or national level? To scale up local programs, geographic differences in behavior and environment must be taken into account.

The NYSERDA Behavioral Research Program

The workshop highlighted two successes of the NYSERDA behavioral research program. For an Albany-area vanpooling program, a personal marketing approach employing images, employer-mediated communication, and personal testimonials resulted in a large increase in participation. In a second project, a pilot study at Ithaca College examined the effect of *descriptive norms* (i.e., observed behaviors) and *injunctive norms* (i.e., descriptions of desirable behavior) to convince students to turn off computer lab equipment when their sessions were finished. Consistent with existing behavioral research literature, the descriptive norm of computers being turned off when students arrived was effective only when attention was called to this norm through an injunctive norm, such as a sign exhorting students to turn off the computer when done.

On which issues would regulatory mandates be more effective than voluntary actions? One area where mandates might be particularly effective is the problem of split incentives in rental properties, where the purchaser and the end user of appliances and energy are not the same.

Does providing consumers with increased information actually allow people to make more-informed decisions? Here, the main issues are informational overload (too much information can lead to analytic paralysis) and the structural obstacles consumers face in adopting new technologies, such as the complexities of hiring contractors and overseeing their work. More research is needed on how to design information to be easily understood, how to disseminate this information through trusted sources, and where well-designed information has the highest impact.

Can financial discounts persuade people to participate in energy conservation efforts? Some research suggests that providing financial incentives can have the opposite effect, leading people to feel that, because they are willing to pay extra, they are justified in using more energy. For this reason an approach based on intrinsic values is often more effective at encouraging participation.

More research is also needed on how to reduce the "rebound" effect, where consumers offset the financial savings from energy conservation by using more energy for other activities.

Session B: Public acceptance of new energy technology

Chair:

Douglas Arent, *Executive Director, Joint Institute for Strategic Energy Analysis, National Renewable Energy Laboratory*

Panelists:

Juliana Birkhoff, *Vice President of Programs and Practice, RESOLVE*
Jeanne Fox, *Commissioner, New Jersey Board of Public Utilities*
Jennifer Layke, *Director, Institute for Building Efficiency, Johnson Controls Inc.*
Eugene Rosa, *Professor of Sociology, Washington State University*

This session addressed the challenges related to acceptance of new energy technologies that introduce new factors into collective decision making, both within communities and among institutions. Panelists presented industry, academic, and public policy perspectives highlighting the complexities of the social dimensions of adopting new energy technology solutions and addressed such issues as privacy, equity, and individual rights.

The panel discussion examined broader issues relating to civil society, including factors and strategies that strengthen public acceptance of energy efficiency and new generation technologies. Panelists noted that a substantial body of research is available on the impact of effective public engagement on policy development and on the reasons for the dearth of public participation in government decision making. Speakers also highlighted many examples of successful dialogues between government, industry, and the public.

Trust is critical to any dialogue. But citizens tend not to trust government; indeed, the level of trust in government agencies has been in decline for several decades. The reasons for this lack of trust include the perception that governments do not tell the truth and are incompetent to carry out programs effectively. Trust is easy to lose; gaining it back is difficult. Another barrier to building trust is the fact that perceptions of costs and benefits differ for individuals and groups, and these perceptions also differ from those held by scientific authorities.

Public participation in decision processes nearly always builds trust and improves the outcome of those processes. Public participation is particularly valuable in building support for science-based decisions but requires clear and common goals, ample planning and resources, broad representation of interests, and transparency about how models are developed.

Public involvement in policy development may fail in several ways to meet the standards suggested by current research. First, the collection of data relevant to the decision may not be coordinated with the dialogue, with the result that when dialogue does happen the necessary data are unavailable or are out of date. Second, the public is often involved at too late a stage in the process, when it is too late to have a conversation about the overall goals of the policy or program. Third, the dialogue may not include all stakeholders, an outcome that is often the result of following a narrowly crafted model for public participation that fails to include all interests. Finally, many government agencies possess insufficient capacity to plan and execute a productive public outreach program, a problem that can be compounded by institutional skepticism regarding the usefulness of such programs.

Public Engagement on Offshore Wind: A Success Story from New Jersey

A large body of research explores the impact of effective public engagement on technology adoption, but application of this research within technology deployment programs has been limited. Public outreach programs often fail to include a broad representation from all sectors, and agencies lack the capacity to adequately involve the public in decision making on issues such as the siting of new generation facilities.

In an example of a successful public engagement effort, the state of New Jersey held public meetings in the spring of 2005 in the four counties bordering the Atlantic Ocean, to receive input on pending proposals for offshore wind farms. Much of the initial reaction was negative, even from interests as diverse as the fishing industry and the New Jersey Audubon Society. The state then embarked on a successful outreach program and commissioned studies on predicted economic impacts and the risks to migrating birds. This outreach effort generated widespread public support for offshore wind; Cape May fishermen even formed a group called Fisherman's Energy to bid for offshore wind leases. In April 2011 the state granted permits to Fisherman's Energy to build New Jersey's first demonstration-scale offshore wind farm, to be located in the waters off Atlantic City.

Nevertheless, third-party intermediaries have facilitated successful and productive dialogues between the public and policy makers. Among numerous examples are the National Wind Coordinating Collaborative, the Nuclear Power Joint Fact-Finding Dialogue, and the National Conversation on Public Health and Chemical Exposures.

Public acceptance of new practices or technologies can be increased in several ways: by emphasizing usefulness, by imposing government mandates, by offering financial incentives, and by touting social image. Additional factors considered by public utility commissioners and other regulators include political considerations, special interest groups, and the impact on ratepayers. Utilities, by contrast, focus on the bottom line and are thus hesitant to adopt technologies that do not increase profits even if they are seen to serve the public good. To get utilities on board often requires the provision of additional incentives or offsetting revenue. One mechanism is to decouple revenues from sales; for example, by financially rewarding utilities for investing in renewable energy.

The leading factor in technology adoption by companies is the potential cost reductions achievable through those technologies. This is particularly true for building technologies. Other factors include reputation gains, greenhouse gas reductions, government policies, and government incentives. A less important factor that is nonetheless growing in importance is employee retention: greener buildings are seen as fostering more attractive workplaces and organizations.

Given these drivers, what factors increase the likelihood that building technologies will be adopted? In the government sector, standardized contracts and General Services Administration and Federal Emergency Management Program procurement guidelines play a large role in achieving energy efficiency goals and provide a venue for collecting feedback on the effectiveness of technologies and regulations.

Energy performance contracting provides an additional means to bundle many technologies together under a single program while financing improvements through third-party mechanisms. Energy performance contracting, whereby third-party service providers install efficiency or other carbon reduction technologies with a guaranteed return on investment, is increasingly common in both government and academic sectors. Colleges and universities are especially attractive locations for large-scale efficiency improvements because of the high level of technology interest and expertise on campuses, a prevailing sense of progress and social good, and the ability to do the long-term planning necessary for deep retrofits with long payback periods.

In the commercial sector, where the general perception is that low-carbon technologies—particularly renewable energy—are not cost-effective, technology acceptance dramatically increases when companies in a peer group engage in facilitated dialogue, which allows them to learn from one another's experiences how to overcome behavioral and technical barriers. Major barriers include financing hurdles, lack of capacity to evaluate technologies, and uncertainty in project design and evaluation. Other needs include providing data in a format that is useful to decision makers and research on how best to accomplish this goal.

The likelihood that any given technology will be accepted in the marketplace is small, and common psychological and social factors determine the acceptance of both large, complex technologies and smaller, individually matched technologies. Such factors include psychological overload, framing effects, interpersonal influence, social status, and trust. These influences on consumer decision making run counter to the commonly used "rational actor" model, which holds that individuals make rational decisions on technology use based on in-depth analysis of all relevant information

and the costs and benefits of all available options. In reality, individuals often make decisions on the basis of incomplete information or the advice of trusted but nonexpert acquaintances.

Particularly for large, complex technologies such as power plants, the research literature demonstrates that experts and laypeople often have divergent perceptions of risk. One reason is that experts emphasize quantitative considerations while laypeople emphasize qualitative features. The gap between lay and expert understanding of complex systems is growing, and thus an ever-increasing level of trust in experts is required of the public. One study found that the French and American publics have similar perceptions of the risks of nuclear power yet exhibit vastly different levels of support because of differing trust levels. Survey data show that public trust in almost every major American institution has declined since the 1960s. A key concept that has developed in recent years is that experts and the general public should collaborate in an analytic deliberative process to assess risk in technology and policy development.

Given the paucity of social science expertise in government agencies, participants asked how the social science community could assist policy makers in identifying high-quality social science research. Professional facilitators can help but only if policy makers know what goal they are trying to achieve. Participants concluded that the research on public participation provides clear direction on how to design successful participatory processes that educate both the public and the experts, incorporate local knowledge, reduce misinformation, and build trust.

Session C: Incorporating behavior in policy analytic tools

Chair:

James Sweeney, *Professor of Management Science and Engineering, Stanford University*

Panelists:

Alan Krupnick, *Research Director, Senior Fellow and Director, Center for Energy Economics and Policy, Resources for the Future*
John A. "Skip" Laitner, *Director of Economic and Social Analysis, American Council for an Energy-Efficient Economy*
Holmes Hummel, *Senior Policy Advisor for Policy and International Affairs, U.S. Department of Energy*

This panel built on the previous two discussions to examine how individual and institutional attitudes and behavior could be more effectively integrated into available tools for developing policy, with special attention to how energy-economic modeling could incorporate actual behavior patterns. Panel chair Jim Sweeney noted the need to improve both the existing mathematical models and also our mental models of causality. In both cases these models are currently dominated by the role of technology, engineering, and economics, with behavioral science being underrepresented. Although economists focus on price, other factors also influence decision making.

Modeling has two general approaches, both of which have strengths and deficiencies. Top-down models embody the principle that economic actors seek maximum economic benefits, but in treating the economy in an aggregative manner these models miss many details about individual technologies. Bottom-up models contain a wealth of information about individual technologies but do not always fit with actual economic data. In both cases economists tend to focus not on energy quantities but on overall welfare—how well-off are people economically? However, several commonly cited metrics for economic prosperity—including gross domestic product (GDP), job growth, and energy quantities—may not be the best measures of social welfare.

Although economics is fundamentally a behavioral science, several aspects of behavior are difficult to incorporate into economic modeling. One issue is the paucity of data for new technologies and the often poor quality of data on old technologies. For example, the supply curve for extracting natural gas is poorly understood. A second problematic aspect of modeling behavior relates to the difficulty of modeling capital investments and innovation. A third problem is the wide variation in data on phenomena such as how consumers respond to energy price increases.

