Climate Change and the Electricity Sector

THE ASPEN INSTITUTE

ENERGY AND ENVIRONMENT PROGRAM

2008 ENERGY POLICY FORUM

Jonathan Lash and Jeff Sterba, Co-chairs
Paul Runci, Rapporteur

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Foreword

With the expectation that a new Administration and new Congress in 2009 will actively consider climate change legislation, the Aspen Institute's 2008 Energy Policy Forum chose the topic of "Climate Change and the Electricity Sector." The Forum, now in its 31st year, convened a select group of leaders and policy experts to discuss commercial and public policy issues at the intersection of energy, the economy and the environment. As in previous years, the format relied heavily on dialogue among the diverse participants who brought a variety of perspectives and areas of expertise to the table. Short introductory presentations kicked off each half-day session, and a spirited, off-the-record discussion followed.

The dialogue was chaired by Jonathan Lash, President of World Resources Institute, and Jeff Sterba, CEO of PNM Resources and Chairman of the Edison Electric Institute and the Electric Power Research Institute. Their years of experience with energy and environment and their active participation in the national climate change policy discussion gave them the ability to focus the discussion on key issues and the skill to chair the meeting with firmness and good humor. They were also of great assistance in shaping the agenda. The highly qualified group of speakers provided a wealth of information and a variety of perspectives, and the diverse expertise of a particularly well qualified group of participants contributed substantially to the richness of the dialogue.

The Institute acknowledges and thanks the following Forum sponsors for their financial support. Most have been participants and supporters for many years. Without their generosity and commitment to our work, the Forum could not have taken place.

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On behalf of the Institute and the Forum participants, I also thank Paul Runci, who served as rapporteur. While no summary can capture the full richness of the discussion, his extensive knowledge of energy and climate change enabled him to identify the important threads and weave them into this summary report. Administrative arrangements for the Forum were admirably handled by Timothy Olson, whose hard work and attention to detail resulted in a pleasant and smoothly run meeting, and I am grateful for his efficient support.

This report is issued under the auspices of the Aspen Institute, and the co-chairs, speakers, participants, and sponsors are not responsible for its contents. Although it is an attempt to represent ideas and information presented during the Forum, all views expressed were not unanimous and participants were not asked to agree to the wording.

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Climate Change and the Electricity Sector

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The Challenge

The 2008 Aspen Energy Policy Forum convened at a noteworthy moment in U.S. energy history. With world oil prices at a record high of nearly $140 per barrel and gasoline in excess of $4 per gallon, energy has reached an important price point in the U.S., prompting consumers to change behavior and curtail energy use. Natural gas and coal prices have also risen dramatically, although with less consumer awareness. Current high gasoline prices and expectations that prices will remain high have shown that there is some elasticity in U.S. energy demand and that, even in the short-term, consumers can adapt creatively in response to energy challenges.

Public awareness of global climate change has grown in parallel with rising energy costs, prompting many government and industry leaders to believe that the U.S. Congress will pass legislation within the next three years mandating greenhouse gas reductions. As that expectation rises, however, energy price increases threaten to make action more difficult. Although the 2008 Lieberman-Warner bill proposing a tradable permit regime for U.S. carbon dioxide emissions failed to reach the Senate floor, many observers regard the bill as a harbinger of Congressional action on climate change following the 2008 elections. Against this backdrop of change and uncertainty, the first session of the Forum provided an overview of the state-of-the-art of climate change science, cost projections for the U.S. electric power industry, and implications of each for the other.

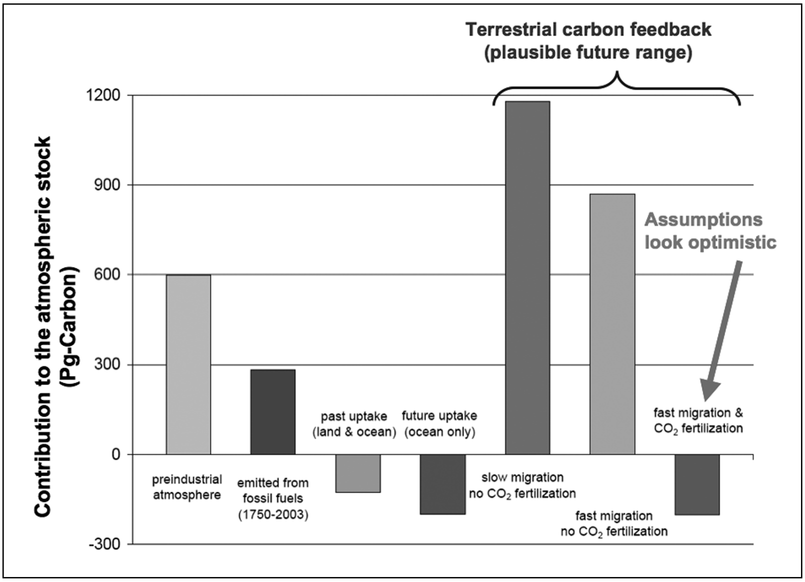
Climate Change Science: A Current Assessment

Recent scientific assessments, such as the 2007 Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, conclude that there is an unequivocal global warming trend now underway driven in large part by human actions. Key evidence supporting this conclusion includes observations of rising land and sea surface temperatures, rising sea levels, melting glaciers and shifting species ranges strongly correlated with rising emissions and concentrations of carbon dioxide and other greenhouse gases in the atmosphere and oceans. Use of fossil fuels, agricultural practices and deforestation have been implicated as the primary sources of greenhouse gas emissions and, subsequently, their rising concentrations. Depending on future patterns of greenhouse gas emissions, global mean temperature is expected to rise between 1.1° and 6.4° Celsius from pre-industrial levels by 2100. Even changes on the lower end of this range have not occurred in human history and could have severe impacts on societies and ecosystems for centuries to come.

Anticipated climate impacts depend on the degree of warming. Some impacts, including increasing frequency and intensity of extreme weather events and melting of glaciers and sea ice are already occurring. Stresses on some biological systems and degradation of ecosystem services such as air and water purification, pollination, and flood control have also been observed, but are likely to vary regionally in response to changes in temperature and precipitation patterns.

Scientists also caution that significant uncertainties remain, and that rapid, non-linear changes and surprise events are possible. For example, as the figure on the opposite page shows, large-scale emissions of terrestrial carbon resulting from the melting of arctic permafrost and changes in land cover and soils could occur as a result of warming from fossil fuel-related emissions. Emissions from carbon currently sequestered in soils and permafrost, estimated at approximately 1,900 petagrams, have the potential to exceed cumulative anthropogenic emissions from fossil fuels by nearly a factor of three. These terrestrial carbon feedbacks could also conceivably far exceed estimated terrestrial and ocean carbon uptake potential (“carbon sinks) and outpace the acceleration of any warming-related plant growth and migration.

Contributions to Atmospheric Carbon Stock.



