



David G. Hawkins

Director, Climate Center

Natural Resources Defense Council

Testimony

Before the Subcommittee on Energy and Air Quality

Committee on Energy and Commerce

United States House of Representatives

Hearing on

Carbon Capture and Sequestration: An Overview

March 6th, 2007

Summary

Coal use today is responsible for large and mostly avoidable damages to human health and our water and land. Coal use in the future, along with other fossil fuels, threatens to wreak havoc with the earth's climate system. Because coal is so abundant, capture of carbon dioxide from industrial coal sources and geologic disposal (CCD) is essential to reconcile continued coal use with avoidance of this profoundly damaging disruption of our climate. New coal plants forecast to be built in the next 25 years, if not equipped with CCD, will emit 30 per cent more carbon dioxide in their operating lives than has been released from all prior human use of coal. We cannot afford to delay use of CCD on new coal plants.

Fortunately, we know enough today to implement large scale CCD for coal plants now in the design stages. Experts have concluded that such operations can be conducted safely if an effective regulatory regime is put in place to license and monitor operations of disposal sites. EPA has the legal authority to write such rules but direction from Congress is needed to assure the rules will be written in a timely manner. Experts also have concluded that we can have confidence that properly selected and operated disposal sites can retain injected CO₂ for the required long periods of time.

Policies to limit CO₂ emissions and set performance standards are essential to drive use of CCD at the required scale and pace. Such policies should be enacted in this Congress. Well designed measures can phase in CCD on new coal plants with only very modest impacts on retail electricity prices.

Finally, CCD is only one of several tools available to cut global warming emissions. The fastest and cheapest method remains energy efficiency, with increased reliance on renewable energy resources providing another essential tool.

Testimony of David G. Hawkins

Director, NRDC Climate Center

Thank you for the opportunity to testify today on the subject of carbon capture and sequestration. My name is David Hawkins. I am director of the Climate Center at the Natural Resources Defense Council (NRDC). NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles and San Francisco, Chicago and Beijing.

Today, the U.S. and other developed nations around the world run their economies largely with industrial sources powered by fossil fuel and those sources release billions of tons of carbon dioxide (CO₂) into the atmosphere every year. There is national and global interest today in capturing that CO₂ for disposal or sequestration to prevent its release to the atmosphere. To distinguish this industrial capture system from removal of atmospheric CO₂ by soils and vegetation, I will refer to the industrial system as carbon capture and disposal or CCD.

The interest in CCD stems from a few basic facts. We now recognize that CO₂ emissions from use of fossil fuel result in increased atmospheric concentrations of CO₂, which along with other so-called greenhouse gases, trap heat, leading to an increase in temperatures, regionally and globally. These increased temperatures alter the energy balance of the planet and thus our climate, which is simply nature's way of managing energy flows. Documented changes in

climate today along with those forecasted for the next decades, are predicted to inflict large and growing damage to human health, economic well-being, and natural ecosystems.

Coal is the most abundant fossil fuel and is distributed broadly across the world. It has fueled the rise of industrial economies in Europe and the U.S. in the past two centuries and is fueling the rise of Asian economies today. Because of its abundance, coal is cheap and that makes it attractive to use in large quantities if we ignore the harm it causes. However, per unit of energy delivered, coal today is a bigger global warming polluter than any other fuel: double that of natural gas; 50 per cent more than oil; and, of course, enormously more polluting than renewable energy, energy efficiency, and, more controversially, nuclear power. To reduce coal's contribution to global warming, we must deploy and improve systems that will keep the carbon in coal out of the atmosphere, specifically systems that capture carbon dioxide (CO₂) from coal-fired power plants and other industrial sources for safe and effective disposal in geologic formations.

The Toll from Coal

Before turning to the status of CCD let me say a few words about coal use generally. The role of coal now and in the future is controversial due to the damages its production and use inflict today and skepticism that those damages can or will be reduced to a point where we should continue to rely on it as a mainstay of industrial economies. Coal is cheap and abundant compared to oil and natural gas. But the toll from coal as it is used today is enormous. From mining deaths and illness and devastated mountains and streams from practices like mountain top removal mining, to accidents at coal train crossings, to air emissions of acidic, toxic, and heat-trapping pollution

from coal combustion, to water pollution from coal mining and combustion wastes, the conventional coal fuel cycle is among the most environmentally destructive activities on earth. Certain coal production processes are inherently harmful and while our society has the capacity to reduce many of today's damages, to date, we have not done so adequately nor have we committed to doing so. These failures have created well-justified opposition by many people to continued or increased dependence on coal to meet our energy needs.

