

**Statement of
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U.S. Department of Energy
to the
Subcommittee on Clean Air, Wetlands, and Climate Change
Committee on Environment and Public Works
U.S. Senate**

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Mr. Chairman and Members of the Subcommittee:

I am pleased to have the opportunity to participate in the discussion today. As Acting Assistant Secretary for Fossil Energy, my remarks will concentrate primarily on the programs in my area. The Administration will have activities that are carried out by many agencies throughout the government. While I will touch on issues and activities in other areas, I would defer to experts in other programs to discuss their efforts with you in more detail.

The Administration strongly opposes including reductions for carbon dioxide in S. 556 or any multi-pollutant bill. Pursuing sharp reductions in CO₂ from the electricity generating sector alone would cause a dramatic shift from coal to natural gas and thus would run the risk of endangering national energy security, substantially increasing energy prices, and harming consumers.

Unlike sulfur dioxide, nitrogen oxides, and mercury, carbon dioxide is not a pollutant. Addressing CO₂ is a question of climate change policy and separate from clean air policy, which the Administration's pending multi-pollutant proposal will address.

The Administration will not support any legislation that would cause a significant decline in our nation's ability to use coal as a major source of current and future electricity. At the same time, the Administration supports efforts to enhance the cleanliness of coal-fired electricity generation and promote a future for clean coal technology. In short, the Administration supports a clean coal policy as a critical component of our nation's energy and environmental policies, recognizing that other sources of energy also have a critical role to play.

The Administration recognizes the seriousness of the buildup of greenhouse gases in the atmosphere, even as scientists attempt to learn more about their actual effect on the earth's climate.

We know that the surface temperature of the earth is warming. We know that there is a natural greenhouse effect caused by atmospheric concentrations of carbon dioxide, water vapor, and other gases that contributes to this warming.

We know that the increases in atmospheric greenhouse gas concentrations since the beginning of the Industrial Revolution are due in large part to human activity.

Yet there is much we do not know. We do not know how much effect natural climate fluctuations have had on warming. We do not know how much our climate could, or will, change in the future. We do not know how fast change will occur, or even how many of our actions could impact it. We do not know the degree to which actions taken by one country, or group of countries, might be offset by the actions, or inactions, of other countries.

None of these uncertainties are cause for inaction, however. As President Bush said on June 11, 2001, “The policy challenge is to act in a serious and sensible way, given the limits of our knowledge. While scientific uncertainties remain, we can begin now to address the factors that contribute to climate change.”

The Framework Convention on Climate Change, to which the U.S. is one of 186 signatories, sets the long-term goal of stabilizing future concentrations of greenhouse gases at a level that would avoid “dangerous anthropogenic interference with the climate system.” There are two ways to achieve this stabilization. One is to avoid emitting greenhouse gases in the first place; the other is to capture and store them after they have been emitted.

While we are not now able to identify a concentration level that would pose “dangerous interference,” the President’s National Climate Change Technology Initiative, which he announced on June 11, will focus on cutting-edge technologies to avoid, capture and store carbon dioxide emissions as we pursue the long term goal of stabilization.

The Nation’s Power Industry

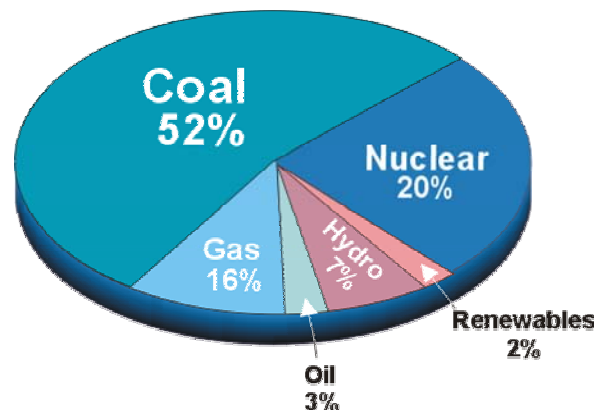
To understand the long-term need for an expanded menu of carbon management options for electric utilities, it is important to understand the current make-up of the Nation’s electric power industry.

The U.S. power generating sector remains the envy of the world. On any given day, 3200 utility and 2100 nonutility generators can make available up to 775,000 megawatts of electricity for virtually every home and business in the country.

