THE FUTURE OF COAL UNDER CARBON CAP AND TRADE

HEARING

BEFORE THE

SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING HOUSE OF REPRESENTATIVES

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THE FUTURE OF COAL UNDER CARBON CAP AND TRADE

THURSDAY, SEPTEMBER 6, 2007

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON ENERGY INDEPENDENCE
AND GLOBAL WARMING,
Washington, DC.

The Committee met, pursuant to call, at 9:30 a.m., in room 2172, Rayburn House Office Building, Hon. Edward Markey (chairman of the Committee) presiding.

Present: Representatives Markey, Blumenauer, Inslee, Larson, Solis, Herseth Sandlin, Cleaver, Hall, McNerney, Sensenbrenner, Shadegg, Walden, Sullivan, Blackburn, and Miller.

The CHAIRMAN. Good morning. In the fight against global warming the single greatest challenge we now face is how to reconcile our reliance on coal with the urgent need to reduce carbon dioxide emissions. Coal-fired plants supply half of all our electricity in the United States, and we have the largest coal reserves in the world. China and India, two of the largest and fastest-growing economies in the world, also have abundant reserves and are even more dependent on coal for electricity generation.

But while coal is plentiful, and ostensibly cheap, it is also the leading source of global warming pollution. Coal-fired powerplants emit twice as much carbon dioxide per unit of electricity as gas-fired plants, and are responsible for over a quarter of all greenhouse gas emissions, both in the United States and globally.

We are at a watershed moment in the history of electricity production, and the future of the planet hangs in the balance. By 2030, U.S. electricity demand is expected to increase by over 40 percent, and global demand is expected to double. As a result, the next two decades will bring the largest and fastest expansion in electricity generation in the history of the world.

We must act now to level the playing field by requiring coal-fired plants to internalize the costs of their global warming pollution. If we fail to do so, all our efforts at expanding renewables and improving efficiency are likely to be drowned by a tidal wave of coal.

There are over 150 new coal-fired powerplants on the boards in the United States, and, globally, it is predicted that something on the order of 3,000 such plants will be built by 2030. These new plants alone would increase U.S. greenhouse emissions by 10 percent and global emissions by 30 percent. That would spell disaster for the planet.

There is a growing consensus that to avoid dangerous global warming we need to reduce global greenhouse gas emissions by 50 percent or more by 2050. The United States will need to reduce emissions by as much as 80 percent by 2050. These objectives, quite simply, will be impossible to achieve if we fail to move quickly to control carbon dioxide emissions from coal-fired powerplants.

Fortunately, carbon capture and storage, or CCS, offers a path forward for coal and a bridge to a low-carbon future powered mainly by renewables. CCS involves capturing carbon dioxide emissions at the source and injecting those emissions into deep geological formations to isolate them from the atmosphere. All indications are that CCS is a viable interim solution to the coal problem, but current DOE projections suggest that CCS will not be commercially available until 2020 or later, after most of the new coal-fired plants now on the boards, both here and in China, will already have been built.

We must pick up the pace. This Congress is already taking steps to do so. The House and Senate energy bills each provide nearly $1.5 billion in funding over the next several years for CCS research, development, and deployment. But subsidies alone will not be enough. To unleash the private sector's vast resources and ingenuity, we need a regulatory driver. We must enact limits on carbon emissions now.

The country is ready for action. While wind and other renewables are booming, public concern about global warming has virtually halted construction of new coal-fired powerplants in the United States. It is in everyone's best interest that Congress act now to require rapid deployment of CCS to provide a path forward for coal and to give utilities the certainty they need to make sound investment decisions.

The policies we adopt will have global impacts. If we fail to bring CCS online in the near future, the fleet of coal-fired plants already being built in China and India will swamp whatever emissions reductions we achieve here or in Europe. But, instead, we now have a chance to blaze this new trail. The world will follow if we give the leadership, and we will reap the environmental and economic rewards of that leadership.

The time for opening statement by the Chair has expired. I turn to recognize the Ranking Member, the gentleman from Wisconsin, Mr. Sensenbrenner.

[The statement of Mr. Markey follows:]

Opening Statement for Edward J. Markey (D-MA)
"The Future of Coal Under Carbon Cap and Trade"
Select Committee on Energy Independence and Global Warming
September 6, 2007

In the fight against global warming, the single greatest challenge we now face is how to reconcile our reliance on coal with the urgent need to reduce carbon dioxide emissions. Coal-fired plants supply half of all electricity in the United States, and we have the largest coal reserves in the world. China and India, two of the largest and fastest growing economies in the world, also have abundant reserves and are even more dependent on coal for electricity generation. But while coal is plentiful and ostensibly cheap, it is also the leading source of global warming pollution. Coal-fired power plants emit twice as much carbon dioxide per unit of electricity as gas-fired plants, and are responsible for over a quarter of all greenhouse gas emissions – both in the United States and globally.

We are at a watershed moment in the history of electricity production, and the future of the planet hangs in the balance. By 2030, U.S. electricity demand is expected to increase by over 40% and global demand is expected to double. As a result, the next two decades will bring the largest and fastest expansion in electricity generation in the history of the world. We must act now to level the playing field, by requiring coal-fired plants to internalize the costs of their global warming pollution. If we fail to do so, all our efforts at expanding renewables and improving efficiency are likely to be drowned by a tidal wave of coal. There are over 150 new coal-fired power plants on the boards in the United States, and globally, it is predicted that something on the order of 3000 such plants will be built by 2030. These new plants alone would increase U.S. greenhouse gas emissions by 10% and global emissions by 30%.

That would spell disaster for the planet. There is a growing consensus that, to avoid dangerous global warming, we need to reduce global greenhouse gas emissions by 50% or more by 2050. The United States will need to reduce emissions by as much as 80% by 2050. Those objectives, quite simply, will be impossible to achieve if we fail to move quickly to control carbon dioxide emissions from coal-fired power plants.

