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Testimony Before the
Subcommittee on Energy and Air Quality
U.S. House of Representatives

Hearing On
H.R. 6258 "The Carbon Capture and Storage Early Deployment Act"

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Thank you for the opportunity to testify today on H.R. 6258, "The Carbon Capture and Storage Early Deployment Act." My name is Michael Goo. I am the Climate Legislative 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.

Chairman Boucher and Ranking Member Upton, thank you for holding this hearing on H.R. 6258, "The Carbon Capture and Storage Early Deployment Act." As you know, there is a pressing need to enact comprehensive global warming legislation immediately. Our planet is warming and we are continuing to emit billions of tons of global warming pollution each year, locking in further warming for decades to come. The effects of this warming will be to inflict large and growing damage to human health, economic well-being, and natural ecosystems. We cannot afford to wait any longer to address this urgent problem and we urge this Committee and the Congress to act as soon as possible.

H.R. 6258, "The Carbon Capture and Storage Early Deployment Act" represents a bi-partisan attempt to begin to address one of the most important issues in the global warming legislative debate: the role of coal and the pressing need for deployment of technologies that can capture and dispose of CO_2 generated from the combustion and use of coal.

Without widespread deployment of such technology, the task of fighting global warming will be more difficult. I commend Chairman Boucher for raising and exploring this important issue and for making clear that such legislation is not intended to substitute for comprehensive global warming legislation. NRDC believes such legislation should only be enacted as part of cap and trade legislation. Keeping in mind that we must enact comprehensive legislation immediately, we are pleased to be invited to explore the merits of the approach embodied in H.R. 6258.

The role of coal combustion in global warming is well established.   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 has historically been a cheap source of energy, which has made it attractive to use in large quantities- but only if we are willing to 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 percent 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 when it is used, specifically systems that capture carbon dioxide (CO_2) from new coal-fired power plants and other industrial sources for safe and effective disposal in geologic formations. To distinguish this industrial capture system from removal of atmospheric CO_2 by soils and vegetation, I will refer to the industrial system as Carbon Capture and Disposal or CCD.

H.R. 6258 would create a fund for "accelerating the commercial demonstration or availability" of CCD technologies. The fund would be financed via a surcharge on electricity generated from fossil fuels. The fund would only be created if electricity producers representing two thirds of the fossil based electricity generation agreed to the surcharge. The fund would be operated as a division of the Electric Power Research Institute and funds would be disbursed for deployment of large scale CCD technologies.

With the current rush to build new coal plants, here and abroad, (and the modest pace of deploying even currently available renewable technologies and energy conservation strategies) it is likely that coal will continue to play a role in our energy future. Accordingly, we need to establish ways in which to encourage and require the widespread capture and disposal of the global warming pollution from these plants as soon as possible.   H.R. 6258 provides a useful proposal that could help us achieve that result, but only in part.

As discussed more fully below, by itself, H.R. 6258 is not sufficient to ensure early deployment of CCD and is only a small part of the legislative work we need to complete in order to effectively combat the threat of global warming. In order to ensure that our climate is protected, we must enact mandatory limits on global warming pollution. And the best way to do that, while also incentivizing technology and lowering costs, is through a cap and trade system. As many analysts, including the Congressional Budget Office,[1] have pointed out, in order to effectively incentivize deployment of CCD and

[1] See "Evaluating the Role of Prices and R&D in Reducing Carbon Dioxide Emissions." Congressional Budget Office, September 2006. at p. 16. "The Congressional Budget Office identified three published analyses that simulate the effects of both emissions pricing and R&D. While CBO recognizes the limitations of those modeling efforts and does not endorse any specific quantitative results, those models suggest that a combination of the two approaches—pricing emissions in the near term and funding R&D—would be necessary to reduce carbon emissions at the lowest possible cost. Further, they suggest that the largest gains in efficiency are likely to come from pricing emissions rather than from funding R&D."

other low carbon technologies, both a carbon price signal (through a cap and trade program) and additional financial incentives are necessary. Neither alone will suffice.

Thus, NRDC's primary point with regard to H.R. 6258 is that it cannot be thought of as a replacement or substitute for a full cap and trade program, nor can it be allowed to serve as a recipe for delay in enacting such a program. In addition, we believe that the amounts of money provided by H.R. 6258 are not adequate to achieve timely deployment of CCD systems on the scale that is warranted. We look forward to discussing these issues with Chairman Boucher and the other Committee members.

We also want to emphasize that technologies to capture and dispose of carbon dioxide emissions from coal fired power plants and other sources are available today. What is needed is a cap and trade system and additional incentives for commercial deployment of the first generation of such systems. At this point, commercial deployment of such systems does not require further substantial research and development efforts, it requires the right economic incentives. Although further research and development for additional technologies will continue to be necessary, pursuing those R&D activities should not serve as an excuse for delaying action in terms of limiting emissions, both nationally and from new coal fired power plants in particular. We already know enough to start limiting emissions now.

Finally, it bears mentioning that the production and use of coal remains one of the most environmentally destructive forms of energy supply for many of our citizens and communities in Appalachia, the West and other coal-producing regions of the country, as well as abroad. Many environmentally preferable and cheaper alternatives for meeting power demand, such as energy efficiency and renewable energy should be the primary focus of our efforts to address the nation's energy need, and must be explored with even greater vigor and zeal than our efforts to encourage CCD. The more those alternatives are explored, incentivized and deployed, the smaller the need will be for CCD. This is especially true in the earlier years of a cap and trade program, which is needed precisely in order to ensure the optimal economic mix between those abatement technologies and CCD-specific incentive measures like H.R. 6258. For that reason, I wish to begin my testimony by reviewing the negative environmental consequences of coal production, in its many forms.

The Toll from Coal

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. When its real costs are ignored, coal appears to be a cheap source of energy compared to oil and natural gas. But in reality 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 percent of coal capacity will still not employ scrubbers and nearly 45 percent will lack SCR equipment. And even these limits are in peril as a result of coal industry litigation. Moreover, because this administration has deliberately refused to require use of available highly effective control technologies for mercury (a potent neurotoxin), 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 CO_2, the global warming pollutant emitted by the more than 330,000 megawatts of coal-fired plants; nor are there any CO_2 control requirements adopted today for old or new plants save in California.