One concern that is often expressed during debates about energy policy is the potential for a large future gap between energy supply and energy demand. However, participants noted that a tenet of economic theory is that rising energy prices will stimulate innovation on both the supply side and the demand side.

Thus, energy modeling could potentially be improved in several areas. Much research needs to be done on improving both top-down and bottom-up economic models: top-down models need to incorporate more detail, whereas bottom-up models need more calibration with real-world data. More research is also needed on how to model imperfect compliance with and enforcement of regulations and on how to incorporate lessons from other behavioral sciences into economic models.

A specific case of how energy models do not predict real-world behavior is the "efficiency paradox" or "efficiency gap," which describes the failure of individuals and institutions to adopt energy efficiency practices that are financially beneficial. Although the efficiency paradox is commonly described as a market failure, it exists at least in part because of hidden costs associated with energy efficiency; for example, the poorer-quality light emitted by high-efficiency lightbulbs. Economic theory holds that government intervention is justified in the case of market failure but not in the case of hidden costs.

Another problem posed by the use of highly detailed models is false precision—how should modelers sort out meaningful results from background noise? A solution might be to rely more on conceptual models that focus on fundamental aspects of the energy system, although these, too, will pose problems that require a more detailed analysis, such as comparing various proposals for a clean energy standard to determine which would be most effective. A single model should be used to compare different policies to provide the most useful conclusions regarding the relative predicted efficacy of those policies. At the same time, comparison of results from multiple models can help reduce errors or biases incorporated into a single model. Finally and critically, models must be kept up to date. This is a particularly difficult problem for models developed outside of government.

One speaker asserted that significantly improving energy efficiency through informed attitudes and behaviors would have a profound impact on American prosperity. This statement is based on a finding that from 1950 to 1980 the efficiency of converting energy production to work increased by 1.4 percent per year, with the economy growing an average of 2.25 percent per year. Since 1980, by contrast, this efficiency has declined by 1 percent per year, and the economy has grown much more slowly than in the previous thirty years. However, other participants questioned both the data and the implied direction of causality.

Desirable behavioral changes will result from changes in attitudes and motivations, not vice versa. For example, technology adoption is affected not only by price but also by payback time. From the consumer standpoint, payback time can be measured as a discount rate: what annual return in energy savings do consumers require before they will use a technology? Because this rate is

profoundly affected by behavioral considerations, social science research can provide guidelines on how to reduce it so the up-front cost of energy efficiency becomes less of a deterrent.

A reduction in the discount rate would lower the carbon price required to drive technological or behavioral change, illustrating the importance of including consumer behavior and preferences in policy analyses. Behavioral parameters can and are being integrated into economic models; however, although ample data exist on behavior, these data are not readily available to economic modelers. Panelists noted the critical need for more coordination on data collection and data assessment in order to organize data so they can be readily inserted into existing models.

Modelers may respond to the problem of insufficient behavioral data by omitting behavioral considerations entirely while nevertheless incorporating overly optimistic estimates of future technological innovation. In such cases the output of the models will likely overweight the potential of unproven technologies such as carbon capture and storage (CCS) or hydrogen fuel cells while underweighting the potential of energy efficiency technologies such as controls for building lighting. In general, most economic models, including the widely used National Energy Modeling System, are relatively insensitive to behavioral changes, resulting in a bias in selecting which policies receive further consideration by policy makers. This problem is compounded by an emphasis among policy makers on using technical improvement metrics as a measure of policy success.

Two general cases where policy makers could benefit from more input from social scientists are in understanding and managing society's tolerance for risk to human health and welfare from new technologies such as natural gas hydraulic fracturing and in developing tools to calculate and demonstrate to the public the societal benefits of these technologies. A specific area of concern is technology commercialization, and participants noted the key role that the social sciences could play in solving the so-called valley of death between technology development and technology deployment, a persistent problem that is not due solely to market failures and can not be entirely explained by standard neoliberal economic theories. A difficulty in studying any of these cases is that they concern the policies of many government agencies, each of which is primarily concerned with evaluating its own policies rather than the interaction of policies across government.

A common theme throughout this session was the paucity of economic analysis on the costs and benefits of various behavioral interventions in the energy system. One reason for the lack of data may be the difficulty of applying economic theories that are based on a certain understanding of the relationship between prices and costs to situations where that relationship does not apply. Also, many factors pertaining to the commercial sector have yet to be integrated into economic modeling, including how manufacturers determine the best timing for capital improvements and the impact of innovative financing mechanisms such as third-party financing on institutional behavior and decision making.

The session closed with a discussion of whether the research community should focus on developing new economic models to account for behavior or should instead concentrate on modifying existing models. Although a large body of social science research could be applied to economic modeling, little funding is available for model development. Participants noted that integrated policy assessment models require millions of dollars and several years to develop, and only a few successful models have been developed. These observations suggest that the best approach may be to reengineer existing models to be more sensitive to consumer choice and behavior.

Session D: Policy durability and adaptability

Chair:
Kelly Sims Gallagher, *Associate Professor of Energy and Environmental Policy, Tufts University*

Panelists:
Kevin Carroll, *Chief of the Energy Branch, Office of Management and Budget*
Margo T. Oge, *Director, Office of Transportation and Air Quality, U.S. Environmental Protection Agency*
Philip R. Sharp, *President, Resources for the Future*

This session examined the extent to which policy durability and adaptability will be necessary to achieve an alternative energy future. Government officials and experts discussed the tension between the provision of consistent and long-term signals and the need to make policy responsive to new information. Participants also explored the complications that stem from relying on quick fixes for enduring energy problems.

The session opened with the observation that other countries are being more innovative than the United States in experimenting with how to construct durable and adaptable energy policies. The United States could learn from these efforts. Panelists also underscored the difference between durable policies and the indefinite provision of subsidies. For example, predictability in energy policy can be achieved through the planned phase-out of subsidies.

Speakers described several attributes that contribute to policy sustainability. These attributes group into two general categories: either the policy is affordable and effective, with broad consensus; or the policy is driven by a group of motivated stakeholders with little vocal opposition and infrequent review or oversight. Sustainability, moreover, implies general agreement about the nature of the problem being addressed. Agreement on energy issues, however, is often difficult to realize. Finally, policy durability can be negatively affected by unforeseen negative consequences if those consequences outweigh the benefits of the policy. Liquid biofuels were cited as a relevant area of concern.

Available policy tools include discretionary tools, such as government research and development funding or loan guarantees, and mandatory programs such as taxation, tax credits, and regulations. An important quality to consider when evaluating policies is whether their scale can change as the magnitude of the problem changes. Such policies are self-extinguishing: as the problem is overcome, the program ends without intervention from policy makers. This approach reduces unnecessary intervention in the market and also provides regulatory certainty to technology investors.

A major challenge for any policy is that the energy supply in the United States has been cheap and abundant for much of recent history, and any alternative fuel must be similarly inexpensive to be considered a valid alternative by a broad section of the populace. This is particularly true for automobiles, where petroleum-based gasoline has been the dominant fuel for over a century and automobile use is an ingrained aspect of American culture. An important question is thus, how will the public respond to advanced energy technologies and how willing is it to pay a premium for those technologies?

One institutional barrier is the number of agencies that exert regulatory influence on the transportation sector, including DOE, the Department of Transportation, EPA, and the state of California. An important recent development was the exercising of presidential authority to direct federal

agencies to collaborate in crafting a revised Corporate Average Fuel Economy (CAFE) standard and to direct EPA to allow California to move ahead with more-progressive standards for its own vehicle fleet.

Why do more consumers not demand greater fuel efficiency, given that for an additional up-front cost of $900 or less they could realize $3,000 in fuel savings over the life of the car? This reluctance is particularly surprising in the commercial freight sector. Complicating factors include the difficulty of estimating fuel savings, the inherent complexity of the vehicle purchasing process, and the many competing attributes that consumers look for in a vehicle.

Panelists discussed three major realities that impact energy policy. First, energy markets are huge and global in nature, with oil being an especially fungible commodity. As a result, the United States has little ability to affect the price of energy through policy development. The U.S. government also exerts little direct control over energy markets within the United States. Most government policies are aimed at influencing private investments; for example, through loan guarantees or tax incentives. Finally, where direct government authority does exist, it is distributed among the three branches of government and among the federal, state, and local levels. Even within a given government institution the goals are constantly changing to reflect political considerations, thereby complicating the creation of durable energy policies.

The discussion period explored more deeply the question of what constitutes a durable policy. Participants discussed whether it is inconsistent to say that regulations are inherently durable when organized opposition to them is often substantial; these two conditions may be mutually incompatible. Speakers suggested that organized opposition can be countered by general public support, as is the case for the Clean Air Act.

A related issue is whether one can demonstrate to those opposed to a given policy that the policy is in their best interest. Participants discussed the specific example of production tax credits for wind power. Economists generally feel that a structured phase-out of production tax credits would be beneficial for the wind industry, but the industry generally opposes this policy. One panelist suggested the problem is that rapid political turnover means an emphasis on short-term goals: short election cycles foster an attitude of "take what you can get when you can get it."

A critical aspect of establishing a durable and effective policy is to ensure an organized, persistent third-party evaluation of its effectiveness in achieving the stated goals in a cost-effective manner. Policy evaluation has been inconsistent, and one area of research might be to explore how to create a comprehensive framework that could be applied to all policies.

Regulations tend to endure while policies with budget implications—taxes and incentives, for instance—do not. Examples of enduring regulations include CAFE standards and the 1978 Public Utility Regulatory Policies Act (PURPA), although in both of these cases effectiveness has waned over time as technology has caught up with the standards. While regulations can be strengthened through subsequent legislation, a much easier approach is to ensure that regulators are given the power to bolster standards over time.

The panelists were pressed on how adaptability can be built into policy, especially in cases such as CCS where the technical (or, in the case of CCS, geologic) constraints are poorly understood and will vary among the individual projects covered by the policy. Citing the Clean Air Act as an example, panelists described how regulators could update the definitions of terms such as *pollutant* as new scientific or technical information becomes available. Policies can also include a

requirement that regulators periodically update relevant standards to reflect technological progress, or policies can be updated through subsequent legislation, as with the 1990 Clean Air Act amendments. Policies ought to be based on sound scientific information so they can adapt to new scientific knowledge.

The private sector should be asked to identify potential risks associated with a policy and to present proposed solutions to regulators, as opposed to relying solely on regulators to identify problems and impose solutions on a resistant industry. The former approach is more common in European countries (e.g., Norway and the United Kingdom), but some American examples exist as well. The auto industry improved the efficiency of catalytic converters from 30 percent to 99 percent in the span of three decades, and this improvement was largely the result of soliciting industry input on how government policies could stimulate technical improvements. Industry input identified the sulfur content in fuels as being a major barrier, and subsequent policies requiring low-sulfur fuels permitted the development of higher-efficiency converters.