Fortunately, carbon capture and storage – or "CCS" – offers a path forward for coal, and a bridge to a low carbon future powered mainly by renewables. CCS involves capturing carbon dioxide emissions at the source, and injecting those emissions into deep geological formations to isolate them from the atmosphere. All indications are that CCS is a viable interim solution to the coal problem. But current DOE projections suggest that CCS will not be commercially available until 2020 or later – after most of the new coal-fired plants now on the boards, both here and in China, will already have been built. We must pick up the pace. This Congress is already taking steps to do so. The House and Senate energy bills each provide nearly $1.5 billion in funding over the next several years for CCS research, development, and deployment. But subsidies alone will not be enough. To unleash the private sector's vast resources and ingenuity, we need a regulatory driver – we must enact limits on carbon emissions now.

The country is ready for action. While wind and other renewables are booming, public concern about global warming has virtually halted construction of new coal-fired power plants in the United States. It's in everyone's best interest that Congress act now to require rapid deployment of CCS, to provide a path forward for coal, and to give utilities the certainty they need to make sound investment decisions. The policies we adopt will have global impacts. If we fail to bring CCS online in the near future, the fleet of coal-fired plants already being built in China and India will swamp whatever emissions reductions we achieve here or in Europe. But if we instead act now to blaze this trail, the world will follow and we will reap the environmental and economic rewards of leadership. It's time for Congress to take bold action and to chart the course forward. I trust that this morning's hearing will help to provide insight on how best to do so. In addition, I note that I have sent a letter inviting over 50 stakeholders to supplement the record with written testimony on CCS-related policy issues.

Mr. SENSENBRENNER. Thank you very much, Mr. Chairman.

Crisis. Catastrophe. Danger. These are the terms you often hear to describe global warming. In fact, former Vice President Al Gore once used all three of these terms in just one sentence.

I prefer the terms “opportunity” and “possibility.” Perhaps nowhere is there greater opportunity for the United States than on the topic of today’s hearing: the development of carbon capture and storage technology. Advancing technologies must be a key element to any global warming policy, and carbon capture and storage may be the most important and promising technology under development.

Why? Effective and affordable carbon capture technologies give the United States an opportunity to fully use our most plentiful energy source—coal—while helping reduce carbon dioxide emissions at the same time. Coal powers nearly half of the electricity production in the United States, and it is estimated that we have a 250-year supply. No state produces more coal than Wyoming, and I am pleased that Governor Freudenthal is here to tell us more about this vital energy source. And I welcome him, even though he is on the other side of the aisle.

It is estimated that electricity demand in the U.S. alone will grow by over 40 percent by 2030, just 23 years. And where will we get this energy? Coal is one of the most readily available energy sources we have, and it simply has to be a part of our energy future.

Already we know that technology exists that can remove up to 90 percent of carbon emissions from coal. These kinds of results will produce tangible benefits for the environment, which must be another essential element of any global warming policy. I am encouraged that there are a variety of carbon capture technologies in development. The government should foster this competition, but under no circumstances should we let government decision who wins and who loses. That is what markets are for.

One competitor in this race is located in my home State of Wisconsin. We Energies is conducting a first-of-its-kind carbon capture test at its Kenosha facility. We Energies is working with the Electric Power Research Institute on this project, and I welcome EPRI’s Director of Generation, Stuart Dalton.

American Electric Power is also in this race, and I am happy that Michael Morris, the company’s Chairman, President, and CEO, is here to tell us more about the research his company is conducting.

Global warming is not just a worldwide problem. It also provides worldwide opportunities for innovative companies like We Energies and American Electric Power. Coal provides for 79 percent of China’s electricity production and 68 percent of India’s. China has already overtaken the United States in carbon emissions, and India’s emissions growth continues to soar. If worldwide emissions are to be lowered, then China and India must be part of the solution.

It appears that American researchers are well on their way to developing the technology to make carbon capture and storage an affordable reality for the entire world. Imagine a giant “Made in the USA” sticker on future Chinese powerplants. What goes around comes back. And that is turning a crisis into an opportunity.

Let me apologize for not being able to stay for most of this hearing today, because I do have another obligation that I had committed to before this hearing was set. But I will read the testimony, and I am certain this will be a constructive input into what the United States ought to do relative to solving this problem.

I thank the Chair.

The CHAIRMAN. I thank the gentleman.

The Chair recognizes the gentleman from Oregon, Mr. Blumenauer.

Mr. BLUMENAUER. Thank you, Mr. Chairman. And I appreciate this opportunity the hearing affords. As both you and the Ranking Member have made clear, this is perhaps the central environmental challenge we face. Coal is a reality, coal is an opportunity, coal is both a threat and a solution, and I look forward to the panel.

I apologize in advance. We have a Ways and Means panel that is going on that our Chairman has labeled the "Mother of All Hearings," which is a hint that I need to spend a little time there, and I will try and come back and forth. But I am keenly interested in the record that is being built and the offers that are coming forward. It is central to global warming, it is central to pollution, it is central to energy, not just for the United States, but, as has been referenced, China and India, which are even more dependent and greater users.

The big questions about how to properly price carbon, how we can encourage and incent the technological developments, what is the appropriate regulatory framework—there will be some, there is some already, what adjustments need to be made—are part of the important work of this Committee, and part that each of our witnesses can help us understand.

And I do appreciate this, and I look forward to the results of the hearing. And I anticipate, Mr. Chairman, an opportunity for us to roll up our sleeves and spend much more time on this in the future.

Thank you very much.

The CHAIRMAN. I thank the gentleman.

The Chair recognizes the gentleman from Arizona, Mr. Shadegg.

Mr. SHADEGG. Thank you, Mr. Chairman, and I want to thank you for holding today's hearing on the future of coal under a mandatory cap and trade program, and the possible technologies for carbon capture and sequestration.

I want to welcome our witnesses and tell you each that I look forward anxiously to your testimony. I have reviewed your written testimony.

I think everyone on this Committee understands the importance of this issue. Many of my colleagues who are from coal-producing states like to point out that we have vast resources of coal, and that coal has to play a part in our energy future. At the same time, there is a clear need to deal with what I will call the ultimate goal, and that is reducing carbon emissions and using energy more efficiently and productively.

I think that with regard to a cap and trade system many have already rushed to embrace it as the right solution to this problem. I personally am not convinced of that. I am not convinced that a more transparent solution and a solution that might be able to be implemented on a global basis wouldn't be, at least to start with, a carbon tax.