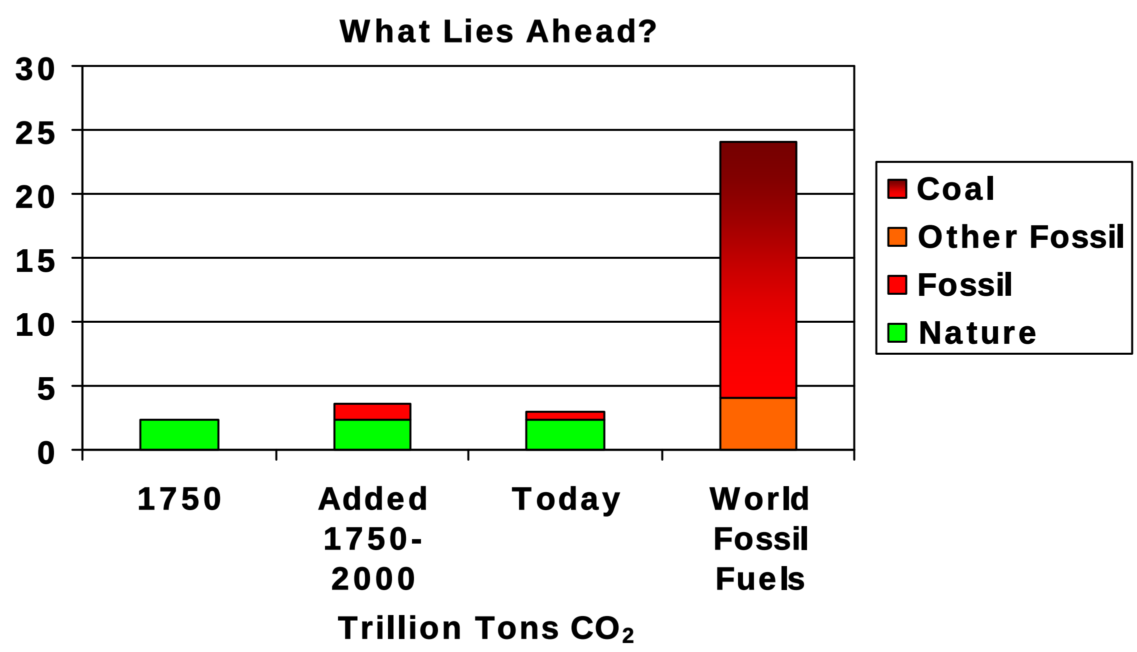
Mr. Chairman and members of the committee, the environmental community has been criticized in some quarters for our generally negative view regarding coal as an energy resource. But consider the reasons for this. Our community reacts to the facts on the ground and those facts are far from what they should 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, my community and other critics of coal might consider whether some of their positions should be re-evaluated. As it is, the mining and use of coal continues to be among the most environmentally damaging of all energy forms.

The Need for CCD

Turning to CCD, NRDC 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 CO_2 to the air is fundamentally in conflict with the need to keep atmospheric concentrations of CO_2 from rising to levels that will produce dangerous disruption of the climate system; thus, any new coal-based facilities that would emit significant quantities of CO_2 should be designed to capture their CO_2 emissions and required to do so. Clearly, an immediate world-wide halt to coal use is not plausible, but analysts and advocates with a broad range of views on coal's role should be able to agree that, for all new plants, CCD should be rapidly deployed to minimize CO_2 emissions from any new coal-based energy production, and applied as soon as feasible to reduce CO_2 from already existing sources.

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, in the view of some, 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. As much as 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.



Source: Natural Resources Defense Council

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, costing 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.

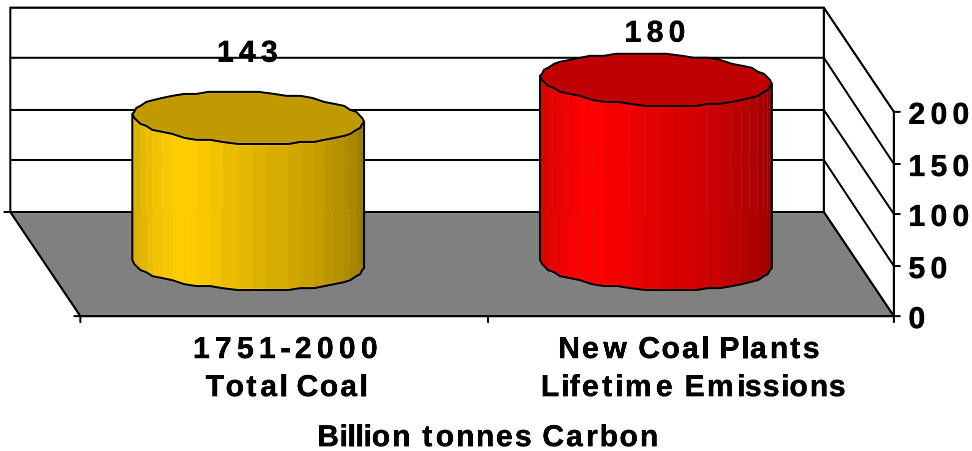
The astounding fact is that under IEA's forecast, 7 out of every 10 coal plants that will be operating in 2030 don't exist today. That fact presents a huge opportunity—many of these coal plants will not need to be built if we invest more in efficiency; additional numbers of these coal plants can be replaced with clean, renewable alternative power sources; and for the remainder, we can build them to capture their CO_2, 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 CO_2 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 CO_2. Each new coal plant that is built carries with it a huge stream of CO_2 emissions that will likely flow for the life of the plant—60 years or more.

Suggestions that such plants might be equipped with CO_2 capture devices later in life might come true but there is little reason to count on it. 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 CO_2 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 CO_2, a total, from just 25 years of investment decisions, that is almost 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 CO_2 emitted during World War I remains in the atmosphere today.

New Coal Plant Emissions 26% Greater Than All Historic Coal CO_2



Source: ORNL, CDIAC; IEA, and WEO 2006

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 more than 200 of these coal plants, according to reports and forecasts published by the U.S. EIA. We should adopt a national policy that new coal plants be required to employ CCD without delay. By taking action ourselves, we can speed the deployment of CCD 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.