A major problem in policy design is how to avoid unintended consequences, a primary example being the use of methyl tertiary butyl ether (MTBE) to raise the oxygen content in gasoline and thus reduce pollutant emissions, as was required by the 1990 Clean Air Act amendments. MTBE was used despite general knowledge that this chemical presents a severe risk of groundwater contamination. Because groundwater contamination is addressed through the Clean Water Act, the Clean Air Act is not required to address this concern. The example of MTBE demonstrates a problem of accountability: if policy designers are not held accountable for unintended consequences, those consequences will not be considered during policy development.

Session E: Federalism

Chair:
Ann Carlson, *Professor of Law, University of California, Los Angeles*

Panelists:
Barry Rabe, *Professor of Public Policy, University of Michigan*
Marilyn Brown, *Professor of Public Policy, Georgia Institute of Technology*
Paul Centolella, *Commissioner, Public Utilities Commission of Ohio*

This panel addressed questions of how federalism relates to energy policy. Key issues included legal and political obstacles to the effective implementation of energy policy; the division of responsibility among the federal government, states, and localities; and possible alterations to the allocation of power among these levels of government that would facilitate the transition to an alternative energy future. Addressing energy challenges requires input from technologists, physical scientists, social scientists, and policy analysts, yet the presence of so many stakeholders can result in a diffusion of responsibility among these communities that impedes the creation of technological and policy solutions.

One approach to understanding how to deal with diffusion of responsibility is to examine the problem of scale. Generally the proper scale of an intervention or policy is analyzed less than the type of intervention. Environmental and energy policy is often dominated by the principle of subsidiarity: problems should be addressed at the lowest possible level; that is, state or local as opposed to regional, national, or international. For example, water pollution issues are often best addressed by local policy action, whereas climate change may be most effectively addressed at the international level.

Political realities often prevent action at a given level. In the absence of effective federal policy governing, for example, building codes, individual states have created their own laws. Thus the establishment of building codes does not require a unified national policy, but the resulting patchwork of building construction standards creates confusion among builders and necessitates a cadre of consultants to advise the industry on the practices of each state. (Another example, renewable portfolio standards [RPSs], is discussed below.)

Polycentric governance offers a mechanism with which to realize the benefits of multiple levels of policy action. The dilemma in blending actions at different levels is that each scale presents different benefits. The diversity of local actions fosters innovation, flexibility, and efficiency, whereas state and, especially, federal actions offer economies of scale and discourage polluters from simply moving to the state with the fewest regulations. Polycentric governance involves the simultaneous operation of energy and climate policies at many scales, while engaging many stakeholders. This approach provides backup policy mechanisms that offset imperfections that arise from intervention at a single level. Challenges include the potential for policy redundancy or conflict, and these issues must be dealt with on a case-by-case basis. A larger challenge to polycentric governance is how to establish such a system. Coordinating policies among states and localities requires federal governments to develop ways to compensate jurisdictions that suffer adverse consequences.

On global issues such as climate change, state governments, driven by anticipation of federal policy action, are often the first to develop policies. For instance, many states developed RPSs in anticipation of international treaties regulating carbon emissions. In a polycentric governance system these standards would combine with a federal carbon pricing regime to lower carbon emissions. To date, no such federal policy is in place. One reason for this lack of action is that states, through their representatives in Congress, have different bargaining positions and seek different objectives, including maximizing the benefits of their existing policies and procuring federal assistance for infrastructure improvements that may be necessitated by federal policy.

If U.S. energy policy is to remain state-dominated in the near term, what types of state policies will prove most effective? As twenty years of policy experimentation among the fifty states demonstrate, an inverse relationship exists between the economic desirability of a given type of carbon-mitigation policy and its political viability (Figure 2-1). The consensus in the economics literature is that carbon taxes are the most cost-effective, followed by cap-and-trade regimes. RPSs are the

Economic Desirability

Political Feasibility	High	Medium	Low
High			**Renewable portfolio standards (29)**
Medium		**Cap and trade (13–23)**	
Low	**Carbon tax (0)**		

Figure 2-1. Relationship between economic desirability and political feasibility of three carbon reduction policies. Numbers in parentheses indicate the number of states that had adopted each regulatory approach as of May 2011.

Examples of polycentric governance

- **Denmark's Electricity System**
  From 1980 to 2004 Denmark lowered its per-GDP carbon dioxide emissions by nearly 50 percent while simultaneously building the world's largest wind turbine export industry. These achievements were made possible by a combination of taxes on emissions, fuels, and electricity; investment subsidies and long-term financing guarantees; and regulatory support for small-scale renewable energy generation and combined heat and power facilities. Denmark's polycentric approach blends small-scale decentralized community control with national standards and policies.

- **Germany's Feed-in Tariff**
  Germany's feed-in tariff is often cited as a model for similar policies around the world. In addition to providing a financial incentive for small-scale renewable energy production, German regulations provide for the participation of utilities while also requiring them to provide grid access to small generation facilities. The feed-in tariffs differ by energy source—they are determined by each source's associated generation costs—and are programmed to decrease over time in concert with expected cost reductions. Germany's polycentric approach integrates residential and community producers of wind and solar energy with federal policy concerning tariffs and digression rates.

- **Brazil's Proálcool Program and Promotion of Flex-Fuel Vehicles**
  Brazil launched its National Alcohol Program (Proálcool) in 1975. As a result of this program ethanol production is now cost-competitive with gasoline production in the absence of subsidies, and the country has recouped its investment through large reductions in oil imports. The program included mandates for blending ethanol with gasoline, partnerships with automobile manufacturers to produce and promote flex-fuel vehicles, the use of gasoline taxes to subsidize the price of ethanol, and partnerships with environmental groups to design regulations to protect rainforests and other environmentally sensitive land.

- **Singapore's Urban Transport Policy**
  Singapore's urban transport policy employs a combination of approaches to reduce road congestion and improve air quality in this island city-state, including the world's first congestion pricing scheme (subsequently expanded to cover a larger area), certificate of entitlement auctions for vehicle ownership, and the integration of land-use and transportation planning. Singapore's polycentric approach harnesses public-private partnerships to operate mass transit systems and works with automobile manufacturers to equip vehicles with electronic road pricing devices.

- **Bangladesh's Grameen Shakti**
  Grameen Shakti is a nonprofit company that provides microcredit-based financing and technical assistance for rural renewable energy projects, including solar photovoltaic and biogas installations and improved cook stoves. A critical aspect of this initiative is the enrollment of local communities, both in project financing and in maintaining the installations, as well as the engagement of district and national policy makers, international donors, and lending firms. The program has resulted in a large reduction in deforestation in Bangladesh, which relies on trees and bamboo for nearly half of its energy.

- **The EPA Toxics Release Inventory**
  The Toxics Release Inventory is a publicly available database containing annually updated information from industry groups and the U.S. government regarding releases of toxic chemicals in the United States. A number of nongovernmental organizations were instrumental in establishing the database and improving public access to it. The project is managed by the national government, but facilities compile and report information on their own releases.

least cost-effective but have gained the greatest acceptance among state legislatures. Cap-and-trade systems have been adopted less frequently. No state has yet instituted a blanket carbon tax, although twenty-eight states have instituted a surcharge on electricity bills that funds renewable energy programs. Although carbon pricing schemes do not enjoy universal political or public support, applying revenues generated from such schemes to renewable energy research and development is broadly supported.

How would a federal RPS be instituted in the face of so many state RPS policies? A large body of social science literature describes how the framing of a policy affects its public acceptance. Across the political spectrum, state policy makers tend to frame state RPS policies not in terms of energy or climate concerns but in terms of economic development and the potential to benefit from anticipated federal policies. Although this framing could be useful for promoting a federal RPS, it might be counterproductive if costs rise more than anticipated or if the RPS fails to deliver economic benefits to every state.

State public utility commissioners face challenges related to economic security, energy security, and cyber security. A major economic challenge is the $1.5–2 trillion investment that will be needed over the next twenty years to replace aging infrastructure and to build new facilities to meet the anticipated growth in electricity demand. Energy security will require greater diversity in energy sources, particularly transportation fuels, and mechanisms must be developed to defend the energy system against cyber attacks. Short-term concerns of maintaining an adequate energy supply and reasonable prices must be balanced against long-term planning to improve the system over time and to adapt to changing environmental and market conditions.

Achieving the proper balance between short-term and long-term planning requires expanding the range of regulatory options and thinking about investment in a different way. How can utilities foster innovation, address market failures related to energy efficiency, engage consumers on the question of dynamic electricity pricing, and pursue smart grid technologies as a platform for innovation? Least-cost planning—the historical model for investments by public utilities—may not be the best approach in the face of uncertainty over future economic, environmental, and regulatory changes. Rather, planners should value the development of an adaptable electricity grid, incremental and modular infrastructure investment rather than large monolithic capital investments, and the ability to delay making irreversible investment decisions when outcomes are uncertain. A critical issue for the social sciences to consider is how planners should value options and risks.

The role of regulators also needs to be restructured. The historical function of regulators has been to decide whether projects proposed by utilities are prudent, reasonable, and necessary. Regulators must learn to be more proactive in clarifying the objectives of existing statutes and aligning stakeholder incentives with those objectives. One means for achieving this goal is to sponsor policy workshops aimed at defining new terminology, facilitating dialogue, and disseminating new information.

Participants asked whether utilities have incentives to sell less electricity and identified two types of *dis*incentives. One is the reliance on volumetric charges to recover fixed costs. Solutions include straight-fixed-variable rate design and direct compensation for revenues lost as a result of energy efficiency programs. A less tractable disincentive, especially for utilities that sell electricity entirely on the wholesale market, is the fact that reducing demand for electricity also reduces its price. A counteracting factor is the expense of replacing retiring generation facilities. In many cases the more cost-effective option is to support demand-reduction programs.

The Smart Grid Interoperability Panel

This session highlighted several examples of successful collaboration between public utility commissions and other stakeholders. The Smart Grid Interoperability Panel is a public-private partnership created by the National Institute for Standards and Technology to accelerate the development of technical standards for the smart grid. Through this initiative, standards that would normally require four or five years to develop are being completed in twelve to eighteen months. This success is due in part to strong early support from the Departments of Energy and Commerce and from about seventy leaders in industry and public policy. Critical social science questions include: How should the development of technical standards for the electric grid be organized and funded in the long term? And what is the most appropriate way to support research and development within a regulated industry?

Combined heat and power (CHP) plants are a more efficient alternative to large, centralized generation facilities. Although common in Europe, CHP has struggled to gain acceptance in the United States. CHP can be facilitated by grid interoperability standards, by available efficiency credits, and by providing higher offer prices for electricity generated by CHP plants located in areas of marginal grid stability. In many locations the major barrier that must be addressed is the existence of exclusive service territory statutes, which prevent microgeneration facilities from selling electricity to nearby consumers.