But put aside the mechanism. The more important thing is to focus on the goal, and that goal is to be able to use the energy we have, including the energy produced by coal, and at the same time reduce carbon emissions. Therefore, I am extremely interested in the testimony of these witnesses regarding the current technology surrounding carbon capture and sequestration regarding its economic viability, regarding what it will cost to our energy, and regarding how soon it can be implemented. I think those are serious questions.

Over the August break, I went to Japan to look at nuclear power being developed there, and I also went to China to look at the energy situation there. China brings on, as you know, a new coal-fired powerplant every week—roughly a 250 megawatt plant—and, unfortunately, they are largely without any emissions controls at all, or at least not emissions controls that are currently being used. And they are clearly without any mechanism to capture the carbon which is emitted by those plants.

The technical solutions that we are going to discuss here are vitally important to our future, and I again thank the witnesses for their testimony and thank you, Mr. Chairman, for the hearing.

The CHAIRMAN. I thank the gentleman.

The Chair recognizes the gentleman from Washington State, Mr. Inslee.

Mr. INSLEE. Thank you. First, I want to comment that I am heartened by Congressman Sensenbrenner's comments of seeing this issue we are talking about today as an economic opportunity. And I think this is one for us in the United States, and I am encouraged by prospects of it, and I look forward to testimony.

There are a couple of things I hope the witnesses will address. One, I hope you will address what needs to occur short term to assure that we don't make a mistake of constructing what we will just call dirty coal plants now in the next decade and lock ourselves into really, really bad investments.

What needs to happen short-term, namely in this Congress, to prevent those unwise investments from being made that we will rue in the future? So far there is some good news that they are not being made, because of some good, common-sense visionary decisions being made not to build those plants in local communities, but I would like to know your thoughts on that.

Second, I hope you will give me—give us your view of what a regulatory structure should look like to regulate all issues regarding CO_2 sequestration, including liability, including ownership, including the permitting process. I very much appreciate your advice about that and how do we think about that, and I will look forward to it.

I learned about clean coal writing this book called Apollo's Fire with another fellow here this last year, and I just want to say that it was eye-opener, because before I wrote the book I really didn't see a lot of prospects for coal. But now, seeing the new technology coming on, it is something we have got to be aware of.

I look forward to your testimony. Thank you.

The CHAIRMAN. Thank you.

The Chair recognizes the gentlelady from Michigan, Mrs. Miller.

Mrs. MILLER. Thank you, Mr. Chairman. Really, I have no opening statement. But coming from the State of Michigan, you mentioned that the average—national average is about 50 percent of our electricity is produced by coal. Actually, in my State of Michigan, it is 68 percent, so I have a very big interest in the testimony of the witnesses today. I certainly want to thank the Chairman for having the hearing, and I look forward to the testimony.

Thank you.

The CHAIRMAN. Okay. The Chair recognizes the gentleman from Connecticut, Mr. Larson.

Mr. LARSON. Thank you, Mr. Chairman, and thank you again for holding this hearing. I, along with Congressman Blumenauer, have to leave to attend a Ways and Means hearing and what Mr. Blumenauer aptly pointed out our Chairman has called the "Mother of All Hearings."

But this certainly is a great hearing this morning and a great opportunity I think, as Mr. Sensenbrenner has pointed out. I am especially glad to see an old friend, Mike Morris, here who headed up Northeast Utilities for so many years, and an outstanding CEO. And I truly, you know, am interested in what a number of you have to say about a system of cap and trade.

And, Governor, I understand that China's Foreign Minister was recently in Wyoming as well talking about coal, and echo the sentiments of Mr. Inslee, but I am equally interested in what you might think about a carbon tax specifically put in a trust fund that has an opportunity to focus on payroll deduction and shifting monies ultimately to the consumers where costs ultimately will be shifted to, and focused research and development that could come from that, and especially as we look down the path to dealing with juggernauts like India and China.

My concern is one of transparency with the program and the need to have funding as we look down the path of dealing with major countries. I believe China is building a coal plant a day, and that raises some grave concerns in the urgency both for clean coal technology but also a system in which we can have the wherewithal to hopefully steer them towards alternatives that will do less harm to the environment.

And I thank the Chairman for this opportunity.

The CHAIRMAN. Great. The gentleman's time has expired.

The Chair recognizes the gentleman from Oregon, Mr. Walden.

Mr. WALDEN. Thank you very much, Mr. Chairman. I, too, am looking forward to hearing from the witnesses, especially with regard to this notion of a carbon tax—how high it might be to achieve the kind of results some people seek, the effect that might have on your industries or the consumers, because it seems to me that the consumers are the ones that are going to end up paying it. Even if it goes into a trust fund and comes back to them somewhere, my guess is the government is going to take its share out of that.

The second is where we are in terms of carbon sequestration. This Select Committee made a trip to Europe. We looked around at various facilities, some of which are trying to make gains in this area. How far out are we on getting affordable and effective carbon sequestration available for coal-fired plants? And at what cost? If there is a cost per kilowatt hour, I would sure like to know that.

And, certainly, this notion of cap and trade. It is one thing to apply to SO2 where we had an identified number of facilities with an identified and effective technology available to do the scrubbing. I am curious what you do when you apply it to carbon and how effective that will be, and, again, at what cost.

There was sort of an I guess humorous report that came out while we were on Congressional District work period, I am told, that four moose belch as much carbon as one car per year. And so this is a pervasive problem across the entire globe, and we have got to do our part, certainly, but I think we have to be thoughtful about it and understand the potential impacts of the decisions we may make here, especially relative to their cost, costs on the economy, costs to the consumers, and whether or not the technology is actually available and whether it will work.

And, finally, I would say that this has been another reckless summer in America's forests and grasslands, with unprecedented fires that release enormous amounts of greenhouse gases into the atmosphere. Catastrophically burned forests releases 100 tons per acre of greenhouse gases and emissions. A healthy green forest sequesters five to six tons per acre. I would sure like to see this Congress do something about better managing our forests and dealing with the whole issue of deforestation internationally as we let ours burn up here.