If we do not, we risk foregoing market and export opportunities while the Chinese commercialize those technologies themselves, and begin selling them to us, at a lower cost and faster than our domestic industries will be able to respond. The signs are already clear that significant progress is being made both in the capture and the disposal front by extremely ambitious and competent Chinese businesses.

Policy Actions to Speed CCD

As the Committee is aware, in the last several years there has been a surge of announcements for planned construction of new coal-fired power plants—almost none of them proposing to use CCD. EIA's energy models currently forecast that as much as 135 GW of new coal capacity might be built in the U.S. between now and 2030. Depending on their efficiency, capacity factors and operating lives, these new coal plants could release as much as 51 billion metric tons of CO_2 cumulatively before they are replaced, if their CO_2 is not captured. Locking in such a huge potential burden of CO_2 pollution would make it difficult, if not impossible, for the U.S. to achieve needed emission reduction targets.

It is worth noting that the actual amount of new coal capacity that will be built, given the unsettled policy environment, is quite uncertain. New coal plants that do not dispose of their CO_2 are being successfully challenged, while regulators and the financial community are increasingly questioning whether investing billions of dollars in high-carbon emitting projects makes any sense as the country stands at the doorstep of a carbon-constrained world. Just in 2007, about a dozen large coal projects have been cancelled, rejected by regulatory bodies or delayed by legal challenges. Nonetheless, we cannot assume that no new coal plants will be built in the U.S. Policies to deploy CCD are needed both to deal with the prospect of new coal plants here and to provide the learning that will be necessary to make CCD a reality in countries like China, where last year a large new coal plant started up about every four days.

While research and development funding is also needed for the medium- and long-term improvement of the technology, it is neither the gateway to the deployment of the technology, nor can it substitute for the incentive that a genuine commercial market for CO_2 capture and disposal systems will provide to the private sector. Indeed, the immediate need is in early deployment incentives and requirements for the first wave of CCD projects, using technology that is available to us *today*. 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 CO_2 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 CO_2 control in the mid and longer term if substantial amounts of new conventional coal construction leads to ballooning demand for CO_2 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 due to increases in both the price and volatility of natural gas 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 scale of deployment of the technology that is needed in the U.S. and other countries if we continue substantial use of coal, as seems likely. The more affordable CCD becomes, the more widespread its use will be throughout the world, including in rapidly growing economies. 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 for what promises to be significant cost reductions to become a reality and, and to see CCD deployed worldwide.

To date our efforts have been limited to funding research, development, and limited demonstrations.[2] Such funding can be one of the necessary elements 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 CO_2 emissions are adopted. In this Congress, serious attention is finally being directed to enactment of such measures. Such measures combined with additional financial incentives (many of which could be funded from within the cap and trade system itself) is the fastest and surest path to rapid deployment of CCD.

Some have argued that key technologies, such as carbon capture and storage (CCD) are not yet available or are only available now at exorbitant cost. Such arguments are incorrect. As discussed more fully below, the elements of CCD systems are actually in use today. But arguments about what is available today, under today's market conditions, fundamentally miss the point, because global warming legislation is about setting the market conditions for technological progress going forward from today. Taking a frozen snapshot of the cost of carbon control technologies today is also misleading. Think how wrong such an assessment would have been if applied to computer technology at any point in the last thirty years. Speed and capacity have increased by orders of magnitude as costs plummeted. We now carry more computing power in our cell phones than the Apollo astronauts carried to the moon. Once market signals are in place, it will be the same for technologies such as carbon capture and storage.

CCD is Available Today

CCD technology is available to us today to begin deployment. With the right price signal from a cap and trade system, combined with appropriate, additional financial incentives or subsidies for deployment, the first wave of CCD can be deployed at commercial scale immediately, consistent with the time required to build a new power plant. As the Chairman and President of BP America, Robert Malone has testified,

"CCS cannot succeed as a commercially successful emission abatement technology without the policy or regulatory frameworks that would allow commercial entities to invest in it. New technology cannot be 'pushed' into industrial-scale deployment, a

[2] Title VII of the Energy Independence and Security Act of 2007 (EISA) contains some provisions that, if funded, will help to make CCD a reality. These include authorizations to conduct at least seven large-scale geologic sequestration projects and separate authorizations for projects for large-scale capture of CO_2 from industrial sources. A third provision requires the U.S. Geological Survey to carry out a comprehensive assessment of capacity for geologic disposal of CO_2. NRDC supports implementation of these provisions but we urge that they be complemented with enactment this year of a comprehensive program to cap CO_2 and other greenhouse gases, along with complementary policies to accelerate CCD deployment.

market is necessary to ‘pull’ it. ***Deploying CCS at scale is not as much a question of technology availability but of economic viability. CCS is available today to play a significant role in reducing greenhouse gas emissions and addressing climate change.”***[3]

Research on CCD has been ongoing for many years now, with major international conferences taking place since the early 1990s. Since then, knowledge on the subject has greatly expanded, to the extent that the Intergovernmental Panel on Climate Change (“IPCC”) issued a special report on CCD in 2005. An extensive Massachusetts Institute of Technology (“MIT”) study on the Future of Coal in 2007 also examined CCD in depth. There is a substantial body of evidence, knowledge, and peer-reviewed literature on CCD.[4]

In many ways, CCD is not new. There are three elements to successful geologic sequestration of carbon dioxide: capture, transportation, and sequestration. All three of these elements have been demonstrated and operated in commercial, large scale installations. There is no technical reason these elements cannot be combined to capture, transport and dispose of CO_2 from coal fired power plants immediately.

The first element of CCD is the initial capture of the carbon dioxide emissions. “Pre-combustion capture” is applied to conversion processes that gasify coal, petroleum coke, or other feedstocks (such as biomass) rather than combusting them in air. In the oxygen-blown gasification process, the feedstock 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 around the world, such as in ammonia and fertilizer production. Hundreds of such industrial gasifiers are in operation today. In power generation applications as practiced today this “syngas” stream is cleaned of some impurities and then burned in a combustion turbine to make electricity in a process known as Integrated Gasification Combined Cycle (“IGCC”). Commercially demonstrated systems for pre-combustion capture from the coal gasification process involve treating the syngas to form a mixture of hydrogen and CO_2, and then separating the CO_2 primarily through the use of solvents. These same techniques are used in industrial plants to separate CO_2 from natural gas and to make chemicals such as ammonia out of gasified coal.