Session F: How do regulations need to change?

Chair:
Granger Morgan, *Professor and Head, Department of Engineering and Public Policy, Carnegie Mellon University*

Panelists:
Edward A. (Ted) Parson, *Professor of Law and Professor of Natural Resources and Environment, University of Michigan*
Robert R. Nordhaus, *Member, Van Ness Feldman*
Jonathan Cannon, *Professor of Environmental Law, University of Virginia*

Changing the energy system will require new regulations as well as alterations to existing policies that inhibit this response. For example, implementation of CCS technologies will require a regulatory regime that does not yet exist. In addition, a variety of existing tax policies must be modified so as not to discourage investments in alternative energy technologies and energy efficiency. The panel examined how energy regulations could be altered to promote the spread of new technologies.

Innovation in the energy system requires either the opportunity for financial gain or regulation that induces innovation. Regulations can also improve the financial outlook for a technology: putting a price on carbon, for instance, would increase the cost-effectiveness of CCS as a carbon-mitigation strategy. Performance standards are another useful regulatory tool.

How can regulation or other public policy measures more effectively promote socially beneficial technological change to reduce environmental burdens? Despite much academic research over the past four decades, few answers are available, and many fallacies persist. New insights into this long-standing question can be gained by more closely examining the problems posed by uncertainty

over future technological capabilities and costs. This uncertainty contributes to a "policy double bind" in which policy makers are expected to design regulations that will drive new technologies without demanding technology improvements that are impossible to achieve. Despite decades of industry success in meeting new technical standards for vehicle and appliance efficiency, policy makers are often faced with the difficult, if not impossible, task of proving that newly proposed standards are technically achievable. Compounding this problem, regulators often do not have full access to industry data regarding the capabilities of technologies that are under development. One solution is to involve a third party from the private sector that has a financial interest in convincing the target industry to disclose critical information. For example, new technical information on the potential for reducing motor vehicle emissions came to light because of efforts to resolve the competing claims of auto companies and oil companies.

In exploring how to design regulations that foster innovative research and cost-effective technologies, a useful step is to study historical cases where policy development was complicated by competing claims over technological capabilities, such as motor vehicle emissions, ozone-depleting chemicals, and dioxin discharge from pulp mills. One can ask what technological breakthroughs were anticipated, how that understanding was advanced by new breakthroughs, and how developing knowledge impacted the policy debate. Such case studies have revealed that regulators have many opportunities to align incentives for the private sector with the goals of government regulations. Conversely, policy makers must be careful not to specify unrealistic penalties for a failure to meet a regulatory requirement, because such penalties are impossible to enforce and hence do not influence industry behavior. For example, the motor vehicle standards in the 1970 Clean Air Act specified damages for failing to meet emissions standards that were twice the average vehicle cost at the time.

The practice of using federal regulations to enable specific technologies dates at least to the 1920 Federal Water Power Act, which established a licensing system for nonfederal hydroelectric projects. The act, which still governs approximately half of all hydroelectric generation in the United States, covers all siting issues in one regulatory package, including environmental considerations, land use, and eminent domain. The 1938 Natural Gas Act took a similar approach to establishing a national system of gas pipelines. Other examples of federal legislation that has fostered technological innovation include the 1954 Atomic Energy Act, the 1970 Clean Air Act, and the 1978 PURPA (Figure 2-2).

Efforts are under way to develop a similarly comprehensive federal regulatory regime for the widespread deployment of CCS. Legal issues that remain to be resolved include who owns the right to make use of deep geological formations, how permitting should be managed, how to resolve long-term liability issues such as compensation for personal injury or property damage, and how eminent domain laws should be applied or modified to develop an extensive carbon dioxide pipeline infrastructure. Regulations on liability should provide both incentives for safe operation and mechanisms for compensating injured parties and should also clearly establish the parties responsible for long-term site remediation. One proposal is to pay for the long-term costs of storage, remediation, and liability through a per-ton fee on sequestered carbon.

Participants noted that carbon dioxide pipelines are already in operation in the United States, primarily for enhanced oil recovery, and asked whether existing regulations would be sufficient to cover an expanded pipeline system. A complicating factor is that carbon dioxide pipelines are currently regulated at the state level, and only a few states have created a regulatory regime for this infrastructure. Furthermore, existing state laws and regulations, including laws pertaining to

- ***Federal Water Power Act*** (1920): Hydroelectric licensing; established a comprehensive facility-siting authority for nonfederal hydroelectric development.
- ***Natural Gas Act*** (1938): Natural gas pipeline regulation; comprehensive regulation of siting and construction of interstate natural gas pipelines and rates, terms, and conditions of service.
- ***Atomic Energy Act*** (1954): Licensing and safety regulation of commercial nuclear reactors, including limitation of liability for nuclear accidents under the Price-Anderson Act (1957) and a framework for permanent disposal of spent nuclear fuel under the Nuclear Waste Policy Act (1982/1987).
- ***Clean Air Act*** (1970): Created statutory standards for light-duty motor vehicle emissions that drove the deployment and use of catalytic converters.
- ***PURPA*** (1978): Opened up electricity markets to nonutility renewable generators and cogeneration facilities.

Figure 2-2. Federal regulatory interventions that have accelerated the deployment of new energy technologies.

eminent domain, vary widely, and this variation would make the construction of interstate pipelines difficult under current state regulations. One panelist recommended an opt-in national program to supplement state-by-state regulation.

Although the legislation listed in Figure 2-2 has been generally effective in meeting energy and environmental goals, instituting a legally effective regulatory regime does not ensure that a technology will gain public acceptance. Hydroelectric power and nuclear waste management are two areas where public opposition has halted projects despite the presence of effective regulatory schemes. Useful mechanisms for increasing public acceptance include community outreach, transparency, and independent technical analyses. Regulations mandating these strategies ensure that policy makers address the societal dimension of technology deployment but also risk imposing burdensome administration and lengthy litigation. For this reason, incorporating decision-related concerns into a workable regulatory regime requires careful attention to how additional administrative requirements will work in practice.

The panel also discussed the value of regulating total greenhouse gas emissions as a driver of technological innovation. Economists generally accept that placing a price on greenhouse gas emissions through a carbon tax or cap-and-trade scheme is more effective at driving change than relying on mandates or other prescriptive regulations. This is because carbon pricing regimes give the private sector the flexibility to experiment with cost-effective ways to reduce emissions without requiring that governments pick winners and losers. Carbon pricing regulations may also have lower administrative costs than do more-prescriptive policies, because developing separate policies for each industry and each sector of society could be time-consuming and expensive.

Pricing carbon emissions can also foster innovation and long-term planning, although companies need to have confidence that the pricing arrangement will be in effect for a long period of time before they will commit to long-term investments and new research and development programs. Where carbon pricing mechanisms are insufficient to achieve ambitious, short-term carbon reduction goals and to drive innovation, they can be complemented by prescriptive regulations such as building, appliance, and automobile efficiency standards and RPSs. As in previous sessions, participants observed that lessons from other countries could be applied to designing regulations in the United States.

A final social science issue concerns the influence of social discourse on the adoption of regulations. The 1970s and the early 1980s saw widespread, bipartisan support for environmental regulations. More recently, market-based solutions such as cap-and-trade policies are increasingly seen as representing an unacceptable level of government intrusion. Although this shift in the social discourse may affect the political feasibility of particular regulatory changes, participants cautioned against basing long-term planning on recent political trends and public opinion. Now is the time to develop an understanding of how to design and implement useful regulatory regimes so that constructive intellectual frameworks are immediately available to policy makers when public support does materialize.

Chapter 3: Toward a Social Science Research Agenda on Energy

Despite several decades of social science research examining the societal aspects of energy (for a bibliography, see chapter 4), many issues are still poorly understood. This report echoes the 2010 PCAST recommendation that DOE and NSF develop and implement a multidisciplinary social science research program with input from the academic community, the private and nonprofit sectors, and state and local governments.[1] As was recommended by PCAST, this research program should be integrated into DOE energy research and applied programs in order to accelerate the introduction and adoption of cleaner and more-efficient energy-supply and end-use technologies.

The workshop panel discussions and breakout groups identified many research questions related to behavior and decision making, policy analysis, and energy regulations that have particular relevance to the near- and long-term challenges facing policy makers. These questions group into three categories: individual behavior, decision making, and technology acceptance; incorporating human factors into policy design and analysis; and policy development and governance.

Individual behavior, decision making, and technology acceptance

Priority topics:

1. How can technologies for energy production and efficient use be designed to address and overcome social and behavioral barriers to their widespread use? Answering this question will require understanding how people actually use and respond to household technologies such as smart meters and how this response differs from modeled behavior, as well as how people think and act in relation to energy production technologies and their siting.
2. How could labels and certification programs be effectively designed to engage the intended users? How could this knowledge be integrated into existing government programs?
3. On what bases do individuals and households make decisions about energy use? How can we help people make informed decisions, and how do people become motivated to take action?
4. How could public utilities best approach consumers on dynamic pricing structures and adoption of smart grid technologies? Particularly useful would be an analysis of examples of effective and noneffective strategies for engaging the consumer at the local level on time-of-use electric billing and other pricing strategies.

Additional research questions:

- How are energy-related norms and behavior influenced by social networks?
- What is the role and impact of energy policies and programs on underrepresented populations?

1. President's Council of Advisors on Science and Technology, *Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy* (Washington, D.C.: Executive Office of the President, 2010), http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-energy-tech-report.pdf.

- What is the relative effectiveness of informational intervention compared to regulatory intervention? How should these types of intervention be combined to best promote beneficial behavior?

Incorporating human factors into policy design and analysis

Priority topics:

1. How can behavioral research be better integrated into energy modeling?
2. What policy designs are highly effective in encouraging people and organizations to undertake actions that have major practical potential but require great effort on their part?
3. What behavioral changes have the greatest economic and technical potential? What additional information is needed on the technical potential of various behavioral interventions?

Additional research questions:

- How does the effectiveness of individual and institutional incentives vary among regions, education levels, and socioeconomic groups?
- How can field experiments on individual and institutional behavior contribute to policy design? In what areas is the need for new field experiments greatest?
- Behavioral research on energy use is more abundant in Europe. How can this research be applied to policy development in the United States?

Policy development and governance

Priority topics:

1. What is the relative effectiveness of existing energy policies? What tools should be developed to enable comparative policy analysis?
2. What mechanisms are available or could be created to facilitate effective polycentric governance mechanisms?
3. What is the role of government in the U.S. energy innovation system?