I have got people that have lost their jobs this summer because the mills have closed, because we are at a record low level of harvest of federal forests. Meanwhile, they burn up in their backyards, and sometimes they burn up their backyards. Enough is enough. This Congress needs to step up and do something about better managing our forests, if you are serious at all about dealing with global climate change and greenhouse gas emissions.

Thank you, Mr. Chairman.

The CHAIRMAN. I thank the gentleman very much, and we will be looking at the forest issue. And I think on your recommendation we might be looking at moose-belching offset legislation as well. [Laughter.]

And so those are two good suggestions.

Let me turn and recognize the gentlelady from California, Ms. Solis.

Ms. SOLIS. Thank you, Mr. Chairman, and I want to applaud you also for holding this hearing this morning. Yesterday, George Shultz, the former Secretary of State under President Reagan, wrote in The Washington Post that our nation and globe is at a golden moment, where if we choose wisely we can improve security and the environment while at the same time continuing economic growth.

But we have to address two issues in my opinion. First, we have to address the use of energy without producing excess greenhouse gases. And then, second, we need to address the reduction and threat of national security because of our excessive dependence on oil. Today's hearing I think will be a good opportunity to discuss the future of coal in that context and how coal fits in an energy portfolio without producing greenhouse gases.

This is going to be a challenge for us. Coal has a high carbon content, and coal-powered fire plants emit twice as much carbon per unit of electricity as natural gas-fired plants. In addition, coal-fired powerplants are responsible for a number of co-pollutants which are harmful to the health and well being of many of our constituents.

In a district like mine, and other communities of color, 5.5 million Latinos live within 15—within 10 miles of a coal-fired powerplant, significantly affecting their health outcomes, developing asthma and other respiratory diseases. The potential for as many as 150 new coal-fired powerplants in the country is troublesome, especially in vulnerable communities—communities of color—who can't defend themselves.

So I am looking at how we can try to address that issue, looking at communities that have been disadvantaged in the past, and might be the easiest location to put these powerplants, and yet trying to have the government treat these communities with a fair and balanced approach. So I am looking forward to hearing from the witnesses today.

And also, as you know, I represent a State that has been very progressive on this issue. In fact, with the passage of AB 32, one of the major legislations that was supported by Governor Arnold Schwarzenegger, is having a tough time making its way through implementation. But I think we can learn a lot from that, and I hope that some of you will address that.

I know some of our environmental groups have also challenged individual corporations who want to continue with building out these different types of powerplants, because they will be harmful to many communities of color that are going to be most vulnerable on the so-called food chain. So if you can help address that, that would be very important to me. Thank you.

Thank you, Mr. Chairman.

The CHAIRMAN. Great. The gentlelady's time has expired.

The Chair recognizes the gentlelady from Tennessee, Mrs. Blackburn.

Mrs. BLACKBURN. Thank you, Mr. Chairman, and thank you to our witnesses. As you have heard from everyone, we all are so interested in the carbon emissions, the sequestration storage capture technologies, and also the cap and trade system. I do have a couple of points that I am looking forward to hearing from you on.

First of all, in my list of concerns is implementing a mandatory cap on carbon emissions and the burden that that would place on the American economy. And some estimates that I have read are that the cost of the cap would increase the cost of electricity to the consumer by as much as 45 percent. That is of tremendous concern to us, that we would see this type increase. And I can assure you to my constituents in Tennessee, and all throughout the Tennessee Valley, this is a point that has not been lost on them.

And what we have read is that possibly Americans are not willing to spend that extra $40 a month when you look at trying to stop the release of carbon dioxide into the atmosphere. Second is that carbon capture technology may not be the most effective method to reduce and harness CO_2 emissions. Current technology already exists after all in an efficient form that enabled the industries to harness CO_2 for other applications, and some of the reading we have had presented to us on that is really quite interesting and definitely innovative.

Some use the technology to recover more oil from wells, and some are using it to capture CO_2 from powerplants and car fumes, to grow algae, which in turn is used to produce biofuels. So I think we are looking forward to hearing your take on that.

A couple of the members have referenced the trip we made to Europe to hold some meetings this year and to look at the cap and trade system. And I do have some serious concerns about the system. I have also had several concerns regarding the use of the carbon capture technology. Many are advocating that the Federal Government buy into the new technology despite what is a tenuous record at best.

And I would say that one of the things we learned in Europe during our meetings that is very instructive is that we should look carefully and evaluate very carefully, both on the technologies and on the cap and trade system, before we leap into this. So we welcome you, and we look forward to hearing from you today.

Thank you, and I yield back.

The CHAIRMAN. Great. The gentlelady's time has expired.

The Chair recognizes the gentlelady from South Dakota, Ms. Herseth Sandlin.

Ms. HERSETH SANDLIN. Thank you, Mr. Chairman. I thank you and the Ranking Member for this very important hearing. I am looking forward to the testimony of the witnesses today.

As has already been stated, more than 50 percent of our nation's electricity comes from coal-fired powerplants today, and demand for energy continues to rise. So we must find ways to use this abundant domestically-produced resource in a way that is economically viable and environmentally sustainable.

One way to do that is, as has already been mentioned in other opening statements of my colleagues, through capture and sequestration of greenhouse gases that are emitted as coal is burned, most specifically CO_2. As I have indicated to the Committee before, the Dakotas, neighbors to the great State of Wyoming, have an impressive story to tell in this regard. Basin Electric is a large electricity generating cooperative headquartered in Bismarck, North Dakota, that serves much of the northern plains, including much of South Dakota. The vast majority of their power comes from burning locally-mined coal.

It also owns a subsidiary, Great Plains Sinfuels, that turns coal into natural gas. In 1997, another of Basin Electric's subsidiaries, Dakota Gasification Company, agreed to send at least 95 million standard cubic feet of 96 percent carbon dioxide from its Great Plains Sinfuels plant through a 205-mile wide pipeline to an oil field near Wayburn, Saskatchewan, Canada.

Dakota Gas has been successfully capturing a portion of its CO_2 emissions and transporting the gas to Canada since September of 2000. Today, Dakota Gas operates the largest carbon sequestration project in the world. Each day Dakota Gas ships approximately 115 million standard cubic feet or 6,000 metric tons of CO_2 to Canada. With the addition of another CO_2 compressor in 2006, the capacity has been increased to 160 million standard cubic feet, or 8,000 metric tons daily.