However, because CO_2 can be released to the air in unlimited amounts under today’s laws, except in niche applications, even plants that separate CO_2 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

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[3] Testimony of Robert Malone Before The Select Committee on Energy Independence and Global Warming, U.S. House of Representatives (September 21, 2007). (Emphasis added)

[4] For further information, I attached as an Appendix testimony prepared by David Hawkins, Director of NRDC’s Climate Center, which discusses the current availability of carbon capture and disposal in greater detail. Mr. Hawkins served as a review editor of the 2005 IPCC Report on CCD.

million tons of CO_2 per year from its lignite gasification plant to an oil field in Saskatchewan (the Weyburn project described below), and ExxonMobil's Shute Creek natural gas processing plant in Wyoming, which strips CO_2 from sour gas and pipelines several million tons per year to oil fields in Colorado and Wyoming.

The principal obstacle for broad application of pre-combustion capture to new power plants (and the main reason behind limited deployment of IGCC with carbon capture) is not technical, it is economic: under today's laws it is cheaper to release CO_2 to the air than capture it. Other capture technologies, including post-combustion and oxyfuel combustion are currently at the bench and/or pilot demonstration stage. The cost of CO_2 capture is by far the most expensive element in the CCD chain of operations, estimated to be in the region of 75% of total costs, depending on the geological setting and the distance of transport.

The second element of CCD is the transportation of captured carbon dioxide to the injection site, if needed. The use of CO_2 for Enhanced Oil Recovery (EOR) began in the U.S. in the early 1960s. Inexpensive industrial CO_2 sources, such as natural gas processing plants, were initially used, although to sustain the expansion this was quickly supplemented and eventually overshadowed by naturally occurring CO_2 discovered in Colorado, New Mexico and Mississippi.

Today, there are around one hundred registered CO_2 floods worldwide, almost 90% of which are in the U.S. and Canada. Some 35 million tons of CO_2 annually are injected in mature oil reservoirs. These floods are primarily in the Permian Basin of Texas and New Mexico, but also in the Bighorn Basin of Wyoming, the Rangeley Field of Colorado and the Mississippi Salt Basin. In North Dakota, CO_2 from the Great Plains Synfuels project is captured and transported across the border to Canada, and injected into the Weyburn and Midale fields in Saskatchewan. CO_2 pipelines today operate as a mature market technology and are the most common method for transporting CO_2. The first long-distance CO_2 pipeline came into operation in the early 1970s. In the United States, over 3,000 miles of pipeline transports more than 40 million tons of CO_2 per year for use in CO_2-EOR. Transport of CO_2 is happening today and it can happen at an even greater scale as CCD is more fully deployed.

The third element of CCD is the sequestration of the carbon dioxide in geological formations. Injection of carbon dioxide has been successfully demonstrated on a large scale, not least in the context of CO_2-EOR projects, some of which like Seminole, SACROC and Wasson are injecting annual amounts of CO_2 well above the quantity that a 500MW coal plant would produce.

There is also considerable scientific knowledge regarding the mechanisms for trapping carbon dioxide in sedimentary geological formations. For example, residual trapping limits carbon dioxide mobility through capillary forces. Solubility trapping occurs when injected carbon dioxide dissolves in fluids within the geological formation. Stratigraphic trapping occurs when overlying impermeable rock formations prevent upward movement of carbon dioxide from underlying reservoirs. Mineralization trapping occurs when injected carbon dioxide forms carbonate minerals and essentially becomes part of the solid rock into which it was injected.

Both the Intergovernmental Panel on Climate Change (“IPCC”) and the interdisciplinary team from the Massachusetts Institute of Technology (“MIT”) concluded that such sequestration methods in appropriately selected and operated geologic reservoirs are likely to trap over 99% of injected carbon dioxide over 1,000 years. This conclusion is based on existing project performance and a number of natural and industrial analogs. Nature itself has stored hydrocarbons and CO_2 for millions to hundreds of millions of years, and humans have successfully stored natural gas and other fluids underground.

There are several commercial and research projects that inject carbon dioxide in sedimentary geological formations for permanent sequestration. For example, the Sleipner project in Norway has been operating since 1996 and injects about 1 million tons of CO_2 annually into a deep saline formation in the North Sea. BP’s In Salah project, operating in Algeria since 2004, injects a similar amount of CO_2 stripped from natural gas back into the water leg of the natural gas field. The Weyburn project receives CO_2 captured and transported from North Dakota to Saskatchewan and has been operating since 2000 and injects 1-2 million tons of CO_2 annually.

All three of these projects include monitoring programs. The results of that monitoring indicate that the CO_2 is remaining sequestered in the formations and that there is no reason to expect any CO_2 leakage from these projects. These projects just mentioned provide a great deal of confidence that CO_2 can remain permanently sequestered in geological reservoirs.

All components of CCD therefore – capture, transportation and injection – have been demonstrated at commercial scale in a number of industrial applications. We believe that the barriers to CCD are not technological, but rather economic and regulatory. We are joined by leaders of major industrial corporations such as NRG Energy, BP America and Tenaska who are all moving forward with CCD projects today—literally putting their money where their mouth is.

As noted above, BP believes that the CCD is “available today.” And BP has joined forces with Rio Tinto in their joint venture, Hydrogen Energy, which has immediate plans to invest billions of dollars into CCD facilities in the U.S., the Middle East, Australia and Europe. Similarly, on February 19, 2008, Tenaska, Inc., publicly announced its proposal for the Trailblazer Energy Center in Texas, a 765 MW gross output and 600 MW net output supercritical pulverized coal electric generation facility with the capability to capture and deliver to the EOR markets 90 percent of CO_2 produced in the boiler. Tenaska’s current plan is that the facility will be operational in 2014. Tenaska estimates that approximately one third of its profit will come from revenues generated from the use of CO2 captured at the project for enhanced oil recovery.