Source: Adapted from Higgins & Harte, 2006

Currently we assume that the land surface will serve as a carbon sink since higher CO_2 concentrations in the atmosphere may stimulate both the growth of plants and their migration to favorable locations. Yet observations and experimental evidence suggest that higher levels of CO_2 may result in smaller than expected plant response and could also stimulate large-scale releases of carbon currently sequestered in soils.

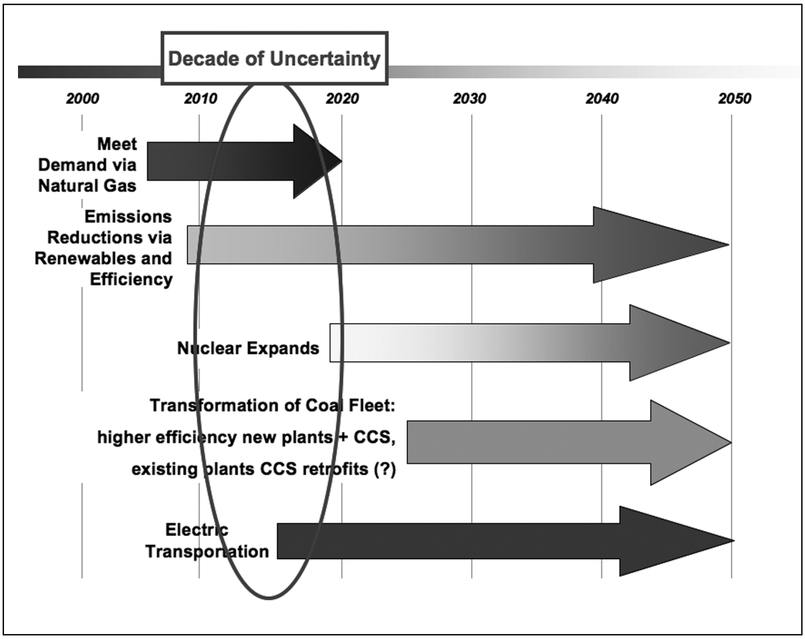
Increasing levels of fossil fuel use and land use change are the principal sources of anthropogenic greenhouse gas emissions, including carbon dioxide, methane, halocarbons and other trace gases that efficiently absorb solar radiation. Given the especially long-lived nature of carbon dioxide in the atmosphere, over 100 years, temperatures are likely to continue to rise for several decades even if emissions are sharply reduced.

Mitigating climate change will require sharp reductions in greenhouse gas emissions over the course of this century, by as much as 50 percent from 2000 levels by 2050 according to the Interacademy Council, an international confederation of national science academies. The implications of such global targets could be particularly serious for the U.S., depending on future global allocations of emissions rights. For example, a global allotment of the cumulative greenhouse gas emissions budget on a per capita basis could necessitate reductions of 80 percent or more from the U.S. and other industrialized countries, depending on the emissions reduction pathway selected. Required reductions will also be influenced by the extent of participation in future stabilization regimes. In the absence of full participation on the part of major developing countries, for example, industrialized countries would have to make far deeper domestic cuts than they would under a regime with broader global coverage.

Managing the Costs of Emissions Reductions

In order to achieve climate stabilization at least cost, emissions reduction trajectories would aim to avoid early retirement of capital such as power plants; however, early retirement of some capital assets could be necessary under the most aggressive emissions reductions scenarios. The cost of stabilization will also be a function of the timing of required emissions reductions and the availability of new technologies. Some analysts advocate policies that call for smaller reductions in the near term, followed by steeper cuts later. They suggest that technological change and innovation will make emissions reduction cheaper in the future and that such a trajectory would avoid early retirement of existing infrastructure. As the figure on the facing page shows, some of the technologies expected to contribute heavily to emissions reductions in the electricity sector are not expected to be available within the next decade. Yet others counter that the widespread commercial availability of new energy and carbon management technologies even at a later date is far from certain and that delaying emissions reductions could raise the costs of emissions reduction significantly. Some scientists also caution that the possibility of unanticipated, non-linear changes in climate argues in favor of earlier action to reduce emissions, even if that course would entail higher overall economic costs.

Timeframes for Key Technologies



Source: © 2008 Electric Power Research Institute, Inc.

Any emissions reductions required of the electric power sector in the next decade will be met primarily with natural gas, renewables, and efficiency. Expanded nuclear and less carbon intensive coal plants are not likely to be available until 2020 and 2025.

Debates over optimal emissions reduction pathways frequently reveal differences between scientists' and economists' thinking about the climate challenge. While economists often focus on least-cost stabilization pathways given a cumulative emissions budget, assuming alternative discount rates, technologies, and greenhouse gas allocations, many climate scientists are concerned about the uncertainties surrounding the climate responses under different emissions scenarios. Since alternative emissions trajectories reach varying peak levels of atmospheric concentrations before declining, climate responses may also vary considerably and in ways that are not well established scientifically. Thus, pathways that appear economically viable may be less optimal from a scientific perspective and vice versa.

While the vulnerabilities of human societies and ecosystems to climate change are great, the possibilities for innovation, adaptation, and increased resilience are also significant. Ongoing improvements in scientific understanding of climate change will help to facilitate more effective risk management and contribute to improved policy responses in the coming decades. Mitigation and adaptation will each play a critical role in response strategies; geoengineering technologies such as iron fertilization of the oceans may also provide important tools for climate stabilization. Geoengineering technologies have not yet been tested on a large scale however, and entail high levels of uncertainty, including the potential for significant negative environmental consequences in themselves.

Climate change presents particularly large challenges and potential costs to electric power, considering the extent and high value of the industry's capital assets. Minimizing the costs and disruptions associated with the industry's transition to a lower carbon future will require a broad portfolio of technologies and policy options that take advantage of the many opportunities for greater efficiencies throughout the system and that allow maximum possible flexibility in achieving emissions reductions. Climate change mitigation will have costs associated with it, but policy design will go a long way in determining the size of the cost burden on the economy.

The Energy Information Agency's 2008 reference case scenario projects 16 percent growth in carbon dioxide emissions from electricity generation in the U.S. between 2006 and 2030, based on an assumption of 29 percent growth in electricity consumption over the same period. Emissions are projected to rise in the reference case despite decreasing energy intensity and a larger share of renewable energy in the fuel mix, underscoring the magnitude of the challenge of reducing emissions by 50 percent from 2000 levels by 2050.

Although no single technology has the potential to achieve the required emissions reductions on its own, a wide variety of possible technology portfolios could be adopted to achieve a 50 percent carbon emissions reduction from power production. Yet the economics, technical viability, and timing of two particular technologies—nuclear power and advanced coal with carbon capture and storage (CCS)—will be major determinants of the composition of the future electricity generating fuel mix.