All told, approximately six million metric tons of CO_2 have been sequestered since the project began in October of 2000. The CO_2 is expected to be permanently sequestered in the oil reservoir, which is monitored by the International Energy Agency. This successful project indicates that such technology is available, and we can make it feasible and economically viable.

So I look forward to any thoughts that the witnesses have on that technology and familiarity with that project, and other issues related to geologic sequestration or other beneficial industrial uses of these gases, and also looking forward to continuing to share the opportunities that the Dakotas have seized as we deal with the issue of promoting energy independence and fighting global warming.

And, Mr. Chairman, before I yield back, I am pleased to hear that we will be addressing in more detail the issue of forest management. Mr. Walden and I have worked on that issue in the past on the Natural Resources Committee, and think it is another area, particularly in rural parts of the country, where we can help find solutions to the issue of greenhouse gases.

Thank you, and I yield back.

The CHAIRMAN. I appreciate that. Thank you.

The Chair recognizes the gentleman from Missouri, Mr. Cleaver.

Mr. CLEAVER. Thank you, Mr. Chairman.

I am pretty much convinced that the legitimate epicenter for the War on Terror is in coal mines, that if we are serious about reducing our dependence on foreign oil we must hasten the development of the technology to produce clean coal.

I was somewhat alarmed to discover that the capital powerplant burned 17,000 tons of coal each year, which produces about 60,000 tons of CO_2. And I think following the leadership of our speaker, and the vision of our Chairman, Mr. Markey, we did pass H.R. 3221, which I think is revolutionary in that we are beginning to install technologies for the capture and storage of CO_2.

I am also, in connecting this with your testimony, concerned about something the President quite often mentions, which is this future gen powerplant. I am interested in how real it is, and if, in fact, it is real, what do those of you who I consider to be members of the coal intelligencia believe we can expect from this future gen powerplant.

Thank you, Mr. Chairman.

[The statement of Mr. Cleaver follows:]

U.S. Representative Emanuel Cleaver, II
5th District, Missouri
Statement for the Record
House Select Committee on Energy Independence and Global Warming Hearing
"The Future of Coal Under Carbon Cap and Trade"
Thursday, September 6, 2007

Chairman Markey, Ranking Member Sensenbrenner, other Members of the Select Committee, good afternoon. I would like to welcome our distinguished panel of experts to the hearing today.

In order to reduce our country's dependence on foreign oil, clean coal technology needs to be perfected and utilized. Coal is our primary fuel source to produce electricity and heat by means of combustion. Our country consumes 1.1 billion tons of coal annually, and 90% is used to generate electricity. Our own Capitol Power Plant provides steam and cooled water for the Capitol Complex. The plant burned over 17,000 tons of coal last year alone, and it produced about 60,000 tons of carbon dioxide emissions.

Coal is an abundant and domestic resource, but it is still a large source of pollution in the atmosphere and global warming. Coal-fired plants are the source of 59% of total sulfur dioxide pollution and 18% of total nitrous oxide emissions annually in the U.S. These plants release over 40% of the total carbon dioxide emissions in this country as well.

So far, the 110th Congress has made great progress in bringing clean coal and carbon capture and sequestration into a reality. H.R. 3221, the New Direction for Energy Independence, National Security, and Consumer Protection Act, included provisions to install technologies for the capture and storage or use of carbon dioxide. The passage of this measure by the House last month is certainly an impressive start, but Congress has much more work to do to make the large-scale use of clean and renewable energy a reality in our country. More progress by Congress will eventually enable the U.S. to achieve real energy independence that will protect our environment and the health of our fellow citizens.

I thank the panel for their insight and their suggestions concerning this vital issue as Congress moves ahead with a national energy policy.

Thank you.

The CHAIRMAN. Great. The gentleman's time has expired.

The Chair recognizes the gentleman from California, Mr. McNerney.

Mr. MCNERNEY. Thank you, Mr. Chairman.

This is a very difficult and interesting subject, and, as I said yesterday in our hearing on coal to liquid, that we need to keep an open mind on this. And I have to find myself in agreement with the Ranking Member in looking at this as a tremendous opportunity for our country and for many sectors of the economy that can take advantage of coal and use it in a way that does not impact the global warming issue.

For example, I heard recently of an interesting study that took place in Canada that affects states like Wyoming that have a lot of wind and a lot of coal. If you put in a large wind powerplant, about 20 percent of that wind power can be considered to be base load, whereas the other 80 percent is intermittent and can be used to process coal to produce energy products and to produce construction materials.

And so the coal and wind make a good partnership, which was quite surprising to me, because I am a wind power advocate and I spent my career in wind energy, so it was interesting to see that development. You would have expected coal and gas to make a good partner, but it doesn't because gas-powered plants require high operating performance. And when you turn them back, when wind comes up, they operate poorly.

So coal and wind is the natural partnership. So I would like to see that kind of advancement, that kind of research, open up new opportunities for both renewable and the old fossil fuel types of power. So I am looking forward to your testimony. Thank you for coming in today, and I will reserve the balance of my time for questions.

Thank you.

The CHAIRMAN. Great. The gentleman's time has expired.

The Chair recognizes the gentleman from New York, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman, and welcome. I was going to call you the co-elite, but thanks to Mr. Cleaver I have changed that to co-intelligencia.

Obviously, this is a question that we are considering today of great importance, because of the abundance of coal in our country and the need for our energy policy to change away from oil, but at the same time, as many have mentioned and as you all know, that getting the carbon emissions under control is critical to our dealing with global warming, which is the other mandate of this Committee.

And so I am just hoping to hear from the panel, in addition to the expert testimony which is about to be given, about our ability to incorporate sequestration technology into new plants; whether we could be doing more to retrofit existing plants with post-combustion methods; the balance between or the choice between cap and trade and carbon tax, which is—they are talked about sometimes as alternatives and sometimes as complementary approaches; about the developing world and how the U.S. can be more of a leader than we are, and how we can take a more cooperative approach from the outset; whether any of our experts are aware of an intergovernmental or international scientific efforts to develop sequestration in cooperation with these other countries to help them deploy them faster; and the potential for direct technology transfer, once we develop better sequestration methods.