Our progress of reducing harms from mining, transport, and use of coal has been frustratingly slow and an enormous amount remains to be done. Today mountain tops in Appalachia are destroyed to get at the coal underneath and rocks, soil, debris, and waste products are dumped into valleys and streams, destroying them as well. Waste impoundments loom above communities (including, in one particularly egregious case, above an elementary school) and thousands of miles of streams are polluted. In other areas surface mine reclamation is incomplete, inadequately performed and poorly supervised due to regulatory gaps and poorly funded regulatory agencies.

In the area of air pollution, although we have technologies to dramatically cut conventional pollutants from coal-fired power plants, in 2004 only one-third of U.S. coal capacity was equipped with scrubbers for sulfur dioxide control and even less capacity applied selective catalytic reduction (SCR) for nitrogen oxides control. And under the administration's so-called CAIR rule, even in 2020 nearly 30 per cent of coal capacity will still not employ scrubbers and nearly 45 per cent will lack SCR equipment. Moreover, because this administration has deliberately refused to require use of available highly effective control technologies for the brain poison mercury, we will suffer decades more of cumulative dumping of this toxin into the air at

rates several times higher than is necessary or than faithful implementation of the Clean Air Act would achieve. Finally, there are no controls in place for CO₂, the global warming pollutant emitted by the more than 330,000 megawatts of coal-fired plants; nor are there any CO₂ control requirements adopted today for old or new plants save in California.

Mr. Chairman and members of the committee, I know the environmental community is criticized in some quarters for our generally negative view regarding coal as an energy resource. But I would ask you to consider the reasons for this. Our community reacts to the facts on the ground and those facts are far from what they should be if coal is to play a role as a responsible part of the 21st century energy mix. Rather than simply decrying the attitudes of those who question whether using large amounts of coal can and will be carried out in a responsible manner, the coal industry in particular should support policies to correct today's abuses and then implement those reforms. Were the industry to do this, there would be real reasons for my community and other critics of coal to consider whether their positions should be reconsidered.

The Need for CCD

Turning to CCD, my organization supports rapid deployment of such capture and disposal systems for sources using coal. Such support is not a statement about how dependent the U.S. or the world should be on coal and for how long. Any significant additional use of coal that vents its CO₂ to the air is fundamentally in conflict with the need to keep atmospheric concentrations of CO₂ from rising to levels that will produce dangerous disruption of the climate system. Given that an immediate world-wide halt to coal use is not plausible, analysts and advocates with a

broad range of views on coal's role should be able to agree that, if it is safe and effective, CCD should be rapidly deployed to minimize CO₂ emissions from the coal that we do use.

Today coal use and climate protection are on a collision course. Without rapid deployment of CCD systems, that collision will occur quickly and with spectacularly bad results. The very attribute of coal that has made it so attractive—its abundance—magnifies the problem we face and requires us to act now, not a decade from now. Until now, coal's abundance has been an economic boon. But today, coal's abundance, absent corrective action, is more bane than boon.

Since the dawn of the industrial age, human use of coal has released about 150 billion metric tons of carbon into the atmosphere—about half the total carbon emissions due to fossil fuel use in human history. But that contribution is the tip of the carbon iceberg. Another 4 *trillion* metric tons of carbon are contained in the remaining global coal resources. That is a carbon pool nearly seven times greater than the amount in our pre-industrial atmosphere. Using that coal without capturing and disposing of its carbon means a climate catastrophe.

And the die is being cast for that catastrophe today, not decades from now. Decisions being made today in corporate board rooms, government ministries, and congressional hearing rooms are determining how the next coal-fired power plants will be designed and operated. Power plant investments are enormous in scale, more than \$1 billion per plant, and plants built today will operate for 60 years or more. The International Energy Agency (IEA) forecasts that more than \$5 trillion will be spent globally on new power plants in the next 25 years. Under IEA's forecasts, over 1800 gigawatts (GW) of new coal plants will be built between now and 2030—

capacity equivalent to 3000 large coal plants, or an average of ten new coal plants every month for the next quarter century. This new capacity amounts to 1.5 times the total of all the coal plants operating in the world today.