In addition, NRG, the tenth largest power producer in the U.S. has also announced plans to move forward, together with Powerspan, to capture CO_2 from its 125 MW WA Parish plant in Fort Bend Texas, and to generate revenue from the sale of CO_2 for enhanced oil recovery. NRG indicates that this plant will be operational in 2012.

Thus, as noted above, immediate deployment of CCD is not a technical or research issue as much as it is a policy and economic issue. As noted in testimony by Tenaska Vice President Gregory Kunkel:

"We have developed Trailblazer in anticipation of federal climate change legislation that would support, through placing a price on greenhouse gas emissions and other means, the significant capital and operating costs of carbon capture technology. Without climate legislation, it appears that revenues from enhanced oil recovery CO_2 sales will be insufficient to cover all carbon capture costs. With proposed climate legislation, projected compliance cost savings and other effects of climate change legislation, combined with EOR revenues, would provide the needed economic incentives to build and operate Trailblazer."[5]

Mr. Kunkel is joined by yet another prominent utility. According to the CEO of NRG Energy, David Crane:

"The company I run, NRG Energy, emits more than 64 million tons of carbon dioxide (CO2) into the atmosphere each year -- more than the total man-made greenhouse gas emissions of Norway. Why do we do it?...We do so because CO_2 emissions are free… in a world where CO_2 has no price, removing CO_2 before or after the combustion process is vastly more expensive and problematic than just venting it into the atmosphere. …If Congress acts now, the power industry will respond. But we need to move as quickly as possible toward implementing the low-emissions ways of combusting coal that are under development or ***in the case of "coal gasification" technology, are ready for commercial deployment***. Effective incentives for these new technologies could easily and readily be included in a cap-and-trade regimen. Lawmakers need to provide both the carrot and the stick to get the CO_2 out of coal."[6]

Mr. Crane therefore points out that the reason that no large integrated power sector CCD project exists today is purely economic: it is simply cheaper to vent the CO_2 under today's laws instead of capturing it, compressing it, transporting it to a suitable reservoir and sequestering it. However, this is not an indication of the state of readiness of the technology, as his statement makes clear.

The USDOE is leading a national research program on CCD. Although we applaud the efforts of the dedicated and talented individuals involved in this program, the resources and funding available are not in line with the deployment timescale needed for CCD to reduce emissions meaningfully. Without an economy-wide cap-and-trade scheme that prices carbon emissions, and without targeted and reliably funded incentives (such as

[5] Testimony of Gregory P. Kunkel, Ph.D. Vice President of Environmental Affairs Tenaska, Inc., before the United States House of Representatives Natural Resources Subcommittee on Energy and Mineral Resources "Spinning Straw Into Black Gold: Enhanced Oil Recovery Using Carbon Dioxide" June 12, 2008

[6] David Crane, CEO of NRG Energy; Washington Post, October 14, 2007 (emphasis added)

auction revenues, as opposed to appropriations) to bring down the costs of CCD in the initial years when the carbon price is too low and volatile to spur investment, CCD is destined to linger in the background as it has done until now.

We are convinced, however that, under the right policy framework, hundreds of MWs of power sector CCD would be deployed in the early years. The DOE's targets and timelines should not be seen as representative of the technology, or its program as the gateway to CCD. In fact, CCD is available for deployment today---what is needed is the appropriate policy, part of which could be a fund similar to that created under H.R. 6258.

A word about costs for CCD 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.

Finally, I should emphasize that although CCD is an important strategy to reduce CO_2 emissions from fossil fuel use, 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, and will come with tremendous public health and environmental co-benefits as compared to fossil fuels. 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, biomass, geothermal and other renewable energy resources, we tap only a tiny fraction of the energy the Earth provides every day. There is enormous potential to expand our reliance on these and other resources.

H.R. 6258: The Carbon Capture and Storage Early Deployment Act.

H.R. 6258 represents one possible approach to encouraging the commercial availability of CCD. Under the bill, a Carbon Storage Research Corporation (CSRC) would be created if entities representing two thirds of the fossil fuel based electricity that is delivered to consumers voted to create such a corporation.

The Corporation would be operated as a division or affiliate of the Electric Power Research Institute (EPRI) and would be managed by a Board of not more than 12 members. The Board will be appointed by EPRI and will include representatives of investor owned utilities, utilities owned by a federal or state agency or a municipality, rural electric cooperatives and fossil fuel producers.

The Corporation would assess fees on distribution utilities for all fossil fuel-based electricity delivered to retail consumers. The assessment would apply to electricity generated from coal, natural gas and oil and would reflect the relative carbon dioxide emission rates of each fuel. Distribution utilities would be allowed to recover the costs of the fee from retail consumers.

The total assessment would result in a fund of approximately $1 billion annually. The fee translates into a roughly $10-$12 total annual increase in residential electricity rates according to the sponsors.

The Corporation would distribute the funds through grants and contracts to private, academic and governmental entities. Although the bill's stated purpose is "accelerating the commercial deployment and availability of carbon dioxide capture and storage technologies", both the amount of funding generated and the description of the projects appear to emphasize pre-commercial development and demonstration. Supported projects are to encompass a range of different fuel varieties, be geographically diverse, involve diverse storage media and employ technologies suitable for either new or retrofit applications. Moreover, such projects shall be large scale projects and not be pilot projects or similar small scale projects. Given that CCD is available today for deployment, the prohibition on funding pilot or small scale projects is appropriate and should probably be given greater definition and clarity under the legislation.

As noted previously, although Chairman Boucher has already indicated his intention to enact a comprehensive cap and trade bill, and stated clearly that H.R. 6258 is only a first step toward such a program, NRDC remains concerned that pursuing H.R. 6258 and other similar legislation in isolation will lend aid to arguments for delaying needed emissions cuts, by suggesting the need for further research and demonstration. Accordingly, while NRDC appreciates the fact that the timeframe in the bill for the life of the CSRC was shortened considerably during the drafting process, NRDC continues to believe that such legislation should only be enacted as part of an overall cap and trade system. This is so, not only because we cannot wait for full implementation of such a program before mandating steep emission cuts, but also because only a combination of cap and trade provisions and initial subsidies will provide a sufficient incentive for us to achieve a build-out rate for CCD that is consistent with the EPA's projection in its model of 60 GW of CCD capacity by 2025.