I am also interested and hoping to hear ideas about incorporating carbon offsets into our trade agreements, and was wondering if Mr. Morris in particular could elaborate a little bit more on that possibility. Your testimony, sir, makes reference to administering a border tax. I am wondering if there is a possible way that this idea could be used to create a carbon tariff to use the market in driving countries like China to deal with emissions, and can we start incorporating these ideas now into our bilateral trade agreements without waiting for a new Kyoto.

So there is plenty to discuss, and, Mr. Chairman, I thank you for holding this hearing. I yield back the balance of my time.

The CHAIRMAN. Great. The gentleman's time has expired, and time for all opening statements from members has expired.

We will now turn to our very distinguished panel, and we will welcome our very first witness, who is Wyoming Governor Dave Freudenthal. Wyoming is the largest coal-producing state in the United States, and it is also the largest energy exporting state overall in the United States. Governor Freudenthal has a very long and distinguished career in public service and in the private sector. And there is probably no one in elected office in the United States that knows more about coal than Governor Freudenthal, and we are very honored to have you with us here today, sir. Whenever you are ready, please begin.

STATEMENTS OF DAVE FREUDENTHAL, GOVERNOR, WYOMING; MICHAEL MORRIS, CEO, AMERICAN ELECTRIC POWER; CARL BAUER, DIRECTOR, NATIONAL ENERGY TECH LABORATORY; DAVID HAWKINS, DIRECTOR, CLIMATE CENTER, NATIONAL RESOURCES DEFENSE COUNCIL; ROBERT SUSSMAN, PARTNER, LATHAM & WATKINS, LLP; AND STUART DALTON, DIRECTOR, GENERATION, ELECTRIC POWER RESEARCH INSTITUTE

STATEMENT OF DAVE FREUDENTHAL

Governor FREUDENTHAL. Mr. Chairman, members of the Committee, thank you. First of all, Mr. Chairman, it is clear that neither you nor I are under oath when you refer to me as having any expertise, so I guess you can get away with that. I do not know as much as I would like to know about this.

I am just going to fire through to try to deal with some of the questions. I think one of the things to understand about Wyoming in context was alluded to by the Chairman, which is that while we are the leading coal producer, natural gas production has actually eclipsed coal production in our State in terms of value to the economy. We are also—we produce half of the uranium that is in this country. We have an immense number of wind reserves, which are generally being tapped, but will be tapped more seriously as you get some powerlines.

So from the point of view of Wyoming, whichever option you decide to pursue, we have an economic viability. What I am concerned about is that we are approaching coal, frankly, failing to understand its role in the energy mix. And I am pleased to hear the Committee acknowledge that no matter what we do we are going to be dealing with coal going forward.

And it is an important element for us to focus on, and in that context I was perplexed that while the bills that were passed by the respective Senate and House talked about incentives and studies with regard to carbon capture and sequestration, they didn't talk about incentives for the coal technologies that are essential to have some carbon to capture.

I mean, if you are going to capture it, transport it, and place it in the ground, you are going to have to be incenting coal plants that have the capacity for that stream of carbon to be captured, either through retrofit of the existing fleet or through underwriting some development of technologies and I think commercial demonstration of some of the new technologies that people are talking about, because we have bifurcated the issue.

We have said, "Let us talk about carbon capture and sequestration," but carbon capture is really tied to the technologies that we are going to encourage to develop, so that there is some carbon to capture, that you have the capacity to capture it, and then the capacity to move it and the capacity to inject it.

The second point that I would make is you need to distinguish between carbon capture and sequestration and the utilization of carbon for enhanced oil recovery. Enhanced oil recovery is—it is a process by which you infuse the CO_2 into the ground, that breaks up the molecules, moves faster. That is not the same as carbon sequestration. That field that is amenable to that—and I think it is some of the low-hanging fruit for us as a country to get carbon sequestered, but that is—you are not sure it is going to stay there.

And so until you have made some significant study or effort to assure yourself that that carbon is going to stay there, that you can cap all of those holes in that field, I would urge you to be careful about equating enhanced oil recovery with carbon sequestration, because they are not the same. Now, they may be able to be the same in the sense that the fields may be amenable.

The other thing is that, be careful about thinking of natural gas as the automatic answer. In our State, we have an immense amount of gas produced. We also have processing plants which for every MCF of gas that is produced and shipped to California, two MCF of CO_2 are thrown off either into the atmosphere or into enhanced oil recovery. So when you are talking about how blessed gas is—and I love natural gas, it is great for my State—but I will tell you, in the context of your environmental calculations, it is an answer, but it is not a perfect answer, and you need to be careful about going forward with that.

With regard to sequestration, we have a lot of experience on enhanced oil recovery. We have found a number of formations which may be amenable to long-term sequestration, but the government, the Federal Government, needs to step up, fund those experiments, and make sure that it works. Don't mandate something without putting in place a pathway for us to get there, a pathway both for the states, the Federal Government, and, more importantly, for the private sector.

One of the things that I was asked to comment on is the role of the states. I have made my career beating up on the Federal Government, and it pains me greatly to be here and suggest that we need a federal mandate and a federal road map to deal with this, because I don't believe that while Oliver Wendall Holmes was right, that states are the laboratories, ultimately the ground rules are going to have to be set by the Federal Government. And you see the individual state efforts and the individual accumulation of states in the northeast, in the west. All we are really doing is vulcanizing this economy.

And if we don't come up with a serious set of ground rules that recognize that this is an interrelated economy throughout the United States, all you are going to do is leave individual states to make decisions and to give signals to the private sector which are contrary to the fact that these are all interrelated transmission grids, these are all interrelated systems, and I would encourage you that the Federal Government—none of the private money is going to move, none of the states are going to know realistically what to do until the Federal Government drops the other shoe, which is to say, "How are we going to monetize carbon in some form?" Be it a tax or a cap and trade.