The astounding fact is that under IEA's forecast, 7 out of every 10 coal plants that will be operating in 2030 don't exist today. That fact presents a huge opportunity—many of these coal plants will not need to be built if we invest more in efficiency; additional numbers of these coal plants can be replaced with clean, renewable alternative power sources; and for the remainder, we can build them to capture their CO₂, instead of building them the way our grandfathers built them.

If we decide to do it, the world could build and operate new coal plants so that their CO₂ is returned to the ground rather than polluting the atmosphere. But we are losing that opportunity with every month of delay—10 coal plants were built the old-fashioned way last month somewhere in the world and 10 more old-style plants will be built this month, and the next and the next. Worse still, with current policies in place, none of the 3000 new plants projected by IEA are likely to capture their CO₂.

Each new coal plant that is built carries with it a huge stream of CO₂ emissions that will likely flow for the life of the plant—60 years or more. Suggestions that such plants might be equipped with CO₂ capture devices later in life might come true but there is little reason to count on it. As I will discuss further in a moment, while commercial technologies exist for pre-combustion capture from gasification-based power plants, most new plants are not using gasification designs

and the few that are, are not incorporating capture systems. Installing capture equipment at these new plants after the fact is implausible for traditional coal plant designs and expensive for gasification processes.

If all 3000 of the next wave of coal plants are built with no CO₂ controls, their lifetime emissions will impose an enormous pollution lien on our children and grandchildren. Over a projected 60-year life these plants would likely emit 750 billion tons of CO₂, a total, from just 25 years of investment decisions, that is 30% greater than the total CO₂ emissions from all previous human use of coal. Once emitted, this CO₂ pollution load remains in the atmosphere for centuries. Half of the CO₂ emitted during World War I remains in the atmosphere today.

In short, we face an onrushing train of new coal plants with impacts that must be diverted without delay. What can the U.S. do to help? The U.S. is forecasted to build nearly 300 of these coal plants, according to reports and forecasts published by the U.S. EIA. By taking action ourselves, we can speed the deployment of CO₂ capture here at home and set an example of leadership. That leadership will bring us economic rewards in the new business opportunities it creates here and abroad and it will speed engagement by critical countries like China and India.

To date our efforts have been limited to funding research, development, and limited demonstrations. Such funding can help in this effort if it is wisely invested. But government subsidies--which are what we are talking about--cannot substitute for the driver that a real market for low-carbon goods and services provides. That market will be created only when requirements to limit CO₂ emissions are adopted. This year in Congress serious attention is

finally being directed to enactment of such measures and we welcome your announcement that you intend to play a leadership role in this effort.

Key Questions about CCD

I started studying CCD in detail ten years ago and the questions I had then are those asked today by people new to the subject. Do reliable systems exist to capture CO₂ from power plants and other industrial sources? Where can we put CO₂ after we have captured it? Will the CO₂ stay where we put it or will it leak? How much disposal capacity is there? Are CCD systems “affordable”? To answer these questions, the Intergovernmental Panel on Climate Change (IPCC) decided four years ago to prepare a special report on the subject. That report was issued in September, 2005 as the IPCC Special Report on Carbon Dioxide Capture and Storage. I was privileged to serve as a review editor for the report’s chapter on geologic storage of CO₂.

CO₂ Capture

The IPCC special report groups capture or separation of CO₂ from industrial gases into four categories: post-combustion; pre-combustion; oxyfuel combustion; and industrial separation. I will say a few words about the basics and status of each of these approaches. In a conventional pulverized coal power plant, the coal is combusted using normal air at atmospheric pressures. This combustion process produces a large volume of exhaust gas that contains CO₂ in large amounts but in low concentrations and low pressures. Commercial post-combustion systems exist to capture CO₂ from such exhaust gases using chemical “stripping” compounds and they have been applied to very small portions of flue gases (tens of thousands of tons from plants that emit several million tons of CO₂ annually) from a few coal-fired power plants in the U.S. that

sell the captured CO₂ to the food and beverage industry. However, industry analysts state that today's systems, based on publicly available information, involve much higher costs and energy penalties than the principal demonstrated alternative, pre-combustion capture.