While the 10 year budget of $10-$11 billion is certainly a large subsidy for a research and development program, the financing hurdles required to launch this technology in commercial applications are only likely to be overcome through a combination of aggressive, short term, and front-loaded subsidies to encourage first to market participants, plus a cap and trade policy over the long term to make the decision to deploy CCD technology a purely economic one.

As an example of these economics, Tenaska's plan to build a carbon capture and storage facility is aided by the partial benefit of selling their CO_2 into the Permian Basin for enhanced oil recovery (EOR). The 600MW Trailblazer post-combustion power plant is projected to cost $3 billion dollars by the time it is completed in 2014 which roughly equates to $5,000/MW for a CCD power plant facility.

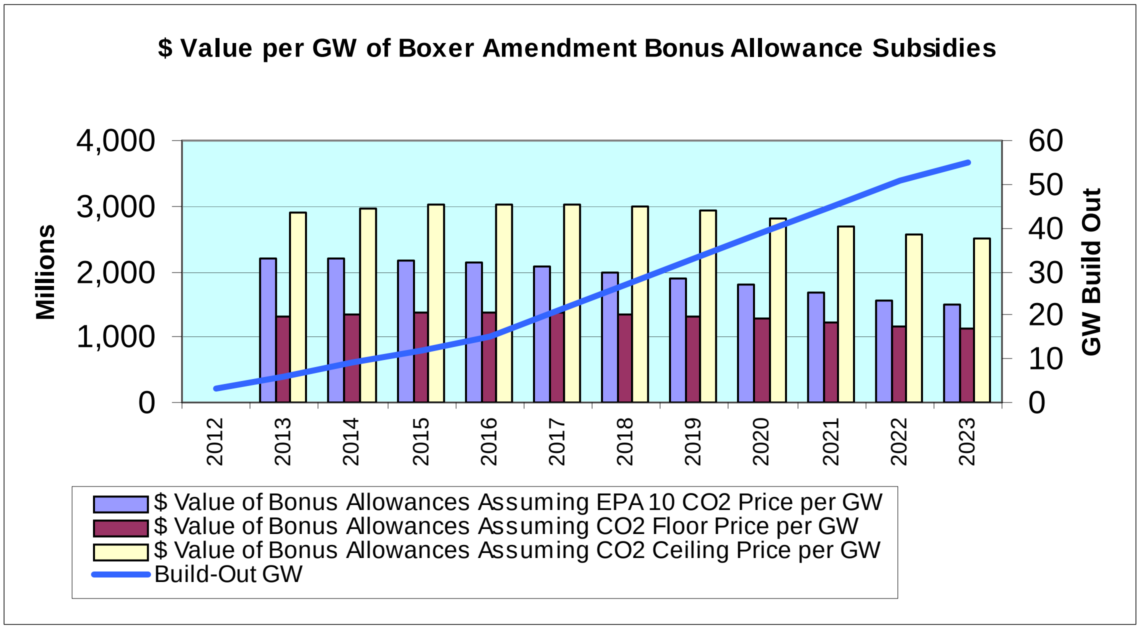
While this large-scale project would be an ideal candidate for the funding mentioned in H.R. 6258, funding from the bill alone would not provide enough support to Tenaska, independently of a cap and trade program, to make this single CCD facility economically viable.

In testimony before the House Committee on Natural Resources, Tenaska has stated that due to the higher capital and operating costs of a CCD power plant, and even with EOR benefits of being able to sell the carbon for $20-25/ton, they would not be able to proceed with the development phase of this project without a cap and trade policy in place.

The value of a cap and trade system, which puts a price on carbon emissions, cannot be underestimated for a facility like Tenaska's Trailblazer plant. Using carbon prices projected by the US Environmental Protection Agency under its "Scenario 10", a cap and trade system would reduce Trailblazers running costs by $4.3 billon dollars in 2008 over 30 years relative to a non-capturing pulverized coal plant. This is far more than would be offered under the most generous funding that could be provided under H.R. 6258 and would ensure that the build-out of CCD technology becomes an economic decision in its own right over time-- as higher carbon costs reduce the profitability of older non-capturing facilities.

Because a cap and trade program creates an enormous amount of potential revenue that the government can decide how to distribute, enactment of a cap and trade system will provide a means for funding CCD at levels well beyond those contemplated in H.R 6258, as well as creating a firm price signal. Thus, it is important to recognize that the subsidies being provided under current cap and trade legislation are designed to provide higher first to market incentives than the ones provided under the Boucher legislation.

For instance, looking at the subsidies provided under the Boxer Substitute to the Climate Security Act, S. 3036, the subsidies allocated to a carbon capture and storage facility in just the "kickstart" portion of the bill (S.3036 Section 1005) would amount to $3,000/MW for the first 5-10 facilities with a total program value of $9-21 billion dollars, depending on the price of carbon. Following this disbursement, the Bonus Allowance subsidies would provide roughly $1.2-2.5 billion dollars per GW or $1,200-2,500/MW for the next 52GW of CCD build out through 2023 (see graph below):



Source: Natural Resources Defense Council

This level of subsidy effectively provides 100% of the additional capital costs of building a CCD power plant with transportation facilities for first movers plus a small subsidy for higher operating costs over the next 10 years. These performance based subsidies, while generous, are expected to allow for the financing of the early projects without the 20-30% implied rates of return that would have to be factored into such facilities on a stand alone basis given the risks and low returns of capturing carbon without a cap and trade system in place.

In sum, the amounts of money needed to launch CCD to scale are significant and will require direct subsidies but at a higher level for early participants than the funds raised in H.R. 6258 would enable to be funded. A cap and trade system, while unlikely to provide incentive to first movers, is expected to be the strongest economic driver of this technology in later years and is considered essential to the long term viability of carbon capture and storage technology.

NRDC notes that there is no guarantee that the CSRC will ever exist, since its creation requires an affirmative vote by representatives of two-thirds of fossil fuel fired electricity generation. That vote may never happen or the vote may fail to garner the necessary two-thirds majority. To the extent that the research funded by H.R. 6258 is needed it should not be left to depend on the voluntary consent of the electric power industry. In order to avoid a situation in which enactment of such legislation fails to provide any fund at all, NRDC suggests that the activity to be funded by H.R. 6258 be enacted as part of a comprehensive cap and trade legislation, that should also include some form of mandatory performance standard and incentive, such as the Low Carbon Generation Obligation/Performance Standard provisions described near the end of this testimony.