Mr. Chairman, I note that my time is up. I appreciate the opportunity to be here. A little more than you wanted to hear, but——

[The prepared statement of Governor Freudenthal follows:]

TESTIMONY OF

**THE HONORABLE DAVID D. FREUDENTHAL, GOVERNOR
STATE OF WYOMING**

BEFORE THE

HOUSE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

EDWARD J. MARKEY, CHAIRMAN

**AT ITS HEARING ON
THE FUTURE OF COAL UNDER CARBON CAP AND TRADE**

Greetings

Mr. Chairman, distinguished members of the Select Committee thank you for the opportunity to appear before you and comment on the future of coal under carbon cap and trade. This is really a discussion on carbon management, more particularly carbon capture and sequestration, which inevitably leads to a discussion of the role of coal in fueling the American and international economy.

Wyoming in Context

Please allow me to place my comments in the factual context of Wyoming as a state committed to both energy production and environmental protection. I find people in Congress are most familiar with our two national parks – Yellowstone and Grand Teton -- and our role as the leading coal producing state in the nation with production of 446 million tons of low sulfur coal in 2006.

What is generally not as well known are the other forms of energy Wyoming produces. Depending on the day of the week and the mood of our friends in Oklahoma, we are either the second or third largest natural gas producing state in the country with annual production a bit over two trillion cubic feet or about 10% of the domestic supply. Wyoming has for several years been the largest producer of uranium in the country with approximately 2 million pounds a year of yellowcake (uranium concentrate) produced. We currently rank in the top quartile of states in wind generation, and have an estimated 8,000 megawatts of developable wind when the transmission constraint is released. Two projects have been announced recently which will add approximately 200 megawatts of capacity and at least 10 wind power projects are in various stages of review and development with state regulatory agencies. We produce about 53 million barrels of oil annually placing Wyoming in 7th place among the states.

Put another way on a net BTU exporting basis, subtracting state consumption from state production, Wyoming is by far the largest energy exporting state in the nation providing about 10 quadrillion BTUs or roughly 10% of the country's energy supply.
[See attached graphic]

Coal in Context

My purpose today is not to argue, but to recognize some fundamental realities.

Like it or not, coal is going to be used in America and the world for some time to come. Even without any new coal fired plants there are 1,522 existing generating plants consuming over one billion tons of coal per year. Over the next twenty years, new and replacement generating capacity is forecast at 292 gigawatts, the equivalent of 25 coal-fired power plants each year. While conservation and efficiency programs are forecast to make a real dent in the rate of growth of electricity consumption, we are going to need every form of energy we can harness including clean coal, natural gas and renewable resources. Non-hydro renewable resources of wind, solar and geothermal meet less than 1% of our energy needs today. Fossil fuel sources provide over 80%. For the foreseeable future, carbon based resources are a necessity if we want to keep the lights on. Hence, any serious carbon management effort must include aggressive support for carbon capture and sequestration.

Who Pays?

Without question, long term carbon management is going to cost a lot of money. Private and public sector investment will be redirected and those costs will ultimately fall to tax payers and consumers. Carbon capture and sequestration will also consume significant energy in the capture processes, compression and transportation which of course will add to operating costs. It would seem an appropriate policy goal then to pick those processes most likely to yield the greatest effectiveness at least cost to the consumer/taxpayer.

Consumer energy costs are not a trivial matter in my state. A recent analysis we completed suggests that the lowest income quartile, those households earning less than \$25,000 per year pay about 16% of their income for energy. Those in the highest quartile pay on average 2-3% of their income for energy. So those that can least afford it, pay 7 to 8 times as much a portion of their income for energy as most of us in this hearing room. Imagine what happens if the cost of energy rises 15, 20 or 25 percent and that differential begins to rise exponentially. In my small state that would affect over 51,000 households or 25% of my constituents. That means nearly 130,000 people are going to have to make very hard choices about how they spend scarce dollars. As policy makers we cannot ignore this issue in our search for solutions.

No Silver Bullets

It is clear the public attitude is changing with respect to greenhouse gas management and as proof you need look no further than the ads surrounding the Sunday morning talk shows. Company advertising now talks about how green they are, not how efficient they are, or how much growth they enjoy. Other advertisements publicly shame firms which make money off of projects or companies which do not meet the "green" test. And much of the public conversation is about increased consumption of natural gas in lieu of coal.

But even the current shift to natural gas is not without carbon implications. Burning natural gas has fewer CO_2 emissions per unit of electricity produced but still has carbon emissions and if one considers the upstream footprint of exploration and production natural gas is an answer, but not a perfect answer. For example, in my state, natural gas processing plants emitted 6.9 million metric tons of CO_2 equivalent in 2005, representing nearly 25% of our net carbon footprint. One of the two largest plants operated by ExxonMobil has a large well field and plant that produces natural gas, helium and CO_2 for the enhanced oil recovery industry. However much of the CO_2 is currently vented to the atmosphere. In fact, for every million cubic feet of natural gas produced, nearly two million cubic feet of CO_2 is produced and a majority of it is vented to the atmosphere. My friends in California where much of the natural gas ends up don't always take this into account when they do their carbon footprint analysis.

State Perspective

We believe the state has a role in managing greenhouse gases and to that end we have begun to construct the legal framework to do so. However, even the simple question of who has the right to sequester CO_2 under state law is amazingly complicated. Does that right belong to the surface owner or to the owner of the mineral estate? How do we take into account the vast federal ownership of both the surface and mineral estate?

From the point of view of a Governor, the absence of a well thought out, cogent federal policy that maps the pathway forward makes the task of setting workable rules, regulations and operating practices that much more difficult. This is equally true for the private sector. Until someone monetizes CO_2 through performance standards with offsets, cap and trade or some variation of these schemes the marketplace is wandering in the desert. The level and pace of technology development will be set largely by the scheme you adopt as the price of carbon, the timeline for implementation and off ramps such as safety valves anchor the assumptions behind any economic investment. With these variables in mind, the structure needs to be set sufficient to promote large scale demonstration projects sufficient to resolve the outstanding questions in a rational but aggressive manner.

We meet with folks who are absolutely serious about developing new plants to supply energy and they assume they will live in a carbon constrained world. They fully anticipate sequestration of CO_2 or the necessity of some other mechanism to manage greenhouse gases. Most are not shy about their dislike of taxes or escalating costs, but uncertainty about future carbon rules absolutely overwhelms every discussion. It appears to me that a number of these investments will never come to fruition until the other shoe drops and the boundary conditions are established for the risk with respect to carbon management.