According to one model, if in 2020 new nuclear generating technologies are available at a cost of $64/MWh and the CO_2 transport and storage portion of CCS is available at $10/ton, these two technologies could account for as much as half of the industry's fuel mix by 2050. On the other hand, should these technologies not prove viable for broad commercial deployment until 2030, and at higher costs of $94/MWh and $30/ton of CO_2 transport and storage respectively, the contributions of nuclear and coal CCS would be down significantly while those of efficiency and renewable technologies such as biomass would account for a larger share of the fuel mix. Nuclear and CCS technologies are likely to play leading roles in almost any scenario in the long term, while the contributions of renewable technologies such as wind and solar will hinge in large part on availability of transmission and improvements in energy storage technologies.

Energy efficiency holds the greatest potential for emissions reductions in the near- to mid-term—as much as 1.3 gigatons CO_2 of abatement potential economy-wide to 2030, and much at negative cost. While they do entail transaction and opportunity costs, end use efficiency measures by one estimate constitute about half of the greenhouse gas abatement opportunities available economy wide to 2030. While low-carbon options (including CCS, renewable and small-scale hydropower technologies) for the electric power industry represent another 26 percent of carbon emissions abatement potential, almost all entail high capital costs and many are still fraught with uncertainties regarding their large-scale commercial viability. Opportunities for emissions abatement will have to be sought in all economic sectors and many will entail significant costs. However, negative cost opportunities for energy efficiency improvements could offset a large part of the incremental costs associated with other abatements measures.

Ideally a future climate regime would have global coverage—incorporating all economic sectors and geographic regions—to facilitate flexibility in the location of emissions reductions. Since the costs associated with emissions reduction opportunities vary significantly, the ability to capture the lowest cost opportunities initially would help to reduce aggregate costs in the long term.

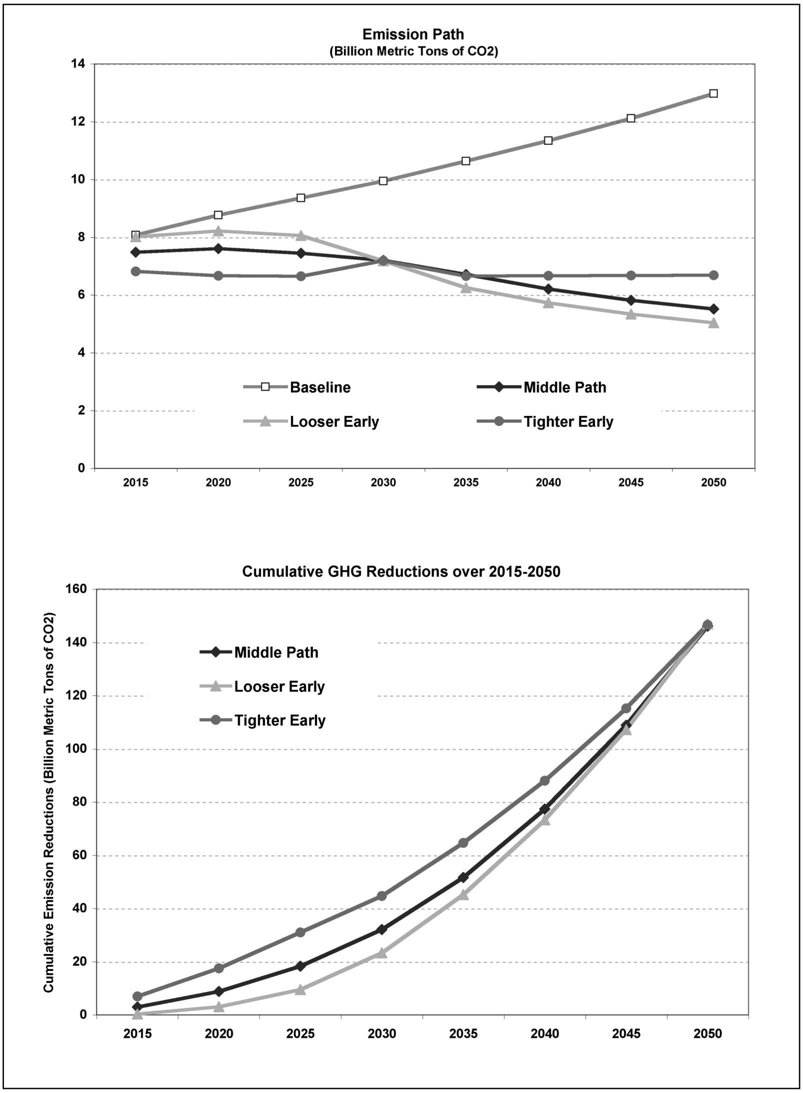
Several participants also called attention to the enormous potential for energy efficiency improvements in the U.S. electricity sector, noting that these may offer some of the most cost-effective opportunities for greenhouse gas emissions reduction. Since there is relatively low price elasticity in U.S. electricity demand, it seemed unlikely to some participants that expected rate increases would provide sufficient incentive for consumers to improve efficiency significantly, in the absence of policy interventions. Federal level policies, such as building codes and standards for appliances and industrial machinery will be needed to spur aggressive energy efficiency gains across all economic sectors.

Another important cost management tool will be mechanisms facilitating flexibility with respect to when, where and which greenhouse gases are controlled. While carbon may be the principle contributor to greenhouse gas emissions by volume, several other gases emitted in smaller amounts have far higher greenhouse warming potential. Allowing firms the flexibility to reduce their overall greenhouse gas emissions by managing a broader suite of gases could result in more cost effective emissions abatement.

Flexibility in the timing of emissions reductions will be as important as targets from a policy design standpoint. In contrast to policy measures mandating reductions along a specified schedule, timing flexibility in conjunction with other policy mechanisms such cap-and-trade systems with emissions banking and borrowing would build resilience into climate change response strategies and help to control costs.

Although some critics may view flexibility in timing as a delay tactic, advocates argue that sound flexibility policies will balance near-term emissions reduction actions with longer-term plans for investments in R&D and for the adoption of emerging low carbon technologies. The strategic combination of near- and longer-term actions will be essential to the attainment of emissions reduction targets while avoiding early retirement of capital and taking advantage of new technologies such as CCS, that could reduce long-term abatement costs. Assuming there are no major negative feedbacks, flexibility in timing also could accommodate emissions reductions along any of several potential long-term emissions pathways, as the figure shows. Each of these pathways has significantly different implications for the electric power industry and fuel providers, despite their similar long-term emissions stabilization levels. Policies imposing tighter constraints on carbon emissions in the near-term will prompt more aggressive fuel switching from coal to gas than policies with looser near-term emissions reduction mandates.

Three Paths to Same GHG Targets



Source: CRA International

One illustrative analysis of the timing of emissions reductions suggests that various options can achieve the same cumulative reductions by 2050.

