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.

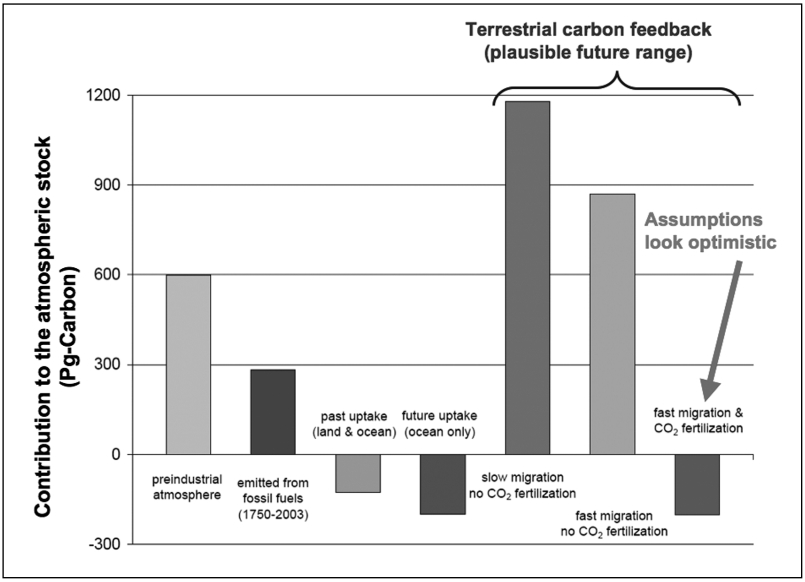
Climate Change Science: A Current Assessment

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.

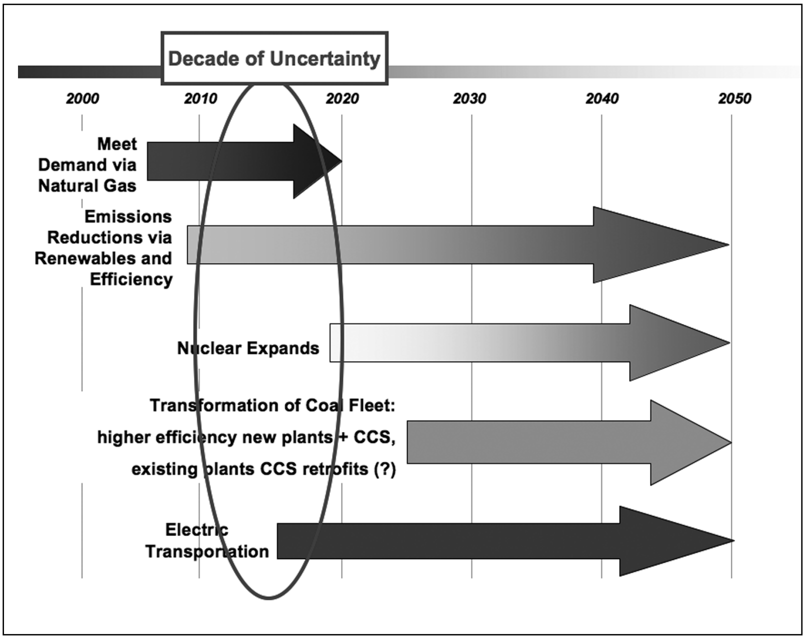
Increasing levels of fossil fuel use and land use change are the principal sources of anthropogenic greenhouse gas emissions, including carbon dioxide, methane, halocarbons and other trace gases that efficiently absorb solar radiation. Given the especially long-lived nature of carbon dioxide in the atmosphere, 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.

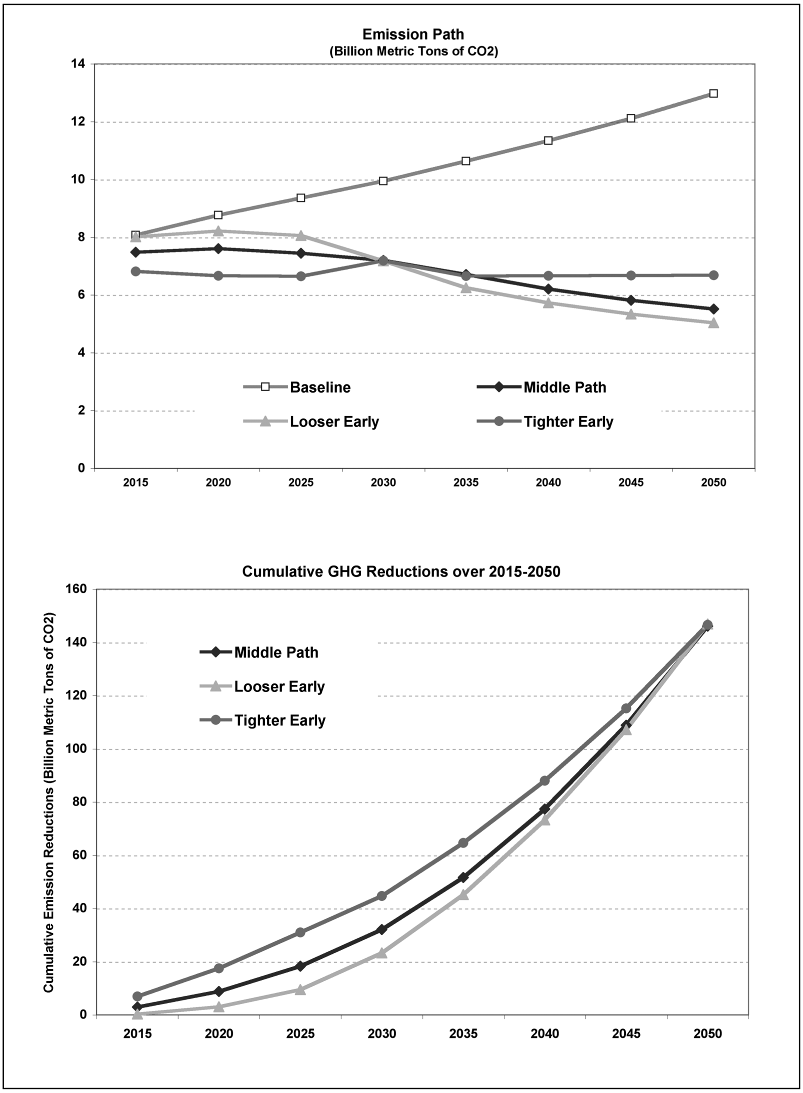
Several participants also called attention to the enormous potential for energy efficiency improvements in the U.S. electricity sector, noting that these may offer some of the most cost-effective opportunities for greenhouse gas emissions reduction. Since there is relatively low price elasticity in U.S. 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.