Additional research questions:

- How can research on the management of common resources be applied to energy policy?
- What guidelines can be developed for translating and scaling up the lessons from federal, state, local, and private practices?
- How can policies and regulations be designed to anticipate and account for the vulnerabilities of the energy system in the face of climate change?

- How does the rapid turnover of public utility commission chairs pose obstacles to collaboration among the fifty state commissions? How can these effects be minimized to facilitate collaborations and promote durable energy policies?
- How do jurisdictional conflicts (especially between state and federal policies) impede public-private partnerships?

Participants emphasized that these questions will be best addressed through interdisciplinary, use-oriented research. This type of research will need to be more strongly valued and supported both by federal grant-making bodies and by academic institutions if researchers are to find answers to the most pressing questions regarding the societal dimensions of the energy future.

The questions listed above illustrate the range of social and behavioral questions that deserve greater attention, but they do not constitute a systematic research agenda. A productive next step would be for DOE and NSF to engage an appropriate scientific group to develop a detailed social and behavioral science research agenda on energy. The agenda should include both use-oriented and fundamental social and behavioral research related to energy supply, demand, reliability, security, technological innovation and diffusion, and policy.

Chapter 4: A Resource Guide to the Social Sciences

Many outstanding social science questions related to energy production and use are in urgent need of attention from researchers. Nevertheless, a large body of literature on the societal aspects of energy is already available to policy makers and technologists. While not comprehensive, the following list of references is indicative of the extent and scope of this research.

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Appendix A: Workshop Agenda

Workshop on Social Science and the Alternative Energy Future

May 19–20, 2011
The George Washington University
Washington, D.C.

Thursday, May 19, 2011

The George Washington University Marvin Center, 3rd Floor
800 21st Street, N.W., Washington, D.C.

Continental Ballroom—3rd Floor

Opening Session

8:30 am–8:35 am	**Welcome**: Steven Knapp, *President, The George Washington University*
8:35 am–8:40 am	**Introductory Remarks**: Leslie Berlowitz, *President, American Academy of Arts and Sciences*
8:40 am–9:10 am	**Keynote Address**: Steven E. Koonin, *Under Secretary for Science, U.S. Department of Energy*
9:10 am–9:20 am	**Workshop Overview**: Robert Fri, *Workshop Chair; Visiting Scholar, Resources for the Future*

Room 307—3rd Floor

Session A: Behavior and decision making related to energy efficiency

How individuals and communities respond to technological changes in the energy system is crucial to the success of energy policy. This session will examine several critical questions pertaining to how individuals and households make decisions about using energy. For example, what household incentives are likely to be most effective in influencing energy-related decisions? How can policy makers anticipate and address resistance to change?

9:30 am–10:20 am	**Panel discussion**
	Chair: Thomas Dietz, *Professor of Sociology and Environmental Science and Policy, and Assistant Vice President for Environmental Research, Michigan State University*
	Panelists: Paul Stern, *Study Director, National Research Council* Charlie Wilson, *Lecturer, Tyndall Centre for Climate Change Research* Marsha Walton, *Senior Project Manager, NYSERDA*
10:20 am–10:45 am	**Q&A**

Session B: Public acceptance of new energy technology

This session will address the challenges related to acceptance of new energy technologies that introduce new factors into collective decision making, both within communities and among institutions. Industry, academic, and public policy perspectives will highlight the complexities of the social dimensions of adopting new energy technology solutions, with attention to issues of privacy, equity, and individual rights.

10:55 am–11:55 am **Panel discussion**

Chair:
Douglas Arent, *Executive Director, Joint Institute for Strategic Energy Analysis, National Renewable Energy Laboratory*

Panelists:
Juliana Birkhoff, *Vice President of Programs and Practice, RESOLVE*
Jeanne Fox, *Commissioner, New Jersey Board of Public Utilities*
Jennifer Layke, *Director, Institute for Building Efficiency, Johnson Controls Inc.*
Eugene Rosa, *Professor of Sociology, Washington State University*

11:55 am–12:20 pm **Q&A**

Continental Ballroom—3rd Floor

12:30 pm–1:50 pm **Lunch**

1:15 pm–1:35 pm **Keynote Address on Social Science and Energy**

Myron Gutmann, *Assistant Director for Social, Behavioral, and Economic Sciences, National Science Foundation*

1:35 pm–1:50 pm **Q&A**

Room 307—3rd Floor

Session C: Incorporating behavior in policy analytic tools

This panel will build on the previous two discussions to examine how individual and institutional attitudes and behavior could be more effectively integrated into available tools for developing policy, with special attention to how energy-economic modeling could incorporate actual behavior patterns.

2:00 pm–2:50 pm **Panel discussion**

Chair:
James Sweeney, *Professor of Management Science and Engineering, Stanford University*

Panelists:
Alan Krupnick, *Research Director, Senior Fellow and Director, Center for Energy Economics and Policy, Resources for the Future*
John A. "Skip" Laitner, *Director of Economic and Social Analysis, American Council for an Energy-Efficient Economy*

Panelists, continued

Holmes Hummel, *Senior Policy Advisor for Policy and International Affairs, U.S. Department of Energy*

2:50 pm–3:15 pm **Q&A**

3:15 pm–3:30 pm **Break**

Session D: Policy durability and adaptability

This session will examine the extent to which policy durability and adaptability will be necessary to achieve an alternative energy future. Government officials and experts will discuss the tension between the provision of consistent and long-term signals and the need to make policy responsive to new information. They will also explore the complications that stem from relying on quick fixes for enduring energy problems.

3:30 pm–4:20 pm **Panel discussion**

Chair:
Kelly Sims Gallagher, *Associate Professor of Energy and Environmental Policy, Tufts University*

Panelists:
Kevin Carroll, *Chief of the Energy Branch, Office of Management and Budget*
Margo T. Oge, *Director, Office of Transportation and Air Quality, U.S. Environmental Protection Agency*
Phil Sharp, *President, Resources for the Future*

4:20 pm–4:45 pm **Q&A**

Closing Remarks

4:50 pm–5:05 pm **Speaker**: Nicholas Donofrio, *Senior Fellow, Kauffman Foundation; former Executive Vice President of Innovation and Technology, IBM*

5:05 pm–5:25 pm **Q&A**

5:25 pm–5:30 pm **Closing remarks**: Robert W. Fri, *Workshop Chair; Visiting Scholar, Resources for the Future*

5:30 pm **Adjourn for the day**

Friday, May 20, 2011

The George Washington University Marvin Center, 4th Floor
800 21st Street, N.W., Washington, D.C.

Room 413—4th Floor

9:00 am–9:10 am **Opening remarks**: Robert W. Fri, *Workshop Chair; Visiting Scholar, Resources for the Future*

Session E: Federalism

This panel will address questions of how federalism relates to energy policy. Key issues include legal and political obstacles to the effective implementation of energy policy; the division of responsibility between the federal government, states, and localities; and possible alterations to the allocation of power among these levels of government that would facilitate the transition to an alternative energy future.

9:10 am–10:00 am **Panel discussion**

Chair:
Ann Carlson, *Professor of Law, University of California, Los Angeles*

Panelists:
Marilyn Brown, *Professor of Public Policy, Georgia Institute of Technology*
Barry Rabe, *Professor of Public Policy, University of Michigan*
Paul Centolella, *Commissioner, Public Utilities Commission of Ohio*

10:00 am–10:25 am **Q&A**

Session F: How do regulations need to change?

Changing the energy system will require new regulations as well as alterations to existing policies that inhibit this response. For example, implementation of carbon capture and storage technologies will require a regulatory regime that does not yet exist. In addition, a variety of existing tax policies must be modified so as not to discourage investments in alternative energy technologies and energy efficiency. This panel will examine how energy regulations could be altered to promote the spread of new technologies.

10:30 am–11:20 am **Panel discussion**

Chair:
Granger Morgan, *Professor and Head, Department of Engineering and Public Policy, Carnegie Mellon University*

Panelists:
Edward A. (Ted) Parson, *Professor of Law and Professor of Natural Resources and Environment, University of Michigan*
Robert R. Nordhaus, *Member, Van Ness Feldman*
Jonathan Cannon, *Professor of Environmental Law, University of Virginia*

11:20 am–11:45 am **Q&A**

Room 403—4th Floor

12:00 pm–1:00 pm	**Lunch**
	Breakout groups—Rooms 409, 411, 414 *Breakout group assignments to be distributed at lunch*
1:00 pm–2:15 pm	**Breakout groups: Identifying key opportunities for research**
	Discussion Leaders: Maxine Savitz, *General Manager for Technology Partnerships, Honeywell, Inc. (ret.)* Paul Stern, *Senior Program Officer, National Research Council* Michael Vandenbergh, *Professor of Law, Vanderbilt University*

Room 403—4th Floor

2:20 pm–3:00 pm	**Reports from breakout groups and general discussion**
3:00 pm	**Meeting adjourns**

Appendix B: Speaker Biographies

Doug Arent, Executive Director, Joint Institute for Strategic Energy Analysis, National Renewable Energy Laboratory. Arent specializes in strategic planning and financial analysis competencies, clean energy technologies and energy and water issues, as well as international and governmental policies. In addition to his responsibilities at the National Renewable Energy Laboratory, he is a Senior Visiting Fellow at the Center for Strategic and International Studies. Arent was recently appointed as a Coordinating Lead Author for the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). In addition, he is a member of the Policy Subcommittee of the National Petroleum Council Study on Prudent Development of North America Natural Gas and Oil Resources and, from 2008 to 2010, served on the National Academy of Sciences panel on *Limiting the Magnitude of Future Climate Change*, as well as the Executive Council of the U.S. Association of Energy Economists. Arent is a member of the Keystone Energy Board and is on the Advisory Board of E+Co, a public purpose investment company that supports sustainable development across the globe. He is also a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Leslie C. Berlowitz, President and William T. Golden Chair, American Academy of Arts and Sciences. At the American Academy, an independent policy research institute and one of the nation's oldest learned societies, Berlowitz oversees its five research areas: science and technology policy; global security; social policy and American institutions; the humanities and culture; and education. Berlowitz established two residential fellowship programs for young scholars: the Hellman Fellowship in Science and Technology Policy and the Visiting Scholars Program. She was a member of the committee that prepared the Academy's 2008 report, *ARISE: Advancing Research In Science and Engineering: Investing in Early-Career Scientists and High-Risk, High-Reward Research*. Berlowitz has coedited *Reflecting on the Humanities*, *Dædalus* (MIT Press, 2009) with Patricia Meyer Spacks; *Restoring Trust in American Business* (MIT Press, 2005) with Jay W. Lorsch and Andy Zelleke; *America in Theory* (Oxford University Press, 1988) with Denis Donoghue and Louis Menand; and *Greenwich Village: Culture and Counterculture* (Rutgers University Press, 1990) with Richard Eric Beard. Before joining the Academy in 1996, she was Vice President for Academic Advancement at New York University. A Fellow of the American Academy, she was named an honorary Doctor of Humane Letters at Northeastern University in May 2011.