Executive Choices

Even without climate change, executives in the electricity industry face many large challenges and constraints in their future operating environments. Regulatory uncertainties, the need for investment capital to expand and improve generating and transmission infrastructure, high and volatile fuel costs, and the challenges of keeping pace with demand growth are all problems with which industry leaders already struggle. The reality of climate change in addition to these other challenges adds significant new risks, uncertainties, and potential opportunities to the operating environment and is now a key strategic consideration for power companies, regulators, and federal and state legislators. Session II of the Forum discussed some of the current dynamics of the power industry and considered the choices facing energy executives as they aim to position their companies for future success.

A Changing Landscape

For more than a century, the primary mission of electric utility executives has been to ensure the provision of affordable, reliable power. For most of the past century, the cost of electricity steadily declined in real terms, with improvements in technology, economies of scale, and fuel choices that aimed to provide power at least cost. Coal was usually the fuel of choice.

Under the assumption that the U.S. electric power industry will operate in a carbon constrained world and possibly face mandatory greenhouse gas emissions reduction of 50-80 percent by 2050, the historic model of power production will no longer be viable. Instead, the industry's business model will have to be based on maximum productivity gains and optimized efficiency in the use of electricity. On the generation side, most or all existing capacity will also have to be replaced, due to age or in response to climate change and other challenges facing the industry. While the future generation portfolio will certainly include larger shares of renewables such as wind and solar, there will likewise be expanded shares of clean coal and nuclear technologies.

There are also large uncertainties with respect to climate change in the short- to mid-term that present strategic challenges to the industry. For example, the possibility—perhaps even the likelihood—of a federal level cap-and-trade system augments investments risks since such a system would, among its impacts, exacerbate price imbalances between gas and coal. A cap-and-trade regime would put enormous upward price pressure on gas because of its relatively low carbon intensity and could result in a very difficult adjustment period for power producers and consumers over the next decade. Since firms plan to operate new plants for at least 20 to 30 years, such legislative and regulatory uncertainties may retard major capital investments in the industry until legislation is passed.

Under these conditions, diversity among assets in the generating portfolio is essential to many utilities and competitive generators. For example, one small California utility recently purchased 1,000 MW of wind turbines to jumpstart its renewable energy program and has also begun to move into solar photovoltaics technology, despite its current high cost. Through bulk purchases of solar panels (250 MW), the utility hopes to reduce the cost of its entry into solar energy and to deploy the panels in a variety of settings ranging from commercial rooftops to large arrays in the Arizona desert.

While many executives feel that there must be a transformation of the generation and transmission businesses, many of the most potent changes in the industry's business model may come in the form of technological changes beyond the meter. There are, for example, major opportunities to optimize the system by monitoring and adjusting electricity end use. Some industry executives may decide that it makes more strategic sense to invest billions of dollars to create a digital, smart-grid infrastructure than to invest similar amounts in the construction of a new nuclear plant.

Rising fuel costs, likely carbon constraints and the need for a transformation of the industry's technology and infrastructure all suggest that power prices will rise significantly over the long term. This likelihood suggests that the industry could face widespread consumer resistance, as it has already in states such as Illinois, Maryland and California where significant rate increases after a freeze caught consumers by surprise. In the light of this possibility, it will be essential for the industry to make concerted efforts to educate consumers about the factors underlying the price increases and particularly to help them understand that there will be costs associated with the industry's actions to mitigate climate change. Consumers will also have to be convinced to accept that, like the power industry, they will have to make changes in their behavior and have some tolerance for higher costs in the interest of future generations. Today there is little evidence that consumers have taken an ownership stake in climate change mitigation; the fact that there were virtually no apparent consequences for members of Congress who voted against the 2008 Lieberman-Warner Bill is indicative in this respect.

State-Level Challenges

Both regulated utilities and competitive power companies are, of course, already responding to the need for major change and positioning themselves for an uncertain future and an evolving business and regulatory environment. In high growth states like Nevada, for example, companies will focus on conservation and efficiency in the first instance, and state regulatory agencies are seeking to manage demand and greenhouse gas emissions through building codes and standards. State regulators have provided incentives for power producers to adopt this approach by amending Nevada's renewable portfolio standards to include rate-based energy efficiency. Even though Nevada has a strong renewable energy base with major solar and geothermal resources and strong policy incentives, its aggressive target of 15 percent renewables by 2015 presents a major challenge to power companies operating in the state.

Power producers in Nevada will still have to expand their conventional generation to meet future demand growth. Power companies built no generation capacity in-state over the past 25 years, having decided to import electricity to meet rising demand. When electricity producers were caught short on one recent occasion, they lost $500 million as a result. Consequently, one company is planning a new coal-fired plant in-state to ensure reliability of service, and has gained the support of state regulators for the project. Yet even under favorable conditions at the state level, the project faces resistance from the federal Bureau of Land Management, and related delays are likely to stall the completion of the plant to 2015.

In California, the 2006 Global Warming Solutions Act has presented new challenges to utilities, which are now struggling with implementation of the law. In addition, utilities are also working to respond to several other pieces of legislation mandating, for example, one million solar roofs, and an aggressive renewable portfolio standard with targets of 10 percent by 2010 and 20 percent by 2017. For fully resourced, vertically integrated California utilities that rely on coal, this environment presents clear difficulties. Key constraints include the fact that renewable energy costs are rising sharply and renewable projects face grid integration problems. Moreover, with climate technologies such as CCS at least 10 to 15 years away from commercial deployment, technological silver bullet solutions appear unlikely. California utilities are responding to these challenges in many ways, for example through concerted customer education campaigns, through efficiency upgrades and replacement of older generating capacity, expansion of renewables, and by taking advantage of tax incentives and options to buy into purchase power agreements.

Technology Needs, Risks, and Opportunities

Several executives noted that technology will be a decisive factor in the success of climate policy and in the industry's ability to respond to climate change. While many existing technologies, including solar, wind and nuclear, are likely to be more widely deployed in the future, at least one critical technology, CCS, has yet to demonstrate its potential on a large scale. Many industry leaders are counting on the commercial availability of CCS by 2020 to sustain the viability of fossil fuel generation in the long term, yet its large-scale viability remains uncertain. The technology itself is still at an early stage, and only a few small- to mid-size demonstration projects have been undertaken.

While many in the industry have high hopes for CCS, other emerging technologies may also have a transformational effect on the industry and on the energy economy as a whole. For example, plug-in hybrid electric vehicles hold the potential to transform transportation by dramatically reducing gasoline use and boosting efficiency from roughly 15 percent (for today's internal combustion engines) to 85 percent or more. With major new investments to update the U.S. grid, plug-in hybrids could potentially be integrated into the electric power system as well to serve as supply technologies rather than solely as system load. In the absence of grid upgrades, the advent of plug-in hybrids could place additional pressures on natural gas and coal prices and increase carbon emissions from electricity production. Even though these emissions increases on some systems could be offset by reduced emissions from gasoline consumption, this situation would place additional pressures on the power industry, especially under a national climate policy.