There are numerous other changes to H.R. 6258 that could improve its overall effectiveness. For instance, NRDC would recommend that the CSRC board have a broader membership base, including representatives of public interest groups, independent experts from the academic community and federal and state governmental representation. In addition, NRDC believes that additional criteria could be included to ensure that there is a comprehensive plan for ensuring the right mix of projects, both pre- and post- combustion, that there is a diversity of conditions and sites, that different coal types are included and that there is compliance with all applicable environmental requirements including those under the Safe Drinking Water Act[7]. We would also raise, but not try to resolve, concerns about the federal government legislating in the state rate recovery arena, which is a complex area of law and policy. Finally, if rate recovery is required for utilities, then to the extent that funds are not expended, and are returned to utilities, corresponding rebates should be required for consumers.

Additional Legislative Proposals Related to CCD.

A. Bonus Allowance Provisions in S. 3036.

As noted above, NRDC believes that the powerful combination of a price signal and billions of dollars in CCD subsidies made possible by a cap and trade program are clearly the best way to achieve our common goals of reducing emissions, at the lowest possible cost while incentivizing deployment of zero and low carbon technologies, including CCD. The bonus allowance provision in the Lieberman-Warner bill (that would provide a bonus allowance for CO_2 that was actually disposed of in geologic repositories,) represents one way to achieve that result. However, the amount of the subsidy represented by the bonus allowance provisions would depend heavily on the price of allowances, and therefore could be either greater than necessary or smaller than necessary. In addition, apart from any increase in allowance prices, the amount of the subsidy for the bonus allowance provisions remained relatively constant through the life of the program, and therefore failed to favor earlier CCD projects over later ones.

B. Fixed Feed in Subsidy Proposal

In light of some of the features of the bonus allowance provision described above, one alternative that NRDC suggests the Committee may wish to explore in this context is creation of a performance based fixed price subsidy that would be set at its highest level for the first three GW of CCD and would decline as additional CCD capacity is deployed. An overall amount of CCD would be incentivized during a set period. This would create a "race" for early CCD deployment and also, depending on the level of subsidy, could guarantee that such early projects were in fact economic.

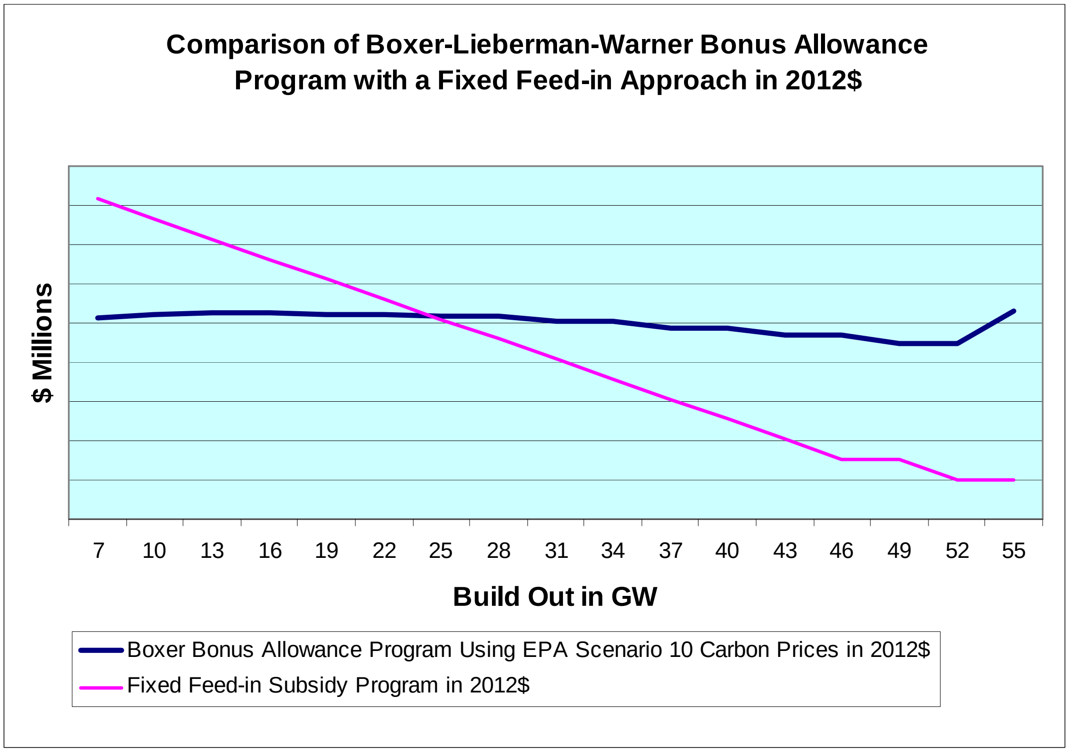
Under this approach, the fixed feed-in subsidy would start at a high dollar payment per ton avoided through CO_2 geologic disposal and would be paid for the first ten years of project operation. The payment level selected for the first 3 GW of capacity would be set

[7] See Robert M. Sussman, "Securing Coals Future: CCS Demonstration Projects at Coal Fired Plants Must Begin Now" June 19, 2008. http://www.americanprogress.org/issues/2008/06/securing_coal.html

at a level to assure that the full incremental costs would be covered with a cushion to address the risk aversion associated with the very first projects. For subsequent projects the payment rate would be reduced, with each successive 3 GW of capacity receiving a lower payment rate until the rate reached a level of perhaps $10/ton as the build out reaches 55GW. NRDC believes such a program would cost less than the estimated costs of the Bonus Allowance provision in the Boxer-Lieberman-Warner bill (estimated at $135 billion assuming EPA Scenario 10 carbon prices).

A fixed feed-in approach would likely be seen as more bankable by the financial community than bonus allowances which would only have a monetary value from 2012 on and then would be subject to price volatility over the coming years.