New and potentially less expensive post-combustion concepts have been evaluated in laboratory tests and some, like ammonia-based capture systems, are scheduled for small pilot-scale tests in the next few years. Under normal industrial development scenarios, if successful such pilot tests would be followed by larger demonstration tests and then by commercial-scale tests. These and other approaches should continue to be explored. However, unless accelerated by a combination of policies, subsidies, and willingness to take increased technical risks, such a development program could take one or two decades before post-combustion systems would be accepted for broad commercial application.

Pre-combustion capture is applied to coal conversion processes that gasify coal rather than combust it in air. In the oxygen-blown gasification process coal is heated under pressure with a mixture of pure oxygen, producing an energy-rich gas stream consisting mostly of hydrogen and carbon monoxide. Coal gasification is widely used in industrial processes, such as ammonia and fertilizer production around the world. Hundreds of such industrial gasifiers are in operation today. In power generation applications as practiced today this "syngas" stream is cleaned of impurities and then burned in a combustion turbine to make electricity in a process known as Integrated Gasification Combined Cycle or IGCC. In the power generation business, IGCC is a relatively recent development—about two decades old and is still not widely deployed. There are two IGCC power-only plants operating in the U.S. today and about 14 commercial IGCC plants are operating, with most of the capacity in Europe. In early years of operation for power

applications a number of IGCC projects encountered availability problems but those issues appear to be resolved today, with Tampa Electric Company reporting that its IGCC plant in Florida is the most dispatched and most economic unit in its generating system.

Commercially demonstrated systems for pre-combustion capture from the coal gasification process involve treating the syngas to form a mixture of hydrogen and CO₂ and then separating the CO₂, primarily through the use of solvents. These same techniques are used in industrial plants to separate CO₂ from natural gas and to make chemicals such as ammonia out of gasified coal. However, because CO₂ can be released to the air in unlimited amounts under today's laws, except in niche applications, even plants that separate CO₂ do not capture it; rather they release it to the atmosphere. Notable exceptions include the Dakota Gasification Company plant in Beulah, North Dakota, which captures and pipelines more than one million tons of CO₂ per year from its lignite gasification plant to an oil field in Saskatchewan, and ExxonMobil's Shute Creek natural gas processing plant in Wyoming, which strips CO₂ from sour gas and pipelines several million tons per year to oil fields in Colorado and Wyoming.

Today's pre-combustion capture approach is not applicable to the installed base of conventional pulverized coal in the U.S. and elsewhere. However, it is ready today for use with IGCC power plants. The oil giant BP has announced an IGCC project with pre-combustion CO₂ capture at its refinery in Carson, California. When operational the project will gasify petroleum coke, a solid fuel that resembles coal more than petroleum to make electricity for sale to the grid. The captured CO₂ will be sold to an oil field operator in California to enhance oil recovery. The principal obstacle for broad application of pre-combustion capture to new power plants is not

technical, it is economic: under today's laws it is cheaper to release CO₂ to the air rather than capturing it. Enacting laws to limit CO₂ can change this situation, as I discuss later.

While pre-combustion capture from IGCC plants is the approach that is ready today for commercial application, it is not the only method for CO₂ capture that may emerge if laws creating a market for CO₂ capture are adopted. I have previously mentioned post-combustion techniques now being explored. Another approach, known as oxyfuel combustion, is also in the early stages of research and development. In the oxyfuel process, coal is burned in oxygen rather than air and the exhaust gases are recycled to build up CO₂ concentrations to a point where separation at reasonable cost and energy penalties may be feasible. Small scale pilot studies for oxyfuel processes have been announced. As with post-combustion processes, absent an accelerated effort to leapfrog the normal commercialization process, it could be one or two decades before such systems might begin to be deployed broadly in commercial application.

Given, the massive amount of new coal capacity scheduled for construction in the next two decades, we cannot afford to wait until we see if these alternative capture systems prove out, nor do we need to. Coal plants in the design process today can employ proven IGCC and pre-combustion capture systems to reduce their CO₂ emissions by about 90 percent. Adoption of policies that set a CO₂ performance standard now for such new plants will not anoint IGCC as the technological winner since alternative approaches can be employed when they are ready. If the alternatives prove superior to IGCC and pre-combustion capture, the market will reward them accordingly. As I will discuss later, adoption of CO₂ performance standards is a critical step to improve today's capture methods and to stimulate development of competing systems.