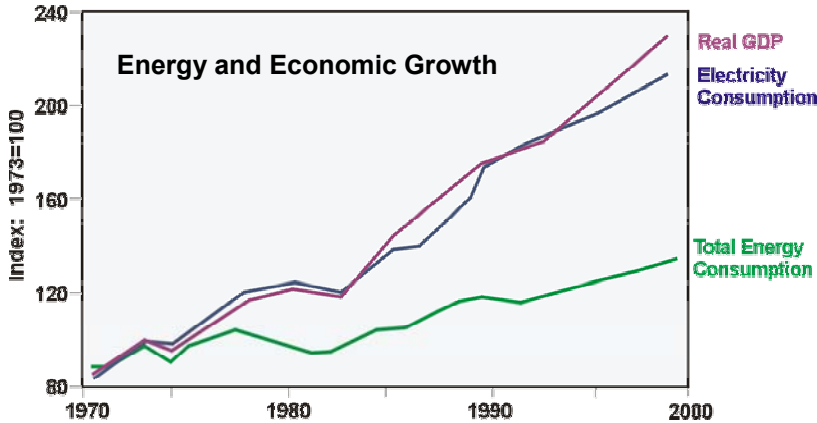
As the pie chart shows, fossil fuels supply about 70 percent of the Nation’s requirements for electricity generation. Coal, alone, accounts for more than 50 percent of the electricity Americans consume.

Primarily because of the power sector’s use of abundant supplies of American coal and natural gas, consumers in the United States benefit from some of the lowest cost electricity of any free market economy.

U.S. Electricity Generation by Fuel



America's economic progress and global competitiveness have benefited greatly from this low cost electricity.



Electricity is an essential part of America's modern economy. As this chart shows, while the Nation has made dramatic progress in "decoupling" overall energy consumption from economic growth, increased economic activity remains closely linked to the availability of affordable electric power – and is likely to remain so for well into the future.

The Nation's demand for electricity is projected to grow significantly over the next 20 years. Between now and 2020, the United States will likely have to add from 350,000 to 400,000 megawatts of new generating capacity to meet growing demand. This is equivalent to adding the entire power generation sectors of Germany and Japan, combined, to the U.S. power grid. Or put another way, to keep up with demand, the United States will have to build 60 to 90 new generation units of typical size each year for the next 20 years – in other words, adding more than one new plant *every week*.

Concurrent with this dramatic – and capital intensive – expansion of the Nation's power fleet, power generators will also be called upon to make new investments in pollution control technologies to meet tightening environmental standards.

Over the past 25 years, America's electric utility industry has invested billions of dollars in advanced technologies to improve the quality of our air. Each year, a substantial portion of normal plant operations costs – again amounting to several billions of dollars a year – are also associated with operating technologies that reduce air emissions.

The investment has returned dividends. By installing new technologies to capture particles of fly ash, the power industry has dramatically reduced particulate matter governed by the PM-10 national air quality standard. The power industry has also installed sulfur dioxide controls on more than 90,000 megawatts of capacity as part of a successful effort that has cut SO₂ emissions substantially since 1970. Many of the nation's coal-fired plants have also installed nitrogen oxide controls that have helped keep these emissions in check until more substantial controls are placed on these units in the future.

In short, advanced technology – given the time to mature and be deployed – can be effective. Technological improvements have permitted the Nation’s power sector to continue generating relatively low cost power and, at the same time, use the energy resources America has in most abundance. America’s use of coal, for example, has actually tripled since 1970 even as our air has become cleaner. Advanced technology also offers a pathway toward the prospects of achieving even greater reductions in air pollutants in the future.

An important question confronting policy makers today is: can the same cost-effective progress be made in reducing carbon emissions using improved technology?

Carbon Management Options for Power Generators

A number of factors – both natural and manmade – contribute to the greenhouse effect. Water vapor in the air, for example, has the largest greenhouse effect, but its concentration is determined internally within the climate system, and on a global scale, is not affected by human sources and sinks. Methane, ozone, nitrous oxide, and chlorofluorocarbons are other greenhouse gases in addition to carbon dioxide.

In terms of carbon dioxide, utilities currently account for about one-third of the CO₂ emissions released in the United States by human activity. One challenge is to decouple greenhouse gas emissions and the use of low-cost, reliable fuel resources – in other words, reduce emissions while avoiding the economic disruption of a massive overhaul of the Nation’s energy supply system.

There are generally three approaches for accomplishing this “decoupling.” One is to use energy more efficiently. The second is to place greater reliance on renewables, nuclear power, and low-carbon fuels such as natural gas (and eventually perhaps, hydrogen). The third is a more recent approach now gaining increasing momentum in the technical community: to capture carbon gases from energy systems and store them.