Several participants called attention to the need for new approaches to energy research and development (R&D) in the light of the many technological challenges facing the nation. Major investments are needed not only in CCS and transportation technologies but in all areas, including renewables, nuclear, fossil fuels, efficiency and storage technologies. The carbon cap-and-trade systems that have been proposed in the U.S. have included some provisions for R&D funding, yet none would raise the estimated $100 billion needed for an aggressive effort to transform energy technology. Many participants were certain that a sufficient R&D funding stream would not be provided through the federal budget process but would more likely result from some off-budget mechanisms such as an R&D wires charge. By one estimate, a 3 mil per kWh charge could yield $11 billion annually for a dedicated R&D fund. Depending on the method of allocation, off-budget funding could also help to reduce earmarks and bureaucracy and allow researchers both the independence and funding stability they need to pursue ambitious projects.

Whether or not the federal government plays a smaller role as a funder and performer of energy R&D in the future, it will play a critical part in managing and buying down the risks associated with new technologies. Since emerging technologies such as CCS entail large risks and uncertainties, the government will be uniquely able to provide incentives and guarantees to early adopters and to garner public acceptance through information and education initiatives. A recent study by the Massachusetts Institute of Technology concluded, for instance, that CCS would only be likely to reach commercial viability after the successful completion of five to seven or more major demonstration projects. If the domestic regulatory environment does not evolve quickly enough and if the U.S. government is not able to work with industry to manage technology risks, some participants felt that the industry might work with other governments, most likely in the developing world, to field new technologies in pilot and demonstration projects.

Policy Design Issues

Most major stakeholders now agree that they must respond to the scientific and the political reality of climate change. Their responses over the next few decades are likely to transform the industry's governance, operations, infrastructure and technology.

Federal climate change legislation and policy, which most Forum participants agreed is likely to be passed during the next Administration, will provide the architecture for the transformation of the electric power industry and, in many respects, the economy as a whole. Thus, the nature of federal legislation will have a major impact on the pace and direction of change in the industry and on the effectiveness of climate change mitigation.

Some participants cautioned that the recognition of an urgent need for federal climate change legislation would not necessarily result in timely or sufficient action to address the problem. They remain skeptical of the federal government's ability to provide leadership on climate change, since it has yet to begin establishing the appropriate regulatory framework and has not yet made real commitments to the development of critical technologies such as CCS. Some observers suggested that the process of passing and implementing climate change legislation and establishing a sound regulatory framework could take another decade, while at the same time climate change science increasingly points to a need for faster and more drastic action.

Bearing in mind both the urgency and the importance of government responses to climate change, participants in this session addressed questions of policy choice and design and considered challenges of passing climate legislation at the federal level.

Congressional Actions and Prospects

Both houses of Congress have been actively considering various climate bills over the past year. In early 2008, the Senate Environment and Public Works Committee reported a climate bill that subsequently failed to make it to a floor vote, even with the addition of more than $800 million of incentives for carbon intensive industries. In the House of Representatives, the Energy and Commerce Committee held more than a dozen hearings on climate change in an effort to educate lawmakers on the state of the science and on policy options.

While the prospects for passage of climate legislation appear unlikely during the current Congress, it appears that a successful climate bill will have many provisions in common with the Lieberman-Warner and other bills recently considered including: a carbon emissions cap-and-trade system; increased support for energy technology R&D; incentives for energy efficiency; allowances for firms to receive credits for carbon offsets; and support to help hard-hit workers and industries transition to a low-carbon economy.

There are also several controversial issues that will still have to be addressed and resolved. For example, Congress remains divided over key policy design questions such as the inclusion of safety valve provisions in a cap-and-trade system, which would effectively set a ceiling price for carbon or, alternatively, the use of carbon taxes to give price certainty. There may also be trade provisions that offer protection to U.S. companies that cut emissions and that will have to continue to compete with foreign firms that do not. Some members of Congress favor border tariffs on imports as a means of leveling the playing field for U.S. companies, while others counter that such measures would be too broad a solution to a narrowly focused problem and would introduce new tensions into relationships with key countries such as China and India.

Although a weakening U.S. economy or the continued opposition of key Republican opponents could still impede its adoption, most participants agreed that comprehensive climate change legislation has considerable momentum behind it going into the next Congress. Since both Presidential candidates have indicated that they intend to sign a climate bill, and since Congress appears likely to remain under Democratic control, odds for the passage of legislation during the next presidential term appear better than even. Many are also eager to see the U.S. take a leadership role in climate diplomacy once again beginning in 2009 at the Copenhagen Conference, where negotiations on the post-Kyoto Protocol international climate policy architecture will commence. Even in the absence of legislation, the incoming President could order the Environmental Protection Agency to move ahead with carbon controls since the U.S. Supreme Court granted that authority in 2007.

Choosing Climate Policy Mechanisms

Any legislation adopted at the federal or state level will have to include concrete mechanisms for greenhouse gas abatement. Two policy tools for emissions reduction, the emissions cap-and-trade system and the carbon tax, are under consideration in the U.S. Cap-and-trade systems with a variety of trading regimes and traders have been adopted already by some U.S. states, by some private firms around the world, and by the European Union, which has by far the world's largest carbon trading system. Each of these options offers what many analysts feel are preferred approaches to emissions reduction and each design has its advantages and disadvantages, advocates and detractors. Forum presenters explained the key features and the relative merits and drawbacks of both approaches.

Proponents of a cap-and-trade system, including many forum participants, argue that one of the most important and fundamental features of this approach to emissions mitigation is that it allows market forces to set the price of carbon and other controlled greenhouse gases. Reliance on the market to determine the price of emissions, they argue, would lead to economically efficient emissions reductions and, at least relative to carbon taxes, would be less likely to engender overwhelming voter resistance. The specified level of annual greenhouse gas emissions under a cap-and-trade system also offers greater certainty in the amount and schedule of reductions, providing greater assurance that emission goals will be met.

Some critics of cap-and-trade point to the volatile first phase of the European Emissions Trading Scheme (ETS) as evidence of inherent shortcomings of this policy approach to carbon management. Yet, other analysts who have watched ETS closely into its current second phase contend that critics have misinterpreted the implementation of the system. By this reckoning, the ETS has achieved modest but real results in terms of emissions reductions and stable carbon prices thus far in its second phase (2008-2012).