I would like to say a few words about so-called “capture-ready” or “capture-capable” coal plants. I will admit that some years ago I was under the impression that some technologies like IGCC, initially built without capture equipment could be properly called “capture-ready.” However, the implications of the rapid build-out of new coal plants for global warming and many conversations with engineers since then have educated me to a different view. An IGCC unit built without capture equipment can be equipped later with such equipment and at much lower cost than attempting to retrofit a conventional pulverized coal plant with today’s demonstrated post-combustion systems. However, the costs and engineering reconfigurations of such an approach are substantial. More importantly, we need to begin capturing CO₂ from new coal plants without delay in order to keep global warming from becoming a potentially runaway problem. Given the pace of new coal investments in the U.S. and globally, we simply do not have the time to build a coal plant today and think about capturing its CO₂ down the road.

Implementation of the Energy Policy Act of 2005 approach to this topic needs a review in my opinion. The Act provides significant subsidies for coal plants that do not actually capture their CO₂ but rather merely have carbon “capture capability.” While the Act limits this term to plants using gasification processes, it is not being implemented in a manner that provides a meaningful substantive difference between an ordinary IGCC unit and one that genuinely has been designed with early integration of CO₂ capture in mind. Further, in its FY2008 budget request, the administration seeks appropriations allowing it to provide \$9 billion in loan guarantees under Title XVII of the Act, including as much as \$4 billion in loans for “carbon sequestration optimized coal power plants.” The administration request does not define a “carbon

sequestration optimized” coal power plant and it could mean almost anything, including, according to some industry representatives, a plant that simply leaves physical space for an unidentified black box. If that makes a power plant “capture-ready” Mr. Chairman, then my driveway is “Ferrari-ready.” We should not be investing today in coal plants at more than a billion dollars apiece with nothing more than a hope that some kind of capture system will turn up. We would not get on a plane to a destination if the pilot told us there was no landing site but options were being researched.

Geologic Disposal

We have a significant experience base for injecting large amounts of CO₂ into geologic formations. For several decades oil field operators have received high pressure CO₂ for injection into fields to enhance oil recovery, delivered by pipelines spanning as much as several hundred miles. Today in the U.S. a total of more than 35 million tons of CO₂ are injected annually in more than 70 projects. (Unfortunately, due to the lack of any controls on CO₂ emissions, about 80 per cent of that CO₂ is sources from natural CO₂ formations rather than captured from industrial sources. Historians will marvel that we persisted so long in pulling CO₂ out of holes in the ground in order to move it hundreds of miles and stick in back in holes at the same time we were recognizing the harm being caused by emissions of the same molecule from nearby large industrial sources.) In addition to this enhanced oil recovery experience, there are several other large injection projects in operation or announced. The longest running of these, the Sleipner project, began in 1996.

But the largest of these projects injects on the order of one million tons per year of CO₂, while a single large coal power plant can produce about five million tons per year. And of course, our

experience with man-made injection projects does not extend for the thousand year or more period that we would need to keep CO₂ in place underground for it to be effective in helping to avoid dangerous global warming. Accordingly, the public and interested members of the environmental, industry and policy communities rightly ask whether we can carry out a large scale injection program safely and assure that the injected CO₂ will stay where we put it.

Julio Friedmann's testimony addresses these questions at length and with much greater authority than I can supply so I will simply summarize the findings of the IPCC on these issues. In its 2005 report the IPCC concluded the following with respect to the question of whether we can safely carry out carbon injection operations on the required scale:

“With appropriate site selection based on available subsurface information, a monitoring programme to detect problems, a regulatory system and the appropriate use of remediation methods to stop or control CO₂ releases if they arise, the local health, safety and environment risks of geological storage would be comparable to the risks of current activities such as natural gas storage, EOR and deep underground disposal of acid gas.”

The knowledge exists to fulfill all of the conditions the IPCC identifies as needed to assure safety. While EPA has authority regulate large scale CO₂ injection projects its current underground injection control regulations are not designed to require the appropriate showings for permitting a facility intended for long-term retention of large amounts of CO₂. With adequate resources applied, EPA should be able to make the necessary revisions to its rules in two to three years. We urge this Committee to act to require EPA to undertake this effort this year.