Approach #1 - More Efficient Energy Use: Most people associate the term “energy efficiency” with the consumption of energy – i.e., more efficient automobiles, home appliances, and manufacturing equipment. Indeed, the U.S. has become a much more energy efficient nation in the past quarter century. Had Americans continued to use energy as intensively as they did in 1970, the U.S. economy would today be consuming about 177 quadrillion Btus (quads) of energy, rather than the 99 quads we actually consume.

But as the President’s National Energy Policy points out, “energy efficiency” improvements can also be applied at the point where power is generated – at the power plant itself.

Today, an average coal-fired power plant converts about 33 percent of the energy value of the incoming fuel into useable electric power. An average natural gas combined cycle turbine plant converts from 40 to 50 percent of its fuel into electricity. Most of the unused energy is discarded as waste heat.

This offers tremendous potential for energy savings – and corresponding carbon reductions – by improving the fuel-to-electricity efficiencies of both current and future power plants. For example, if we could boost just the average coal-fired power plant efficiency, alone, from 33 percent to 35 percent, the energy savings would be equivalent to:

- weatherizing 82 million homes – or roughly every home in the country that isn’t currently weatherized, or
- replacing 300 million 100-watt incandescent light bulbs with fluorescents, or
- installing 7.4 million commercial heat pumps.

Such an efficiency gain would also reduce carbon emissions from power generators by nearly 26 million tons per year.

Achieving this modest efficiency improvement in today’s power plants could be relatively cost-effective. In some cases, advances in computer systems – i.e., the use of artificial intelligence to optimize burner performance and other plant operations – might be sufficient to achieve the increased efficiencies.

Moreover, 66 percent of U.S. coal-fired power plants – representing 200,000 megawatts of power capacity – are 20 to 40 years old and could be candidates for “repowering” with improved, higher efficiency combustors or new, even more efficient power generating options.

A renewed interest in supercritical coal-fired power plants is occurring as power plant designers incorporate major improvements in materials for boilers and steam turbines that have occurred since the early 1980s. These plants, which operate at higher steam temperatures and pressures, will show significant efficiency advantages over older “sub-critical” units.

As important as these incremental advances in efficiency will be, in actuality, we believe they are only a small step toward what might ultimately be feasible. With technology development underway in the United States and overseas, the power industry is now preparing for a major step forward with a new generation of even more efficient power plants.

We see the potential for coal-based power technologies emerging within this decade with efficiencies in the range of 40-45 percent; and by the middle of the next decade, we could have technologies in place to boost efficiencies to as much as 60 percent.

One of the best prospects for achieving these significant boosts in power efficiencies is *coal gasification combined cycle* – an emerging technology in which coal is converted into a combustible gas, rather than burned directly, and the gas is cleaned and burned in a gas turbine. The exhaust from such a system remains hot enough to drive a conventional steam turbine, producing a second output of power – accounting for the name combined cycle – and resulting in the significant boost in efficiencies.

The first pioneering coal gasification combined cycle plants are already operating. Two are in the United States. Built as government-industry “clean coal technology” partnerships, commercial-scale (250-megawatt class) power plants are running near Tampa, FL, and West Terre Haute, IN. They are the cleanest coal-fired power plants in the world. Their first-of-a-kind efficiencies are already approximately 40 percent or more, and they are providing the essential “real-life” data that engineers can use to make further efficiency improvements in the future.



The Tampa Electric Coal Gasification Combined Cycle Plant

Natural gas systems are also benefiting from gains in efficiencies brought about by recent R&D. Within the last two years, as a result of DOE-industry technology partnerships, U.S. turbine manufacturers have introduced advanced turbines that will top the 60-percent efficiency mark for combined cycle operation – a threshold once considered the “four minute mile” of turbine technology.

Not only will advanced high-efficiency turbines be used in future gas-fired power plants – including plants now being built in New York and Florida – they also provide a means for enhancing the performance of future coal gasification power plants.

Even higher efficiencies may be possible by developing “hybrid” combinations of advanced gas turbines and fuel cells. The first prototype systems are being designed and tested. A 220-kilowatt solid oxide fuel cell/microturbine is being readied for operation in California. A 1-megawatt system is on the drawing boards for Ft. Meade, Maryland. If the current high costs of fuel cells can be reduced and the technical challenges of linking a fuel cell with a turbine can be overcome, it may be possible in the future to generate electric power from fossil fuels at efficiencies of 75 to 80 percent or higher.