The initial allocation of emissions permits is one of the most controversial questions surrounding cap-and-trade proposals. Many analysts advocate free distribution of a fixed percentage of permits, at least for a period of time, to the most carbon-intensive emitters—those who would incur the greatest hardships under the cap-and-trade system. The remaining permits would be auctioned on the open market. Using free allowances to reduce inherently unequal burdens could be an important means of garnering the support of firms and industries that might otherwise be powerful political opponents. Auction of permits, on the other hand, would not favor major carbon emitters and would generate more funds for research and development, adjustment assistance, and other desirable goals that could help win Congressional support. Advocates of cap-and-trade emphasize that a well-functioning system would also necessarily incorporate design features to prevent allowance hoarding and price manipulation. Whether permits are allocated at no charge or by auction, however, providing for banking and borrowing of emissions credits would introduce greater flexibility into the system by allowing emitters to either save or draw down emissions allowances in response to market conditions.

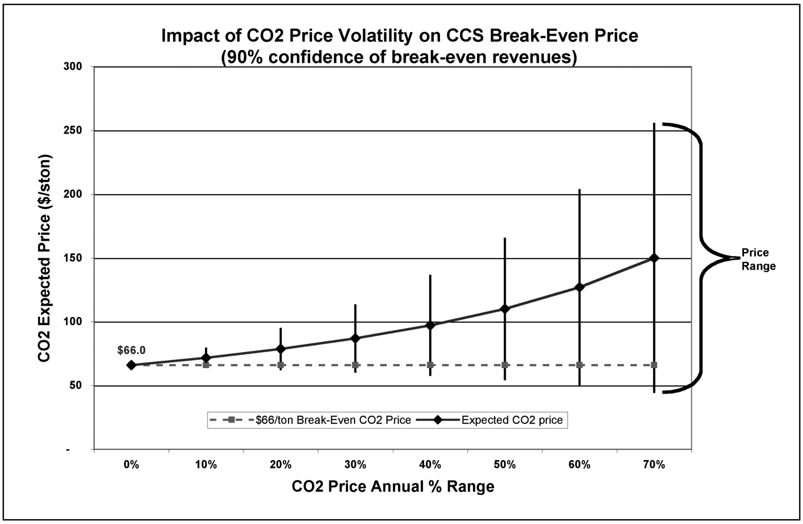
Carbon offsets managed through the Clean Development Mechanism (CDM) could also be incorporated into a cap-and-trade system as a means of controlling cost. Offsets would allow emitters in wealthier countries to fund emissions reductions in developing countries in cases where cheaper emissions reductions can be found there. Offsets, while promising, present an accounting challenge. They would require independent verification by a third party, such as the CDM Board in Bonn since both purchasers and providers would have incentives to exaggerate the effectiveness of offset projects. Currently however, there is no established federal level regulatory framework for carbon trading in the U.S. and no global governance structure either for carbon allowances or for carbon offsets. Some analysts believe that effective management of offsets will require the establishment of a baseline emissions scenario prior to the approval of any particular project, since offset projects are often based on counterfactual measurements of avoided emissions. Effective offset programs will require more rigorous measurement and documentation methods.

The "safety valve" is another cap-and-trade system design feature that has sparked controversy. Since emissions prices are set by the market, cap-and-trade systems offer no guarantees that prices will not rise to unanticipated high levels. For example, carbon prices in the European Union are expected to continue to rise throughout Phase II of the Emissions Trading Scheme (2008-2012) and beyond from the current level of approximately €23. A safety valve would effectively set a ceiling price for emissions in any given year as a means of controlling allowance prices for affected industries. Opponents of the idea argue that safety valves provide a disincentive for firms to reduce emissions and, unless it is set very high, amounts to a de facto carbon tax, resulting in an inefficient, hybridized climate policy. Moreover, critics argue that other hedging mechanisms could be used to reduce a firm's potential exposure to high carbon prices.

For those who favor carbon taxes over cap and trade, the ability to provide certainty on carbon prices and their impact on the economy is the most attractive feature. Since it is not possible to control both the quantity and the price of emissions reduction, tax proponents fear that the statutory emissions reductions under a cap-and-trade system would be likely to lead to high price volatility, as has often characterized the SO_2 tradable permit regime, and overall high carbon prices. Recent analyses also suggest that adoption of the cap-and-trade system proposed under the Lieberman-Warner bill could introduce significant price volatility into both carbon and gas markets.

While emissions banking and borrowing provisions could help to alleviate some of the CO_2 price volatility under cap and trade, extensive volatility could preclude sufficient investment in critical new technologies. One analysis suggests the extent to which greater volatility would raise the average expected price investors might require to invest in CCS. (See Figure 4.)

CO_2 Price Uncertainty and Investment



Source: The Brattle Group

Assuming a level price of $66 per ton of CO_2 were needed to break even on an investment in carbon capture and storage, price variability would raise the average expected price needed to ensure that 90 percent of the time the investment will break even or make a profit.

Similarly, one analysis suggests that carbon prices would be highly sensitive to changes in natural gas prices. For example, under one coal-to-gas redispatch scenario, a 20 percent rise in natural gas price would necessitate a 30 percent rise in carbon price to maintain the same emissions reduction.

Proposed cost control mechanisms under cap and trade aim to make carbon prices less volatile and thus more tax-like, in the opinion of carbon tax proponents. Yet these features may still be insufficient to allow cap and trade to deliver sufficient stability in terms of either price or emissions reductions.

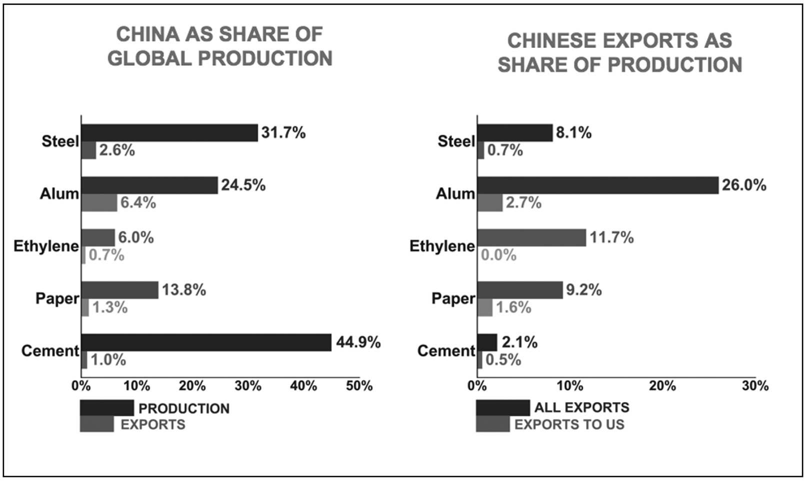
Trade Implications of U.S. Climate Policy Choices

Regardless of the climate policy course that the U.S chooses in coming years, industry and lawmakers have expressed concerns that it will give major trade advantages to countries that have not also adopted mandatory limits on greenhouse gas emissions. Globalization has already put great pressure on some U.S. manufacturing, and a primary concern now is that climate policy will disadvantage U.S. industry further, benefiting competitors in China particularly.