Do we have a basis today for concluding that injected CO₂ will stay in place for the long periods required to prevent its contributing to global warming? The IPCC report concluded that we do, stating:

“Observations from engineered and natural analogues as well as models suggest that the fraction retained in appropriately selected and managed geological reservoirs is very likely to exceed 99% over 100 years and is likely to exceed 99% over 1,000 years.”

Despite this conclusion by recognized experts there is still reason to ask what are the implications of imperfect execution of large scale injection projects, especially in the early years before we have amassed more experience? Is this reason enough to delay application of CO₂ capture systems to new power plants until we gain such experience from an initial round of multi-million ton “demonstration” projects? To sketch an answer to this question, my colleague Stefan Bachu, a geologist with the Alberta Energy and Utilities Board, and I wrote a paper for the Eighth International Conference on Greenhouse Gas Control Technologies in June 2006. The obvious and fundamental point we made is that without CO₂ capture, new coal plants built during any “delay and research” period will put 100 per cent of their CO₂ into the air and may do so for their operating life if they were “grandfathered” from retrofit requirements. Those releases need to be compared to hypothetical leaks from early injection sites.

Our conclusions were that even with extreme, unrealistically high hypothetical leakage rates from early injection sites (10% per year), a long period to leak detection (5 years) and a prolonged period to correct the leak (1 year), a policy that delayed installation of CO₂ capture at new coal plants to await further research would result in cumulative CO₂ releases twenty times greater than from the hypothetical faulty injection sites, if power plants built during the research period were “grandfathered” from retrofit requirements. If this wave of new coal plants were all required to retrofit CO₂ capture by no later than 2030, the cumulative emissions would still be

four times greater than under the no delay scenario. I believe that any objective assessment will conclude that allowing new coal plants to be built without CO₂ capture equipment on the ground that we need more large scale injection experience will always result in significantly greater CO₂ releases than starting CO₂ capture without delay for new coal plants now being designed.

The IPCC also made estimates about global storage capacity for CO₂ in geologic formations. It concluded as follows:

“Available evidence suggests that, worldwide, it is likely that there is a technical potential of at least about 2,000 GtCO₂ (545 GtC) of storage capacity in geological formations. There could be a much larger potential for geological storage in saline formations, but the upper limit estimates are uncertain due to lack of information and an agreed methodology.”

Current CO₂ emissions from the world’s power plants are about 10 Gt (billion metric tons) per year, so the IPCC estimate indicates 200 years of capacity if power plant emissions did not increase and 100 years capacity if annual emissions doubled.

Policy Actions to Speed CCD

As I stated earlier, research and development funding is useful but it cannot substitute for the incentive that a genuine commercial market for CO₂ capture and disposal systems will provide to the private sector. The amounts of capital that the private sector can spend to optimize CCD methods will almost certainly always dwarf what Congress will provide with taxpayer dollars. To mobilize those private sector dollars, Congress needs a stimulus more compelling than the offer of modest handouts for research. Congress has a model that works: intelligently designed policies to limit emissions cause firms to spend money finding better and less expensive ways to prevent or capture emissions.

Where a technology is already competitive with other emission control techniques, for example, sulfur dioxide scrubbers, a cap and trade program like that enacted by Congress in 1990, can result in more rapid deployment, improvements in performance, and reductions in costs.

Today's scrubbers are much more effective and much less costly than those built in the 1980s.

However, a CO₂ cap and trade program by itself may not result in deployment of CCD systems as rapidly as we need. Many new coal plant design decisions are being made literally today.

Depending on the pace of required reductions under a global warming bill, a firm may decide to build a conventional coal plant and purchase credits from the cap and trade market rather than applying CCD systems to the plant. While this may appear to be economically rational in the short term, it is likely to lead to higher costs of CO₂ control in the mid and longer term if substantial amounts of new conventional coal construction leads to ballooning demand for CO₂ credits. Recall that in the late 1990's and the first few years of this century, individual firms thought it made economic sense to build large numbers of new gas-fired power plants. The problem is too many of them had the same idea and the resulting increase in demand for natural gas increased both the price and volatility of natural gas to the point where many of these investments are idle today.