Juliana Birkhoff, Vice President of Programs and Practice, RESOLVE. An experienced trainer and teacher, Birkhoff has designed and conducted a wide variety of negotiation, collaboration, and conflict resolution trainings for non-profits, governmental agencies, and advocacy groups. Her training focuses on helping technical and scientific experts to work productively in collaborative processes and to expand the capacities of stakeholders, agency conflict resolution specialists, and team leaders to handle project leadership, collaboration, and conflict resolution. Birkhoff has extensive background in multi-disciplinary research on conflict and conflict analysis, with a particular focus on using collaborative decision making processes in politically charged and technically complex issues. Her previous research projects include best practices for integrating complex scientific and technical information into collaborative processes and how stakeholders and team leaders integrate different ways of knowing in collaborative processes.

Marilyn Brown, Professor, School of Public Policy, Georgia Institute of Technology. Prior to joining Georgia Institute of Technology in 2006, Brown held various leadership positions at Oak

Ridge National Laboratory (ORNL). Her research focuses on the design and impact of policies aimed at accelerating the development and deployment of sustainable energy technologies. Brown has led several energy technology and policy scenario studies and is a national leader in the analysis and interpretation of energy futures in the United States. She is the author of *Climate Change and Global Energy Security* (MIT Press) and more than 200 other publications; she edited *Thirteen Energy Myths* (Springer). Her work has had significant visibility in the policy arena as evidenced by her numerous briefings and testimonies before committees of both the U.S. House of Representatives and the U.S. Senate. Brown has served on four committees of the National Academies of Sciences, and in October 2010 she was sworn onto the board of directors of the Tennessee Valley Authority, the nation's largest public power provider, following her nomination by President Barack Obama.

Jonathan Cannon, Director of the Environmental and Land Use Law Program and Blaine T. Phillips Distinguished Professor of Environmental Law, University of Virginia School of Law. Before coming to the University of Virginia in 1998, Cannon held positions at the U.S. Environmental Protection Agency (EPA) as General Counsel from 1995–1998 as well as assistant administrator for administration and resources management and chief financial officer from 1993–1995. Cannon has also been in private law practice and served in previous positions at the EPA as a senior career executive. He currently serves on the National Academy of Sciences (NAS) Board of Environmental Studies and Toxicology and was a member of the NAS committee on *America's Climate Choices*, which recently released its final report. Cannon's areas of scholarly interest include the design and implementation of environmental programs, the Supreme Court's environmental jurisprudence, protection of watersheds and landscapes, and climate change.

Ann Carlson, Shirley Shapiro Professor of Environmental Law and Faculty Director of the Emmett Center on Climate Change and the Environment, University of California, Los Angeles, School of Law. As the inaugural faculty director of the Emmett Center on Climate Change and the Environment, Carlson is also on the faculty of the UCLA Institute of the Environment. Her research in environmental law focuses on climate change law and policy, federalism and the role social norms play in affecting environmentally cooperative behavior. Her recent work involves analyzing unusual models of environmental federalism, with a focus on the unique role California plays in regulating mobile source emissions, including greenhouse gas emissions, under the Clean Air Act. Carlson's article "Takings on the Ground" was selected by the *Land Use and Environmental Law Review* in 2003 as one of the top ten environmental articles of the year. Carlson teaches property, environmental law, and climate change law and policy and was the recipient of the 2006 Rutter Award for Excellence in Teaching. She served as the law school's academic associate dean from 2004 to 2006. She is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

J. Kevin Carroll, Chief, Energy Branch, Energy Science and Water Division, Natural Resources Programs, Office of Management and Budget. Carroll has been the branch chief in energy since September 2006. Prior to returning to OMB, Kevin was the Staff Director of the Energy Subcommittee of the House Committee on Science for three years. The subcommittee had jurisdiction for all non-defense R&D carried out by the Department of Energy. During his tenure as Staff Director, the committee passed three reauthorization bills for DOE's R&D programs, either unanimously or by voice vote, as well as several minor authorization and reauthorization bills, also unanimously or by voice vote. Before working for the Science Committee, Kevin was the fossil energy examiner at OMB from 1999 to 2003. He got his start in policy as a canvasser and community organizer in Connecticut.

Paul A. Centolella, Commissioner, Public Utilities Commission of Ohio. Centolella has over thirty years of experience in utilities, energy, and environmental law and economics. He serves as the vice president of the Organization of PJM States and is a member of National Association of Regulatory Utility Commissioners (NARUC) Smart Grid Working Group and the Federal Energy Regulatory Commission/NARUC Smart Response Collaborative. Centolella represents NARUC on the Electric Power Research Institute's Advisory Council and serves on the advisory council's executive committee as well as the governing board of the Smart Grid Interoperability Panel, an effort led by the National Institute of Standards and Technology to accelerate the development of standards for the smart grid. Before joining the Commission, he was a Senior Economist in the Energy Solutions Group of Science Applications International Corporation, where he managed projects involving the integration of information technology into electric power system operations and the design and economic analyses of energy markets and policies. He has also served at the Office of the Ohio Consumers' Counsel and has practiced law in California and Washington State.

Thomas Dietz, Assistant Vice President for Environmental Research, Professor of Sociology, and Professor of Environmental Science and Policy, Michigan State University. At Michigan State University, Dietz also holds appointments in the Animal Studies Program, was the Founding Director of the Environmental Science and Policy Program, and has served as associate dean in the Colleges of Social Science, Agriculture and Natural Resources, and Natural Science. He is currently vice chair of the panel on Advancing the Science of Climate Change of the *America's Climate Choices* study and has previously served as chair of the National Research Council Committee on Human Dimensions of Global Change as well as the panel on Public Participation in Environmental Assessment and Decision Making. In addition, Dietz is a Fellow of the American Association for the Advancement of Science, and has been awarded the Sustainability Science Award of the Ecological Society of America. His current research examines the human driving forces of environmental change, environmental values, and the interplay between science and democracy in environmental issues. He has co-authored or co-edited eleven books and more than 100 papers and book chapters on these topics. He is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Nicholas M. Donofrio, Senior Fellow, Kauffman Foundation; former Executive Vice President of Innovation and Technology, IBM. Since joining IBM as a college co-op student in 1964 to work on the legendary IBM System/360 mainframe computing system, Donofrio held numerous technical management positions and, later, executive positions in several of IBM's product divisions until his retirement in 2008. He spent the early part of his career in integrated circuit and chip development as a designer of logic and memory chips and has led many of IBM's major development and manufacturing teams—from semiconductor and storage technologies, to microprocessors and personal computers, to IBM's entire family of servers. He was also vice chairman of the IBM International Foundation and chairman of the Board of Governors for the IBM Academy of Technology. The holder of seven technology patents, he is member of the National Academy of Engineering, and serves on many boards including the Board of Directors for the Bank of New York/Mellon, the Republic of China's Advisory Board of Science and Technology, the Board of Trustees at Rensselaer Polytechnic Institute, the Board of Directors of Liberty Mutual, and the Board of Directors of AMD. He is a Senior Fellow of the Kauffman Foundation and a member of the U.S. Department of Energy's Secretary of Energy Advisory Board; he was appointed an IBM Fellow in 2008. In addition, Donofrio is a Fellow of the Institute of Electrical and Electronics Engineers and a Fellow of the Royal Academy of Engineering. He is also a Fellow of the American Academy.

Jeanne M. Fox, Commissioner, New Jersey Board of Public Utilities (NJBPU). At NJBPU, Fox previously served as president and a member of the governor's cabinet from 2002 to 2010. Under her leadership, NJBPU has become a leader among states in developing clean energy policies and promoting renewable energy and energy efficiency. Prior to her appointment to the board, Fox served as a Regional Administrator of the United States Environmental Protection Agency and as Commissioner and Deputy Commissioner of the New Jersey Department of Environmental Protection and Energy. Fox is active with the National Association of Regulatory Utility Commissioners as a member of the Board of Directors; chair of the committee on *Energy Resources and the Environment*; and a member of the committee on Critical Infrastructure and the Task Force on Climate Policy. She is also a member of the Electric Power Research Institute's Public Advisory Council on Smart Grid; the Harvard Electricity Policy Group; and the National Council on Electricity Policy, which she chaired for five years. She has served as president of the Mid-Atlantic Conference of Regulatory Utilities Commissioners and as a member of the National Academy of Science Panel on Public Participation in Environmental Assessment and Decision Making, the National Leadership Group on Energy Efficiency, and the Advisory Council to the Board of Directors of the Electric Power Research Institute.

Robert W. Fri, Visiting Scholar and Senior Fellow Emeritus at Resources for the Future. Fri has served as Director of the National Museum of Natural History, President of Resources for the Future, and Deputy Administrator of both the Environmental Protection Agency and the Energy Research and Development Administration. He is currently a director of American Electric Power Company, vice-chair and a director of the Electric Power Research Institute, a trustee and vice-chair of Science Service, Inc., and a member of the National Petroleum Council. Fri is active with the National Academies, where he is national associate and vice-chair of the Board on Energy and Environmental Systems; he recently chaired a National Academies summit on *America's Energy Future*. In addition, he chaired the Panel on Limiting the Magnitude of Future Climate Change for the NAS study *America's Climate Choices*. He is a Fellow of the American Academy and chairs the American Academy study on *The Alternative Energy Future*.

Kelly Sims Gallagher, Associate Professor of Energy and Environmental Policy, The Fletcher School, Tufts University. Gallagher directs the Energy, Climate, and Innovation research program in the Center for International Environment and Resource Policy at the Fletcher School. She is also Senior Associate and a member of the Board of Directors of the Belfer Center for Science and International Affairs at Harvard University, where she previously directed the Energy Technology Innovation Policy research group. Broadly, she focuses on energy and climate policy in both the United States and China. She is particularly interested in the role of policy in spurring the development and deployment of cleaner and more efficient energy technologies, domestically and internationally. Gallagher speaks Spanish and basic Mandarin Chinese and is the author of *China Shifts Gears: Automakers, Oil, Pollution, and Development* (MIT Press, 2006) and editor of *Acting in Time on Energy Policy* (Brookings Institution Press, 2009); she has also written numerous academic articles and policy reports. In addition, she is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Myron Gutmann, Assistant Director for Social, Behavioral, and Economic Sciences, National Science Foundation. In addition to his responsibilities with NSF's Social, Behavioral, and Economic Sciences Directorate, Gutmann is also professor of history and information as well as research professor in the Institute for Social Research at the University of Michigan. Prior to joining NSF, he was director of the Inter-university Consortium for Political and Social Research (ICPSR).