The carbon reduction potential is significant. If power plant efficiencies can be increased by 50 percent over today’s deployed plants, greenhouse gas emissions could be reduced by more than 340 million tons of carbon per year by 2050.

Approach #2 – Greater Reliance on Low- or No-Carbon Fuels: *Natural gas* currently provides only 16 percent of U.S. electricity generation. But natural gas is projected to be the dominant source of fuel for new power plants in the next two decades. As much as 90 percent of capacity additions between 1999 and 2020 could burn natural gas. The amount of natural gas used in electricity generation is projected to triple by 2020.

Natural gas emits about half the carbon emissions of coal. Yet, the dominant growth of natural gas use in the power markets is neither certain, nor necessarily desirable from an energy diversity and economic standpoint.

Low natural gas prices in 1998 and 1999 caused the industry to scale back drilling and production. In 2000, natural gas prices quadrupled, which led to substantially higher prices for electricity generated with natural gas. While supplies are up this winter, these price fluctuations illustrate some of the difficulty of over-reliance on natural gas.

Natural gas will likely be the preferred fuel for new power capacity if natural gas prices remain below \$3.00 per thousand cubic feet. If gas prices, however, rise much above \$4.00 per thousand cubic feet, it is likely that many power generators will turn back to coal or other power generating options.

Nuclear energy accounts for 20 percent of all U.S. electricity generation. Nuclear power emits no carbon dioxide emissions at all; therefore it holds great potential for contributing to the long-term goal of stabilizing greenhouse gas concentrations. Yet, for a variety of reasons, including uncertain capital costs and length of construction, no new nuclear plants have been ordered in the United States since 1973.

Since the 1980s, nuclear power plant operations have substantially improved. While U.S. nuclear plants once generated electricity only 70 percent of the time, today's average plant is online close to 90 percent of the time, which has helped lower the cost of nuclear-generated power. As the President's National Energy Policy describes, by increasing operating performance to 92 percent, an additional 2,000 megawatts of electricity could be generated from existing plants, and by "uprating" current plants with new technologies and methods, another 12,000 megawatts of generating capacity might be possible.

Utilities are also considering nuclear energy as an option for new generation. The Nuclear Regulatory Commission has certified three standardized nuclear power plant designs, and Congress enacted legislation in 1992 to reform the nuclear licensing process. Advanced reaction designs offer the enhancements to safety and economics needed for these technologies to come to market in the next decade and beyond. New nuclear generators could also be built on existing sites; many current sites were designed for 4-6 reactors, and most operate only 2-3.

Renewable energy, although a relatively small contributor to current U.S. power generation, could play a major role in achieving greenhouse gas stabilization. Wind energy, for example, currently accounts for only 0.1 percent of total electricity supply; however, technological advances have helped cut wind energy's costs by more than 80 percent during the last 20 years. The President's National Energy Policy supports activities that could lead, by mid-century, to a national energy system comprised increasingly of distributed energy generation devices that use wind, solar, biomass, hydroelectric and geothermal sources, and some of which would be supplied by natural gas. Renewable energy technologies could also be used for baseload power in central stations or to produce hydrogen. For this to occur, advanced technologies will need to be developed. These include biopower technologies that can be fueled by biomass or perhaps a combination of coal and biomass fuels, advanced hydropower such as micro-hydro systems (less than 100 kilowatts), biomass-fuel cell power technology, advanced wind energy, geothermal energy, and advanced photo-conversion power systems.