Moreover, delaying the start of CCD until a cap and trade system price is high enough to produce these investments delays the broad demonstration of the technology that the U.S. and other countries will need if we continue substantial use of coal as seem likely. The more affordable CCD becomes, the more widespread its use will be throughout the world, including in rapidly growing economies like China and India. But the learning and cost reductions for CCD that are desirable will come only from the experience gained by building and operating the initial

commercial plants. The longer we wait to ramp up this experience, the longer we will wait to see CCD deployed here and in countries like China.

Accordingly, we believe the best policy package is a hybrid program that combines the breadth and flexibility of a cap and trade program with well-designed performance measures focused on key technologies like CCD. One such performance measure is a CO₂ emissions standard that applies to new power investments. California enacted such a measure in SB1368 last year. It requires new investments for sale of power in California to meet a performance standard that is achievable by coal with a moderate amount of CO₂ capture.

Another approach is a low-carbon generation obligation for coal-based power. Similar in concept to a renewable performance standard, the low-carbon generation obligation requires an initially small fraction of sales from coal-based power to meet a CO₂ performance standard that is achievable with CCD. The required fraction of sales would increase gradually over time and the obligation would be tradable. Thus, a coal-based generating firm could meet the requirement by building a plant with CCD, by purchasing power generated by another source that meets the standard, or by purchasing credits from those who build such plants. This approach has the advantage of speeding the deployment of CCD while avoiding the “first mover penalty.” Instead of causing the first builder of a commercial coal plant with CCD to bear all of the incremental costs, the tradable low-carbon generation obligation would spread those costs over the entire coal-based generation system. The builder of the first unit would achieve far more hours of low-carbon generation than required and would sell the credits to other firms that needed credits to comply. These credit sales would finance the incremental costs of these early units. This

approach provides the coal-based power industry with the experience with a technology that it knows is needed to reconcile coal use and climate protection and does it without sticker shock. A bill introduced in the other body, S. 309, contains such a provision. It begins with a requirement that one-half of one per cent of coal-based power sales must meet the low-carbon performance standard starting in 2015 and the required percentage increases over time according to a statutory minimum schedule that can be increased in specified amounts by additional regulatory action.

A word about costs is in order. With today's off the shelf systems, estimates are that the production cost of electricity at a coal plant with CCD could be as much as 40% higher than at a conventional plant that emits its CO₂. But the impact on average electricity prices of introducing CCD now will be very much smaller due to several factors. First, power production costs represent about 60% of the price you and I pay for electricity; the rest comes from transmission and distribution costs. Second, coal-based power represents just over half of U.S. power consumption. Third, and most important, even if we start now, CCD would be applied to only a small fraction of U.S. coal capacity for some time. Thus, with the trading approach I have outlined, the incremental costs on the units equipped with CCD would be spread over the entire coal-based power sector or possibly across all fossil capacity depending on the choices made by Congress. Based on CCD costs available in 2005 we estimate that a low-carbon generation obligation large enough to cover all forecasted new U.S. coal capacity through 2020 could be implemented for about a two per cent increase in average U.S. retail electricity rates.

Conclusions

To sum up, since we will almost certainly continue using large amounts of coal in the U.S. and globally in the coming decades, it is imperative that we act now to deploy CCD systems.

Commercially demonstrated CO₂ capture systems exist today and competing systems are being researched. Improvements in current systems and emergence of new approaches will be accelerated by requirements to limit CO₂ emissions. Geologic disposal of large amounts of CO₂ is viable and we know enough today to conclude that it can be done safely and effectively. EPA must act without delay to revise its regulations to provide the necessary framework for efficient permitting, monitoring and operational practices for large scale permanent CO₂ repositories.

Finally CCD is an important strategy to reduce CO₂ emissions from fossil fuel use but it is not the basis for a climate protection program by itself. Increased reliance on low-carbon energy resources is the key to protecting the climate. The lowest carbon resource of all is smarter use of energy; energy efficiency investments will be the backbone of any sensible climate protection strategy. Renewable energy will need to assume a much greater role than it does today. With today's use of solar, wind and biomass energy, we tap only a tiny fraction of the energy the sun provides every day. There is enormous potential to expand our reliance on these resources.

We have no time to lose to begin cutting global warming emissions. Fortunately, we have technologies ready for use today that can get us started.

Mr. Chairman, that completes my testimony, I will be happy to take any questions you or other committee members may have.