Gutmann has broad interests in interdisciplinary historical research, especially health, population, economy, and the environment. As Director of ICPSR, he was a leader in the archiving and dissemination of electronic research materials related to society, population, and health, with a special interest in the protection of respondent confidentiality. He has written or edited five books and more than eighty articles and chapters. Gutmann has served on a number of national and international advisory committees and editorial boards.

Holmes Hummel, Senior Policy Advisor for Policy and International Affairs, U.S. Department of Energy. As a senior policy advisor in the Department of Energy, Hummel attends to the implementation of a wide range of executive authorities to advance national energy policy objectives. The *Blueprint for a Secure Energy Future* recently issued by the White House presents a multiagency view of that activity landscape, which includes initiatives to engage Americans in rapid adoption of clean energy technologies. In addition to prior work in the cleantech sector, she previously served as a Congressional Science Fellow and taught at the Energy Resource Group at the University of California, Berkeley. Her prior research focused on exploring energy technology and policy implications of paths to climate stabilization.

Steven E. Koonin, Under Secretary for Science, U.S. Department of Energy. As the second Under Secretary for Science in the Department of Energy (DOE), Koonin brings to the post a distinguished career as a university professor and administrator at the California Institute of Technology (Caltech) as well as experience in industry. Koonin joined the Caltech faculty in 1975, was a research fellow at the Niels Bohr Institute during 1976–1977, and was an Alfred P. Sloan Foundation Fellow during 1977–1979. He became a professor of theoretical physics at Caltech in 1981 and served as chairman of the faculty from 1989–1991. Koonin was the seventh provost of Caltech and, in that capacity, he was involved in identifying and recruiting a third of the Institute's professorial faculty and left an enduring legacy of academic and research initiatives in the biological, physical, earth, and social sciences, as well as the planning and development of the Thirty-Meter Telescope project. As the chief scientist at BP between 2004 and early 2009, Koonin developed the long-range technology strategy for alternative and renewable energy sources. He managed the firm's university-based research programs and played a central role in establishing the Energy Biosciences Institute at the University of California, Berkeley, the Lawrence Berkeley National Laboratory, and the University of Illinois at Urbana-Champaign. Koonin was a member and past chair of the JASON Study Group, advising the U.S. government on technical matters of national security. He has served on numerous advisory committees for DOE, the National Science Foundation, and the Department of Defense, including the Defense Science Board and the CNO's Executive Panel. His research interests have included nuclear astrophysics; theoretical nuclear, computational, and many-body physics; and global environmental science. He has been involved in scientific computing throughout his career and is a strong advocate for research into renewable energies and alternate fuel sources. His academic research in computational and nuclear physics has impacted the direction of science both nationally and internationally. He has supervised more than 25 PhD students, produced more than 200 peer-reviewed research publications, and authored or edited 3 books, including a pioneering textbook on computational physics in 1985. He is a member of the Council on Foreign Relations, a Fellow of the American Physical Society, a Fellow of the American Association for the Advancement of Science, and a Member of the National Academy of Sciences. He is a Fellow of the American Academy.

Alan J. Krupnick, Research Director, Senior Fellow and Director, Center for Energy Economics and Policy, Resources for the Future. As director of the Center for Energy Economics and

Policy, Krupnick works with the full complement of Center researchers to establish and carry out the Center's research agenda. His own research focuses on analyzing environmental and energy issues, in particular, the benefits, costs, and design of pollution and energy policies, both in the United States and in developing countries. Krupnick was lead author for *Toward a New National Energy Policy: Assessing the Options,* a study examining the costs and cost-effectiveness of a range of federal energy policy choices in both the transportation and electricity sectors. His primary research methodology is in the development and analysis of stated preference surveys, but he has also undertaken research on natural gas supply and impact on energy prices and policies; the costs and benefits of converting the U.S. heavy-duty truck fleet to run on liquefied natural gas; and the costs and benefits of expanded regulation around deepwater oil drilling. He has been a consultant to state governments, federal agencies, private corporations, the Canadian government, the European Union, the World Health Organization, and the World Bank. He co-chaired an advisory committee that counseled the U.S. Environmental Protection Agency (EPA) on new ozone and particulate standards. Krupnick also served as senior economist on the President's Council of Economic Advisers, advising the Clinton administration on environmental and natural resource policy issues. He is a regular member of expert committees for the National Academy of Sciences and the EPA.

John A. "Skip" Laitner, Director of Economic and Social Analysis, American Council for an Energy-Efficient Economy. Laitner previously served as a Senior Economist for Technology Policy for the Environmental Protection Agency (EPA), but chose to leave the federal service in 2006 in order to focus on his research, which is aimed at developing a more robust technology and behavioral characterization of energy efficiency resources for energy and climate policy analyses as well as within economic policy models. In 1998, he was awarded EPA's Gold Medal for his work with a team of other EPA economists to evaluate the impact of different strategies that might assist in the implementation of greenhouse gas emissions reduction policies. In 2003, he was honored by the U.S. Combined Heat and Power Association for his contributions to the policy development of that industry. Laitner's 2004 paper, *How Far Energy Efficiency*?, catalyzed new research into the proper characterization of efficiency as a long-term resource. The author of more than 260 reports, journal articles, and book chapters, he has been involved in the energy, environmental, and economic policy arenas for 40 years.

Jennifer Layke, Director, Institute for Building Efficiency, Johnson Controls Inc. As director of Johnson Controls' Institute for Building Efficiency, a global initiative to provide information and analyses of technologies, policies, and practices in high-performance buildings and smart-energy systems from a practitioner's perspective, Layke leads the Institute's research agenda and collaborations with a network of global experts on topical areas including: commercial building efficiency, smart buildings and the smart grid, green building design, and renewable energy technologies. Prior to joining Johnson Controls, she was the deputy director of the Climate and Energy Program at the World Resources Institute (WRI), where she founded The Green Power Market Development Group in 2001, which, by 2009, had supported the development of 1,000 MW of new, cost-competitive renewable energy projects in the United States for corporate use. Her work also included analysis of U.S. climate policy design options as lead WRI staff negotiator in the U.S. Climate Action Partnership's Call for Action and subsequent *Blueprint for Legislative Action*. Layke's international experience also includes consulting for the World Bank and the U.S. Environmental Protection Agency on technology transfer under the Montreal Protocol. She is an accomplished author on energy and climate action as well as founder of Beyond Grey Pinstripes, a sustainability ranking of business schools conducted in partnership with the Aspen Institute.

M. Granger Morgan, Professor and Head, Department of Engineering and Public Policy, Carnegie Mellon University. At Carnegie Mellon University, Morgan is also the University and Lord Chair Professor in Engineering and holds academic appointments in the Department of Electrical and Computer Engineering and in The H. John Heinz III School of Public Policy and Management. His research addresses problems in science, technology, and public policy with a particular focus on energy, environmental systems, climate change, and risk analysis. Much of his work has involved the development and demonstration of methods to characterize and treat uncertainty in quantitative policy analysis. Also at Carnegie Mellon, Morgan directs the National Science Foundation Center on Climate and Energy Decision Making as well as the CCSReg Project. With Lester Lave, he co-directs the Carnegie Mellon Electricity Industry Center. Morgan is a member of the National Academy of Sciences and a Fellow of the American Association for the Advancement of Science, Institute of Electrical and Electronics Engineers, and the Society for Risk Analysis. He is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Robert R. Nordhaus, Member, Van Ness Feldman. Nordhaus specializes in federal energy and environmental regulation. He is a member of the Washington, D.C., law firm of Van Ness Feldman, P.C., and is also a member of the adjunct faculty at the George Washington University Law School, where he teaches energy and environmental law. Nordhaus originally joined Van Ness Feldman in 1981, after serving three years as the Federal Energy Regulatory Commission's first General Counsel. He practiced with the firm until 1993, when he was appointed General Counsel of the Department of Energy by President Clinton. He rejoined the firm in 1997.

Margo T. Oge, Director, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. Oge has been with the Environmental Protection Agency (EPA) since 1980, where she has held various management positions. As director, she has been instrumental in the EPA's efforts to reduce air pollution and greenhouse gas emissions from the U.S. transportation sector. Under her leadership, EPA finalized two significant rules in 2010: the Agency's first-ever national greenhouse gas emission standards for cars and trucks and the final expanded renewable fuels standard, which will significantly increase the volume of biofuels in our nation's fuel supply. Other successes completed by EPA under Oge's guidance include the clean Tier 2 vehicle and gasoline sulfur program, the 2007 clean diesel truck and bus program, and the clean non-road diesel engine and fuels program. In recognition of her leadership in shepherding the Tier 2 and heavy-duty diesel rules to fruition, Oge was the first nonpolitical appointee to be awarded the Woman of Achievement Award from the Women's Council on Energy and the Environment. In addition, she was a recipient of the 2004 Presidential Distinguished Executive Rank Award for her outstanding leadership on environmental transportation issues and is a previous winner of the Presidential Meritorious Award. In 2009, she received the California Air Resources Board's Haagen-Smit Clean Air Award for her efforts to protect California air quality and public health.

Edward A. Parson, Joseph L. Sax Collegiate Professor of Law and Professor of Natural Resources and Environment, University of Michigan. Parson's research examines international environmental law and policy, the role of science and technology in public policy, and the political economy of regulation. His articles have been published in *Nature*, *Science*, *Climatic Change*, *Issues in Science and Technology*, the *Journal of Economic Literature*, and the *Annual Review of Energy and the Environment*. His most recent books are *The Science and Politics of Global Climate Change*, with Andrew Dessler, and *Protecting the Ozone Layer: Science and Strategy*, which won the 2004 Harold and Margaret Sprout Award of the International Studies Association. Parson has

chaired and served on several senior advisory committees for the National Academy of Sciences, the U.S. Government Global Change Research Program, and other bodies, including the Synthesis Team for the U.S. National Assessment of Climate Impacts. In 2005, he was appointed to the National Advisory Board of the Union of Concerned Scientists. Parson has worked and consulted for the White House Office of Science and Technology Policy, the Office of Technology Assessment of the U.S. Congress, the Privy Council Office of the Government of Canada, the United Nations Environment Program, and the International Institute for Applied Systems Analysis. He also spent twelve years on the faculty of Harvard's Kennedy School of Government. Formerly, he was a professional classical musician and an organizer of grassroots environmental groups.