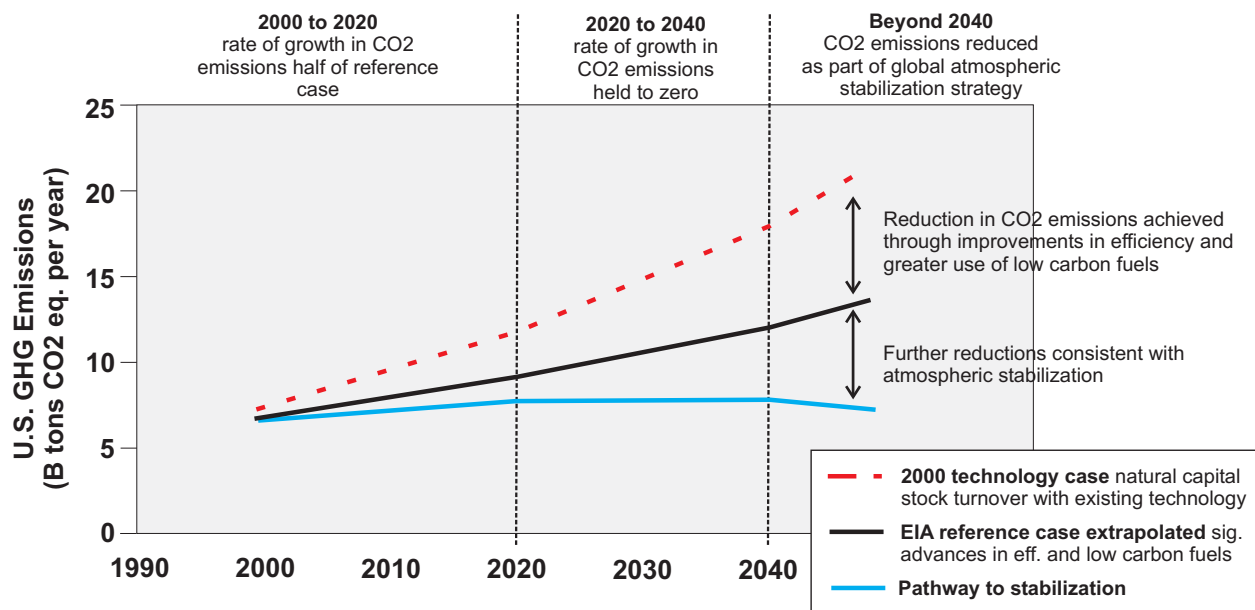
Approach #3 – Carbon Sequestration: Barely five years ago, virtually no one discussing climate change mitigation options used the term “carbon sequestration.” The concept of removing carbon dioxide from either manmade emissions or the atmosphere, then safely and permanently storing it or converting it to value-added products was thought too farfetched for serious discussion.

Today, however, there has been a remarkable turnaround in the scientific and engineering community.

Carbon sequestration is now considered to be a viable “3rd option” for future greenhouse gas reductions. President Bush gave it special attention in his June 11, 2001, remarks, saying “We all believe technology offers great promise to significantly reduce [carbon] emissions – especially carbon capture, storage and sequestration technologies.”

Carbon sequestration, if it can be developed to the point where it is practicable, affordable and environmentally safe, offers the potential for dramatic CO₂ reductions over the long-term, perhaps even more than would be possible through efficiency improvements and low-carbon fuels together.

The following shows one possible pathway to the long-term goal of stabilizing atmospheric concentrations of greenhouse gases. This scenario is but one of many which could be envisioned. In it the growth in greenhouse gas emissions is slowed over the next 20 years and eventually stopped at the reference case 2010 level. The upper arrow refers to current Energy Information Administration projections for efficiency advances and low-carbon fuel use; the lower arrow, consistent with atmospheric stabilization, assumes a combination of additional efficiency gains and a large contribution from carbon sequestration.



By working with growth and natural capital stock turnover, this pathway to stabilization allows time for new technology and low-cost options and the long-term introduction of carbon sequestration. It also prevents a rapid increase in greenhouse gas emissions over the next 20 years, thus reducing the need for steep, economically harmful reductions in the future.

Why the recent surge of interest in carbon sequestration? There are three primary reasons.

First, many in the technical community now believe it will be possible to develop carbon capture and storage technologies which will add less than a 5 percent increase in energy system costs – equivalent to only 2/10ths of a cent per kilowatt-hour to today's average cost of electricity.

Second, the past five years have seen a wealth of high-potential concepts emerge from the scientific and engineering community, and many of the “blue sky” ideas of four or five years ago are now maturing into actual processes on the threshold of their first field trials.

A third reason may be the realization of many in the energy industry that carbon sequestration may be geographically and economically practical, and in some cases, could actually become a revenue-generating venture. For example, from a geographic standpoint, storing CO₂ in underground saline formations has the benefit of being in close proximity to many large power plants. From a revenue standpoint, storage of CO₂ in oil reservoirs and unmineable coal seams could lead to increased oil and natural gas recovery, generating additional cash flow.

Five years ago, the Department of Energy offered modest, \$50,000 grants to proposers who might have worthwhile ideas for carbon sequestration. Twelve grants were awarded, but the number of good proposals far exceeded the funding available. Today, the Department's Office of Fossil Energy has more than 50 carbon sequestration research projects, with an FY 2002 budget of more than \$32 million.