Lastly, when looking at both subsidy approaches in terms of dollar value per GW (see graph below), the fixed feed-in approach offers a better incentive structure to encourage first to market participation by offering declining incentives over time. This is not the case under the bonus allowance approach where the relatively constant subsidy profile could encourage players to wait in order to take advantage of the declining technological learning curve for CCD.



Source: Natural Resources Defense Council

A fixed feed-in subsidy would attempt to target the cost spread differential between Pulverized Coal (PC) and IGCC-CCD power plants. Since this cost differential is expected to narrow over time, as the higher carbon costs and lower CCD capital costs erode the all-in cost differential between PC and IGCC-CCD, the program is designed as a declining feed-in subsidy to reward early participants who would be forced to shoulder this initially higher cost differential.

C. Low Carbon Generation Obligation and Performance Standard.

An additional measure to speed CCD deployment is a low-carbon generation obligation (LCGO) 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 CO_2 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.

The Sanders Boxer bill, 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. 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 recent CCD costs, 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.

However, by itself, a low carbon generation obligation would not necessarily prevent the building of new power plants without CCD technology. Such plants cost billions of dollars and will operate for 60 years or more. It is critical that we stop building new coal plants that release all of their carbon dioxide to the air. While the Low Carbon Generation Obligation would provide a strong financial incentive to build plants with CCD technology, it would need to be combined with a mandatory performance standard in order to ensure climate protection from coal fired power plants.

The Sanders-Boxer bill, S. 309, contains both a low carbon generation obligation and a complementary performance standard for coal plants. The Markey Bill, H.R. 6186, also contains a performance standard for coal fired power plants. We recommend the

Subcommittee and Committee consider including provisions of these kinds in future legislative efforts. S. 309 includes a CO_2 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 plants using CO_2 capture. Combined with an LCGO, this provision would ensure both the availability and deployment of new CCD plants as soon as possible. We urge the committee to explore this option for incentivizing and, ultimately, requiring CCD at new power plants.

Conclusions

In light of the number of current coal plant proposals, and government projections of future coal use, it appears that we are likely to continue using coal in the U.S. and globally in the coming decades in amounts that are incompatible with the scientifically dictated greenhouse gas reduction targets. Therefore it is imperative that we act now to deploy CCD systems instead of highly-polluting conventional coal facilities. Commercially demonstrated CO_2 capture systems exist today and competing systems are being both researched and developed. Improvements in current systems and emergence of new approaches will be greatly accelerated by requirements to limit CO_2 emissions. Commercial deployment of such systems will only happen with enactment of comprehensive climate bills that cap CO_2 emissions and also incorporate complementary policies to promote accelerate deployment of CCD. These bills will also ensure that deployment of CCD is not done at the expense of cheaper, truly clean and renewable technologies and measures, which we consider preferable. Geologic disposal of large amounts of CO_2 is viable and we know enough today to conclude that it can be done safely and effectively.

Chairman Boucher, by introducing H.R. 6258, you, and the other members of the House who have cosponsored your legislation, have initiated an inquiry into one of the most critical issues related to solving global warming. We commend you for seeking ways to accelerate the deployment of CCD technology and we look forward to working with you in that regard. Although the objective of speeding CCD deployment is one we support, we believe that H.R. 6258 by itself would not be effective in achieving this objective and that such programs should be included as part of a larger cap and trade program. Moreover, we believe that other funding approaches to achieve CCD deployment should be considered. Finally, we believe that further improvements can be made to H.R. 6258, in terms of its efficacy and transparency.

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

APPENDIX A

Is CCD Ready for Broad Deployment?

David Hawkins

Director, Climate Center

Natural Resources Defense Council

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 CO_2 from power plants and other industrial sources? Where can we put CO_2 after we have captured it? Will the CO_2 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 CO_2.

CO_2 Capture

The IPCC special report groups capture or separation of CO_2 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 CO_2 in large amounts but in low concentrations and low pressures. Commercial post-combustion systems exist to capture CO_2 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 CO_2 annually) from a few coal-fired power plants in the U.S. that sell the captured CO_2 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 globally, 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 CO_2 and then separating the CO_2, primarily through the use of solvents. These same techniques are used in industrial plants to separate CO_2 from natural gas and to make chemicals such as ammonia out of gasified coal. However, because CO_2 can be released to the air in unlimited amounts under today's laws, except in niche applications, even plants that separate CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 to the air rather than capturing it. Enacting laws to limit CO_2 can change this situation, as discussed in my testimony.

While pre-combustion capture from IGCC plants is the approach that is ready today for commercial application, it is not the only method for CO_2 capture that may emerge if laws creating a market for CO_2 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 CO_2 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 and see whether 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 CO_2 emissions by about 90 percent. Adoption of policies that set a CO_2 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 discussed in my testimony, adoption of CO_2 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. 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 CO_2 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 CO_2 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 CO_2 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 CO_2 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 CO_2 into geologic formations. For several decades oil field operators have received high pressure CO_2 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 CO_2 are injected annually in more than 70 projects. (Unfortunately, due to the lack of any controls on CO_2 emissions, about 80 per cent of that CO_2 is sources from natural CO_2 formations rather than captured from industrial sources. Historians will marvel that we persisted so long in pulling CO_2 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 CO_2, 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 CO_2 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 CO_2 will stay where we put it.

Let me summarize the findings of the IPCC on the safety and efficacy of geologic disposal. 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 CO_2 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 CO_2. With adequate resources applied, EPA should be able to make the necessary revisions to its rules in two to three years. We urge the members of this Committee to support legislation to require EPA to undertake this effort this year.

Do we have a basis today for concluding that injected CO_2 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 about the implications of imperfect execution of large scale injection projects, especially in the early years before we have amassed more experience. Is the possibility of imperfect execution reason enough to delay application of CO_2 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 CO_2 capture, new coal plants built during any "delay and research" period will put 100 per cent of their CO_2 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 CO_2 capture at new coal plants to await further research would result in cumulative CO_2 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 CO_2 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 CO_2 capture equipment on the ground that we need more large scale injection experience will always result in significantly greater CO_2 releases than starting CO_2 capture without delay for new coal plants now being designed.

The IPCC also made estimates about global storage capacity for CO_2 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 CO_2 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.