Some members of Congress and U.S. industry have proposed tariffs on energy-intensive imports from China and other developing countries to prevent such "carbon leakage." These measures would impose comparable costs on imports from targeted countries and protect U.S. heavy industries expected to be most affected by climate policies including steel, chemicals, aluminum, paper, and cement.

Yet closer analysis suggests that such tariffs would offer little protection to U.S. industry or leverage to the U.S. government and would serve principally to exacerbate relations between the U.S. and China, for several reasons. First, China is a minor source of U.S. imports in each of the industries mentioned as vulnerable, with the exception of cement, ranking it behind major partners by a factor of three or more. Second, demand for energy- and carbon-intensive Chinese goods is growing much faster domestically and in other developing countries than it is in the U.S. or other OECD countries, where demand is even decreasing in some cases (e.g. steel, cement). Thus, U.S. tariffs would be likely to impose next to no pressure on China's carbon-intensive industries (see figure below).

Extent of U.S. Trade Leverage over China



Source: Peterson Institute and World Resources Institute. Data from UN Comtrade, IISI, IAI, FAOStat, OGJ, USGS and CSA estimates.

Both concern that a cap-and-trade program will cause carbon-intensive U.S. industries to lose market share to China and hope that broad trade restrictions could prevent such a loss appear to be exaggerated. China is not a large exporter of these products, and Chinese exports are not a large share of U.S. imports.

Third, the Chinese government is already seeking to rein in exports of carbon-intensive goods, not because of potential climate impacts, but because of the impacts heavy industry has on human health domestically. For example, the Chinese government's removal of a value added tax rebate on steel exports in June 2007 has amounted to the equivalent of a \$50/ton tax on steel. Combined with the effect of a weakened U.S. dollar, Chinese steel imports already face a de facto U.S. import tariff of \$300.

Some analyses show that the structure of the Chinese economy may already be changing in important ways that have not yet been recognized by the International Energy Agency and others making projections of China's future carbon emissions. While mainstream projections show Chinese emissions on a steep, upward trajectory, China's discernible shift toward importing more energy-intensive goods and manufacturing less energy-intensive ones for the domestic and import markets could reshape China's emissions trajectory fundamentally. Rather than impose tariffs or other measures that are likely to do more harm than good, the U.S. should focus on constructive engagement with China through, for example, technical cooperation that will accelerate the reduction of industrial energy intensity and promote engagement on climate change and other key issues.

The perceived recent growth in protectionist sentiment in the U.S. Congress stems in large part from the desire to preserve U.S. manufacturing jobs, which appear threatened by the prospect of a climate policy, in the eyes of some observers. Yet it may be that the growth in new green jobs in the U.S. stimulated by climate policies could more than offset losses due to the closure of carbon-intensive manufacturing facilities and carbon leakage overseas. Moreover, as one analyst suggested, international trade and growth need not be a zero-sum game. Like other high tech industries such as information technology, green industries such as renewable energy are likely to constitute a large, international network. The success of a single company might entail job growth in the U.S., China, India, and Europe simultaneously, as some tasks are outsourced and others are performed at home.

Financial and Regulatory Issues

Climate change presents many shared challenges to private sector investors and energy regulators at the state and federal levels. Uncertainties surrounding future policy choices and direction, at the federal level especially, cloud decision makers' abilities to plan future technology and infrastructure investments and to ensure adequate, reliable service in the longer-term. While regulators and private sector executives may not need perfect information in order to make sound decisions, some degree of certainty with regard to the likely choices of climate policy instruments (e.g., carbon taxes, cap-and-trade system) and some degree of confidence in the stability of those policies once implemented will be necessary to catalyze large new investments in energy infrastructure in the U.S.

Dispelling Misleading Assumptions about Climate Policy

Particularly in the current climate of uncertainty, some Forum participants felt that it is important to dispel a few widely held assumptions regarding energy and climate change policy. In their opinion, challenging these assumptions will also be an important step in the development and adoption of sound and politically sustainable climate policies.

Assumption #1: Climate change can be managed at no cost. Several political leaders contend or imply that climate change mitigation could pay for itself, through efficiency gains, growth of green industry, and other unspecified means. Yet climate change may possibly be the largest problem in human history and one that will require major transformations of infrastructure, technology, and the economy as a whole. The expectation that such a transformation might be achieved without any net costs to the economy appears highly unlikely and, if proven false, could ultimately undermine support for climate change policies.

Assumption #2: All megawatts are created equal. Due to its carbon intensity, coal has drawn attention from many analysts and legislators who advocate emissions reductions from electricity production. Yet wind and solar are not perfect substitutes for coal, due to their different operating characteristics. Significant expansion of renewable energy would require a large-scale modernization and expansion of the grid, which will be difficult to attain considering the many state and municipal-level jurisdictions and siting regimes that would necessarily be involved. These jurisdictional constraints present major barriers to the expansion of more distributed and intermittent generating technologies.

Assumption #3: We can get by without coal. Coal's abundance, low price, and prevalence as a baseload generating fuel in U.S. electricity generation suggest that it will remain unrivaled by any other fuel in the foreseeable future. Given the scale of U.S. electricity consumption and demand growth, and the value of investment in coal-generating plants, coal is likely to remain the industry's predominant fuel even under a climate change policy. If CCS technologies prove commercially viable in the coming years, these systems would lend even greater certainty to the predominance of coal as the fuel of choice in the power industry for the next century.

Assumption #4: While technology will be a critical element of climate change strategies, technology alone will be insufficient in the absence of well-designed policies, markets, and behavioral changes to address the climate problem.

Also, while there will be technological advances and breakthroughs in the future, these advances may not be achieved on schedule and at projected cost. Thus, delaying action on climate change in the short-term with the expectation that better technologies will facilitate adequate mitigation later will necessitate costlier and more drastic policy actions in the long term.

Assumption #5: Barriers to energy efficiency will fall away under climate policy. Barriers to energy efficiency exist at the federal, state, and municipal levels, in current codes, standards and regulations, and in many industrial practices. While there are enormous opportunities for energy efficiency in the U.S., barriers to higher levels of efficiency will have to be actively removed and will not be as easy to achieve as some observers suggest.

Assumption #6: Expansion of nuclear power will not be necessary. In the light of anticipated growth in U.S. electricity demand, nuclear power may be uniquely able to expand baseload generating capacity without contributing additional greenhouse gas emissions. However, the expansion of nuclear capacity is likely to be limited by several factors including cost and waste management concerns.

Investment Risks and Challenges

Climate change mitigation will create new markets that require large capital flows. While many large investors are already poised to enter these markets, the continuing uncertainties surrounding questions of market design and policy choice have thus far precluded significant new investments in technologies to manage carbon emissions reductions. While investors are confident that climate change will be a game-changing opportunity for energy industry incumbents as well as new entrants, these players are now waiting on the periphery until the federal government fills what many regard as a climate policy vacuum in the U.S.