Barry Rabe, Professor of Public Policy, University of Michigan. Also at the University of Michigan, Rabe holds appointments in the School of Natural Resources and Environment and in the Program in the Environment. He is also a non-resident senior fellow in the Governance Studies Program at the Brookings Institution. Much of his recent research examines state and regional development of policies to reduce greenhouse gases; his research has been conducted in collaboration with the Brookings Institution, the Miller Center of Public Affairs at the University of Virginia, and the Pew Center on Global Climate Change. From 2008 to 2009, he was a visiting professor at the Miller Center of Public Affairs at the University of Virginia, where he organized the National Conference on Climate Governance. At Michigan, he previously served as director of the Program in the Environment and as interim dean of the School of Natural Resources and Environment. In 2006, Rabe became the first social scientist to receive a Climate Protection Award from the U.S. Environmental Protection Agency in recognition of his contribution to both scholarship and policy making, and, in 2007, he received the Daniel Elazar Award for Career Contribution to the Study of Federalism from the American Political Science Association. In addition, he was named a Fellow of the National Academy of Public Administration in 2009.

Eugene A. Rosa, Edward R. Meyer Distinguished Professor of Natural Resource and Environmental Policy and Professor of Sociology, Washington State University. At Washington State University, Rosa is also an affiliated professor of fine arts and a faculty associate in the Center for Environmental Research, Education, and Outreach. In addition, he is a Visiting Scholar at Woods Environmental Institute at Stanford University. He is a Fellow of the American Association for the Advancement of Science, has served on six committees of the National Academy of Sciences, is a frequent invited speaker in the United States and abroad, and is a member of several national and international scientific advisory bodies. His principal areas of research are environmental and technological risks, human dimensions of global environmental change, science policy, and risk governance. He has published four books, over 40 book chapters and reports, and over 50 journal articles on these topics, several of which have received awards of distinction. Among his current research activities are the investigation of the impacts to human well-being from environmental threats, the development of a methodology for comparing risks across broad, previously unrelated risk domains, and further contributions to the epistemology of risk. With two other leading social scientists he is now preparing a book on risk theory and risk governance.

Maxine Savitz, General Manager for Technology Partnerships, Honeywell, Inc. (ret.) During her career at Honeywell, Savitz oversaw the development and manufacturing of innovative materials for the aerospace, transportation, and industrial sectors. From 1979–1983, she served in the capacity of Deputy Assistant Secretary for Conservation at the Department of Energy. Currently, Savitz is vice president of the National Academy of Engineering and is a Fellow of the California Council on Science and Technology. She was appointed to the President's Council of Advisors

for Science and Technology in 2009. In addition, she is a member of advisory boards for Sandia, Pacific Northwest National Laboratory, and the DOE Office of Energy Efficiency and Renewable Energy; she is also a member of the board of directors of the American Council for an Energy Efficient Economy and the Federation of American Scientists. Previously, Savitz served on the National Academy committee for *America's Energy Future* and as vice chair of the panel on *Energy Efficient Technologies.* She was also a member of the study committee for the American Physical Society's 2008 report *Energy Future: Think Efficiency* and chaired the Technical Review Committee report recently issued by the American Energy Innovation Council. During the past year, she has made presentations regarding energy efficiency at Harvard University, Washington University, MIT, and Honeywell, Inc. She is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Philip R. Sharp, President, Resources for the Future. Sharp's career in public service includes ten terms as a member of the U.S. House of Representatives from Indiana and a lengthy tenure on the faculty of the John F. Kennedy School of Government and the Institute of Politics at Harvard University. During his 20-year congressional tenure from 1975 to 1995, he took key leadership roles in the development of landmark energy legislation. Sharp helped develop a critical part of the 1990 Clean Air Act Amendments, was a driving force behind the Energy Policy Act of 1992, and served on several House committees. Currently, he serves on the board of directors of the Duke Energy Corporation and as vice chair on the board of the Energy Foundation. He was appointed to the National Academies' committee on *America's Climate Choices* and to the *Blue Ribbon Commission on America's Nuclear Future*. In addition, he serves on the National Petroleum Council, which is a federal advisory committee; on the Planetary Skin Institute's Global Advisory Council; on the External Advisory Board of the Massachusetts Institute of Technology (MIT) Energy Initiative; and on the International Advisory Board of the Harvard Environmental Economics Program. He also chairs the External Advisory Committees for both the MIT Nuclear Fuel Cycle Study and the MIT Future of Solar Energy Study. He recently served as the congressional chair for the National Commission on Energy Policy.

Paul C. Stern, Study Director, National Research Council. Stern's research interests include the determinants of environmentally significant behavior, particularly at the individual level; participatory processes for informing environmental decision making; and the governance of environmental resources and risks. He is a long-time contributor to behavioral science research on energy consumption and recently served on the American Psychological Association's *Task Force on the Interface between Psychology and Global Climate Change*. He is a Fellow of the American Association for the Advancement of Science and the American Psychological Association. He is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

James L. Sweeney, Director of the Precourt Energy Efficiency Center and Professor of Management Science and Engineering, Stanford University. Sweeney's professional activities focus on economic policy and analysis, particularly in energy, natural resources, and the environment. He currently is Senior Fellow of the Stanford Institute for Economic Policy Research; Hoover Institution on War, Revolution and Peace; Freeman Spogli Institute for International Studies; Woods Institute for the Environment; and Precourt Institute for Energy. Also, Sweeney is a Senior Fellow of the U.S. Association for Energy Economics, a lifetime National Associate of the National Academies, a council member and Senior Fellow of the California Council on Science and Technology, and a member of the External Advisory Council of the National Renewable Energy Laboratory. At Stanford, he has served as director of the Energy Modeling Forum, chairman of the Institute for

Energy Studies, and director of the Center for Economic Policy Research (now the Stanford Institute for Economic Policy Research). In addition, he has served as a member of numerous committees of the National Research Council and, in the early 1970s, was director of the Office of Energy Systems Modeling and Forecasting of the U.S. Federal Energy Administration. He is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Michael P. Vandenbergh, Professor of Law and Tarkington Chair in Teaching Excellence, Vanderbilt University Law School. Vandenbergh is a leading scholar in environmental and energy law whose research explores the relationship between formal legal regulation and informal social regulation of individual and corporate behavior. His work has appeared in leading journals, including the *Columbia Law Review*, the *Harvard Environmental Law Review*, the *Michigan Law Review*, *Nature Climate Change*, the *New York University Law Review*, the *Proceedings of the National Academy of Sciences*, and the *Stanford Environmental Law Journal*. Before joining Vanderbilt's law faculty, Vandenbergh was a partner at Latham & Watkins in Washington, D.C. He began his career as a law clerk to Judge Edward R. Becker of the United States Court of Appeals for the Third Circuit in 1987–88 and served as chief of staff of the Environmental Protection Agency from 1993–1995. In addition to directing Vanderbilt's Climate Change Research Network, Vandenbergh serves as director of the law school's Environmental Law Program. A recipient of the Hall-Hartman Teaching Award, he teaches courses in environmental law, energy, and property. He has also been a visiting professor at the University of Chicago Law School and at Harvard Law School. He is a member of the steering committee for the American Academy study on *The Alternative Energy Future*.

Marsha L. Walton, Senior Project Manager, New York State Energy Research and Development Authority (NYSERDA). Walton has been at NYSERDA in Albany, New York, since 1992; she works on energy efficiency and exploratory research. She directs NYSERDA's Behavior Research Program, collaborating with a team of researchers to apply behavioral insights from academic disciplines such as social psychology and behavioral economics to programs designed to promote energy efficiency and renewable energy in New York State. Walton also manages NYSERDA's Lighting Research Program. Other areas of her research include climate change communication to motivate individuals and businesses to reduce their carbon footprints.

Charlie Wilson, Lecturer in Energy and Climate Change Research, Tyndall Centre for Climate Change Research, University of East Anglia (United Kingdom). Wilson's research interests lie at the intersection between innovation, behavior, and policy in the field of energy and climate change mitigation. At a micro-scale, this includes work on individual and household decision making and behavior, with a particular emphasis on energy efficiency. At a macro-scale, this includes work on innovation systems and technological change, with a particular emphasis on low carbon energy supply technologies.

Appendix C: Participant List

Workshop on Social Science and the Alternative Energy Future

May 19–20, 2011
The George Washington University
Washington, D.C.

Kathleen Alexander
U.S. Department of Energy

Douglas Arent
National Renewable Energy Laboratory

Ruth Greenspan Bell
World Resources Institute

Leslie Berlowitz
American Academy of Arts and Sciences

Juliana Birkhoff
RESOLVE

Linda Blevins
U.S. Department of Energy

Marilyn Brown
Georgia Institute of Technology

Jonathan Cannon
University of Virginia

Ann Carlson
University of California, Los Angeles

Kevin Carroll
Office of Management and Budget

Paul Centolella
Public Utilities Commission of Ohio

Thomas Dietz
Michigan State University

Nicholas Donofrio
IBM (ret.); Kauffman Foundation

Kimberly Durniak
American Academy of Arts and Sciences

Alison Fox
American Academy of Arts & Sciences; Fox Strategic Group

Jeanne Fox
New Jersey Board of Public Utilities

Robert Fri
Resources for the Future

Kelly Sims Gallagher
Tufts University

Myron Gutmann
National Science Foundation

Adam Henry
West Virginia University

Holmes Hummel
U.S. Department of Energy

Roger Kasperson
Clark University

Christopher King
House Committee on Science, Space, and Technology

Steven E. Koonin
U.S. Department of Energy

Alan Krupnick
Resources for the Future

Alison La Bonte
White House Office of Science and Technology Policy

John "Skip" Laitner
American Council for an Energy-Efficient Economy

Jennifer Layke
Johnson Controls Inc.

Carol Lenox
Environmental Protection Agency

Jane Long
Lawrence Livermore National Laboratory

Robert Marlay
U.S. Department of Energy

Christa McDermott
U.S. Department of Energy

Granger Morgan
Carnegie Mellon University

Elisabeth Moyer
University of Chicago

Robert Nordhaus
Van Ness Feldman

Robert O'Connor
National Science Foundation

Margo Oge
Environmental Protection Agency

Edward A. Parson
University of Michigan

Tod Perry
National Renewable Energy Laboratory

Barry Rabe
University of Michigan

Bonnie Ram
Ram Power, LLC

John Randell
American Academy of Arts and Sciences

Eugene Rosa
Washington State University

Maxine Savitz
Honeywell, Inc. (ret.)

Maura Shannon
American Academy of Arts and Sciences

Philip R. Sharp
Resources for the Future

Rachael Shwom
Rutgers University

Adele Simmons
Chicago Metropolis 2020

Tobin L. Smith
Association of American Universities

Paul C. Stern
National Research Council

James Sweeney
Stanford University

Rita Teutonico
National Science Foundation

Michael Vandenbergh
Vanderbilt University

Marsha Walton
NYSERDA

Charlie Wilson
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