Partners in our carbon sequestration program range from small entrepreneurial developers to large energy companies such as BP and environmental organizations such as The Nature Conservancy.

Today our development program encompasses five major technological “pathways:” (1) carbon separation and capture, (2) geologic storage, (3) terrestrial storage, (4) ocean storage, and (5) novel sequestration systems.

Progress is being made in all five. For example:

- We now have empirical evidence that advances in sodium carbonate technology can capture 50 percent of the CO₂ emission from a power plant at cost of \$15 per ton of carbon – a 10-fold reduction in costs compared to previously available technology.

- An innovative “CO₂ Wash” process is being used at the New Jersey EcoComplex to capture CO₂ before it escapes from a nearby landfill and use it to clean impurities from the landfill gas, which can then be used as a clean fuel.
- Preparations are underway to begin monitoring the injection of carbon dioxide from the Great Plains Coal Gasification Plant in North Dakota into the Weyburn oil field in southeastern Saskatchewan. Although 30 million tons of CO₂ are injected into geologic formations each year in the United States as part of enhanced oil recovery, this is will be the first large scale test to monitor the capacity, movement, and storage integrity of CO₂ injected into a geologic formation.
- Terrestrial carbon sequestration projects are underway in Pennsylvania and Kentucky, both using surface mine reclamation lands to determine if newly planted trees and vegetation can serve as “biological scrubbers” for carbon dioxide.
- Scientists at the Department’s Albany Research Center have made dramatic breakthroughs in a process that converts CO₂ into an environmentally benign mineral by reducing processing times from weeks to under 30 minutes, an advance that greatly improves prospects for a future commercially-viable process.

If it can be successfully developed, carbon sequestration could ultimately lead to a fossil fuel-fired power plant that has virtually no net emissions of any type.

As described in *Approach #1 - More Efficient Energy Use*, gasification combined cycle technologies are becoming increasingly attractive for the next fleet of coal-fired power plants. Not only do these plants offer the potential for 99% or greater reductions in air pollutants (such as sulfur dioxide, nitrogen oxides, and particulates), most configurations will also produce a highly concentrated stream of CO₂ (in contrast to a conventional coal-burning plant in which the CO₂ is diluted with large quantities of nitrogen from the air). This makes processes for separating and capturing CO₂ much easier and more cost-effective. Future concepts using gasification to produce hydrogen will separate the CO₂ as part of the production process.

The concept of an emission-free fossil fuel energy plant is far from unreasonable. In fact, the Department, in collaboration with the power industry, has set a goal to develop the basic configuration of such a plant by 2015.

Termed *Vision 21*, the new energy plant would virtually eliminate concerns over emissions of regulated air pollutants. Combined with carbon sequestration, such a plant could virtually eliminate all environmental concerns over carbon dioxide buildup from fossil fuel power generation.

A Question of Timing

As I've described in this testimony, there are a wide range of potential options for reducing greenhouse gas emissions from power generating plants and other energy facilities. Most are in various stages of development, and none by themselves offer a "silver bullet" to resolving climate change concerns.

Even if they did, requiring sharp reductions in CO₂ before new technologies can be developed and deployed can have major negative ramifications for both America's economy and our energy diversity. Imposing compliance requirements before a wider range of options is available would drive many power suppliers to shift away from coal to natural gas and, to a lesser extent, renewable fuels.

This sudden and sharp change in fuel mix would inevitably drive up prices. Analyses by the Energy Information Administration of S. 556 show the likelihood that a CO₂ emission cap could increase electricity prices by 43 percent in 2010 and by 38 percent in 2020 over the reference case. As much as \$80 billion in 2010 and \$63 billion in 2020 could be diverted from other areas of the economy to pay the Nation's increased electricity bill.

The Administration strongly urges the Congress to take a more prudent, deliberative approach to climate change mitigation. We strongly request that Congress work with the Administration to create a technology R&D and investment climate that will produce low cost options to address climate change.

Finally, a program that focuses exclusively on power plants ignores opportunities for cheaper reductions in greenhouse gas emissions that may exist elsewhere in the economy and around the world. While electric power generation represents a large portion of direct emissions -- and reducing those emissions will be a necessary part of a long-term solution -- it does not follow that they represent the only or even greatest opportunity for inexpensive emission reductions in the shorter term. A reasonable and balanced approach to climate change should consider this broader universe of opportunities.

This concludes my prepared statement. I will be pleased to answer any questions Members may have.