Private investors will have strategies to manage risk and to profit in the new markets for energy, technology, and emissions credits regardless of whether the market rises or falls, yet the absence of government action to establish basic market structures to date prompt investors to make only small market commitments sufficient to grant them access to information and remain in the game for now. Since investments in the energy industries can have life spans of 50 years, investors are wary of the highly dynamic, non-linear nature of the situation in the U.S., which could lead to another round of large stranded investments in the power industry.

One fundamental question concerns the mechanisms of eventual federal government action on climate change. Will the government use blunt policy instruments that act primarily to "bulldoze" bad behaviors and penalize emissions, or will it be able to adopt a more flexible and nuanced approach that provides incentives for preferred behaviors and technologies, acknowledges regional differences, and involves key stakeholders? Advocates of the latter strategy, with its emphasis on harmony of contending interests, policy integration and resilience, contrasted this "Zen garden" approach to the "bulldozer" approach. While some combination of these alternative approaches may be warranted, the establishment of markets and mechanisms that are durable over the long term may require more tailored and flexible designs.

The absence of a transparent mechanism for carbon price discovery is the most important barrier to private investments in carbon management technologies such as CCS. Yet it is also important to recognize that emerging technologies such as CCS entail additional risks that will not be solved by the establishment of functioning carbon markets. For example, since CCS has not been demonstrated at scale, investors cannot assume that it will be technically viable once the market structures are in place. For large-scale technologies like CCS that involve high capital costs and high risks, the federal government may have an important role to play in catalyzing deployment by limiting the liability of those who initially adopt these systems. Without some federal government protection, fears of endless litigation could inhibit critical investments in emissions mitigation infrastructure. Some Forum participants suggested that these risks make a strong case in favor of a stronger role for the Federal Energy Regulatory Commission which, in their opinion, needs clear regulatory jurisdiction in carbon management.

While some observers have argued that the adoption of cap-and-trade legislation will not create price certainty, many state regulators and electricity providers agree that the structural stability associated with the adoption of a cap-and-trade or other policy is more important than price stability. Like private firms, state regulatory agencies will be able to plan based on analysis and educated guesses once an architecture is erected to establish emissions reduction targets, compliance dates, cost containment mechanisms (e.g., safety valves) and procedures for allocating allowances.

Regulatory Risks and Challenges

Policy uncertainty also presents many risks and challenges to state energy regulators. Like private investors, state regulators need some degree of certainty in order to ensure reliable, affordable service in both the short and the long term, particularly in traditionally regulated states. Continued delay in climate policy making at the federal level makes it extremely difficult for state regulatory agencies to decide which resources should be approved, what regulatory actions might be necessary, and how to ensure that the competitive market will provide adequate supply. Like private sector decision makers, many state regulators are responding to uncertainty by attempting to do as little as possible in the short term to avoid doing harm in the longer term. Yet at some point, inaction also becomes an action plan with its own consequences for the future.

Coping with the short-term consequences of policy uncertainty is in many ways more challenging than coping with long-term ones. Regulators are encouraging power companies to boost energy efficiency to reduce demand and to develop renewable energy to the extent that it makes sense in the light of its relatively high cost and intermittency. These options are clearly not risk free and will be insufficient responses in the long term to control prices and guarantee reliability of service. With major questions still clouding the futures of nuclear power and CCS, state regulators are adopting a near term strategy that relies primarily on gas, despite serious concerns about cost and availability. In the longer term, sparing approval of new pulverized coal plants appears to be the best option, with the intention that some combination of nuclear and clean coal technologies is likely to be the best pathway ultimately.

Regulators and industry both agree that there are steps that they can take together now to reduce the longer-term likelihood of political turmoil in reaction to climate change policies. Since responding to climate change will impose costs on consumers, it is essential that the public is informed prior to the adoption of climate policies. The fact that a policy will raise costs does not mean that it ought not be adopted. But the public must buy in to the importance of climate change mitigation, especially since it will also be asked to tolerate additional rate increases to fund the overhaul and expansion of the nation's aging electricity infrastructure. Recent experiences in California, Maryland, and Illinois, where sudden rate increases prompted political backlash, are instructive in this regard. While there can be no guarantee that legislators will not change policy course again once a policy has been adopted, concerted public education efforts could go a long way toward the avoidance of unpleasant surprises and costly reversals of course later on. The responsibility for educating the public lies with those who are already informed.

APPENDICES

Agenda

Climate Change and the Electricity Sector

Co-Chairs:
Jeff Sterba, Chairman and CEO, PNM Resources
Jonathan Lash, President, World Resources Institute

Sunday, July 6

SEMINARS: Timeless Values, Timely Action

Seminar A. Values-Based Leadership in the 21st Century

Moderator: **D. Louis Peoples**
Vice Chairman and CEO Emeritus
Orange and Rockland Utilities, Inc.

Seminar B. The Big Trade-Offs: Efficiency, Equality, Liberty

Moderator: **Todd Breyfogle**
Director of Seminars
The Aspen Institute

Monday, July 7

SESSION I: The Challenge

Chair:	**Eileen Claussen**, President, Pew Center on Global Climate Change	
Speakers:	**Paul Higgins,** American Meteorological Society	Latest science, target
	Scott Nyquist McKinsey and Co.	Economy wide projections, with breakout of electricity sector
	Hank Courtright EPRI	Electricity sector projections, effects of timing of technology on costs
	Anne Smith CRA International	Projections, and effects of program design on costs
Respondent:	**Billy Pizer,** Senior Fellow and Director of Research, Resources for the Future	

SESSION II: Executives' Choices

Chair:	**Jeff Sterba,** CEO, PNM Resources
Speakers:	**David Crane** CEO, NRG Energy
	Theodore F. Craver, Jr. President, Edison International
	Phyllis Currie General Manager, Pasadena Water and Power
	James E. Rogers CEO, Duke Energy
	Michael Yackira CEO, Sierra Pacific Resources

Tuesday, July 8

SESSION III: Policy Design Issues

Chair: **Jonathan Lash,** President, World Resources Institute

Speakers:

Margaret Kriz
Reporter, National Journal

Robert N. Stavins
Professor and Director, Harvard Environmental Economics Program

Marc Chupka
Principal, The Brattle Group

Trevor Houser
Visiting Fellow, Peterson Institute for International Economics

Respondent: **Eileen Claussen,** President, Pew Center on Global Climate change

Wednesday, July 9

SESSION IV: Financial and Regulatory Issues

Chair: **Joseph T. Kelliher,** Chair, FERC

Speakers:	**Henry Derwent,** President and CEO International Emissions Trading Assn.	Regulating carbon markets
	Joel Swisher, Director of Technical Services, Camco	Flexibility in carbon markets
	Samuel J. Ervin IV, Commissioner, North Carolina Utilities Commission	Mitigating cost impact
	P.R. (Jeff) Miller, Partner, The Tremont Group	Investors' views

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