In a minute I will list some specific actions I think make sense, but first I want to make an observation as a predicate to those recommendations. It is the simple notion that when it comes to carbon management, it is difficult but necessary to admit what we don't know. Because in the absence of full knowledge we tend toward absolutist positions like 'only wind', 'no nukes', 'only biomass' or 'no coal'. I am not sure the federal government knows how we should construct the greenhouse gas management regime and I am not sure industry knows either.

If you will grant me this observation for a moment, it seems a prudent course would be to pick those activities we believe must be undertaken no matter what path ultimately proves to be the correct one. For example, we know we need studies and demonstrations putting CO_2 in the ground in quantity to determine the physical facts i.e. measuring, monitoring and verifying sequestration data in the real world. We favor an array of these demonstrations as proposed by the Department of Energy carbon sequestration partnerships as a sensible approach given different conditions across the country.

Additionally, we know there are differences between enhanced oil recovery (EOR) and carbon sequestration which may or may not overlap. Monetizing a CO_2 stream for the purposes EOR may mitigate the cost impact on consumers in the early years of a carbon policy. This needs to be studied with some degree of granularity.

Staying with the theme of moving from the abstract to real world data, I believe we need to accelerate those programs that lead quickly to economically viable, commercial scale electric generation plants. This would include both super critical pulverized coal plants with significant carbon capture and sequestration as well as integrated gasification combined cycle (IGCC) plants with carbon capture and sequestration. My observation is that substantial federal underwriting to hasten this process is required to assist those companies willing to pursue these types of plants. Short of constructing and operating these plants and learning the lessons required to engineer follow on plants, we will be confined to the laboratory bench and speculation.

While I have heard and seen a number of presentations I am not sure there is definitive information on available technologies and the quantitative analysis surrounding commercial deployment of carbon sequestration. Academics and companies have their plausible estimates but I have yet to see money changing hands in a commercial transaction. In fact the discussion with the individuals charged with financing these projects, quickly becomes an exercise working through a list of the uncertainties. On that list are not only questions about the technologies involved with carbon management but the impact of the hyper-inflation in material, manpower and construction costs. Simple questions such as whether CO_2 capture and sequestration costs (capital and operating) will be recoverable as part of a utility's rate base has yet to be answered.

With respect to the federal – state interface and their respective roles in this enormous undertaking, we favor a model of federal standards and state implementation. The Clean Air Act is an example of how this might work. One important difference however between that process and our current situation is the state of development of the technology enabling implementation. Hence another threshold activity would seem to be the federal underwriting of the research and development of capture and storage technology to the point of commercialization. We need to not only understand the capital costs but the operating and maintenance costs through time. Additionally, the likely internal energy requirements to implement both a robust capture system and preparing CO_2 for transport and sequestration are most probably significant. This needs to be understood not only by the plant design engineers but by public policy makers as well.

Indemnification and risk assumption and at what juncture are also critical unresolved issues. There is precedent that the private sector absorbs the operational risk related to capture, transportation and injection. But post-injection risk, namely in situ liability of harm to human health, the environment and property related to CO_2 leakages needs to transfer to the public sector at a reasonable point in time when the operational risk of the initial process has practically concluded. Funding for this long-term risk management pool would likely need to derive from the monetization of CO_2 through a federal cap and trade or taxation system.

Another point of separation between the historically successful management of sulfur dioxide and carbon dioxide is the amount of material involved. In rough terms there is about 250 times the amount of material involved in dealing with CO_2 as with SO_2 in electric power generation. It would seem a detailed study of the required infrastructure would make sense. What will it take to move significant amounts of CO_2 from generation source to ultimate sequestration site? How much pipeline capacity will be needed and where will it need to be installed? What are the energy requirements to move large amounts of CO_2? What design standards will need to be in place and in force to ensure safe handling?

Resolving these vital questions requires a long-term commitment to fund demonstration projects at scale, to monitor, measure and verify the CO_2 activity and begin to build a risk assessment profile. According to a recent MIT study, to do so requires an 8-10 year commitment and a federal commitment of at least $1 billion/annum. But with a projected decline in GDP growth of $400-800 billion if carbon capture and sequestration is not deployed, our economy stands to suffer a far worse outcome if CCS is not commercially available in the next few decades.

State Activities

As I mentioned before, Wyoming has undertaken a number of activities to address the management of greenhouse gases. We are a founding member of the Climate Registry.

We are in the process of conducting an inventory of greenhouse gas sources to establish our emissions baseline and begin to identify practical opportunities for reduction. Many of our significant oil and gas companies are members of EPA's Natural Gas STAR Program which implements best practices to reduce methane emissions in natural gas exploration and production. For a number of years, our Department of Environmental Quality has employed a permitting protocol requiring best available control technology (BACT) for oil and gas minor sources which significantly reduce greenhouse gases. We have for many years had a Carbon Sequestration Committee investigating terrestrial sequestration opportunities springing from our agriculture lands and forests.

We have funded a study underway by the Wyoming State Geological Survey to identify optimal CO2 sequestration sites and to date they have found a site that is calculated to store all emission from every source in Wyoming for 350 years (20 billion tons). We have funded and operated the Enhanced Oil Recovery Institute at the University of Wyoming which assists primarily independent oil producers in finding suitable fields and employ CO2 floods to produce more oil. We participate in two carbon sequestration partnerships and have proposals for large scale demonstration projects at two promising sites. We have established the Wyoming Infrastructure Authority, a state instrumentality to address the electricity transmission constraint that keeps our vast wind resource from the marketplace. Recently, Rocky Mountain Power has announced plans to build nearly 1200 miles of high voltage power lines across four western states. We have competed in the FutureGen competition making the case for a western mine mouth plant located near both enhanced oil recovery well fields and deep saline aquifers for long term carbon sequestration. We have actively and seriously pursued section 413 of the Energy Policy Act of 2005 which calls for an Integrated Gasification Combined Cycle (IGCC) electric generation plant with carbon sequestration at an altitude above 4,000 feet with low ranked coals in a western state. We have signed a Memorandum of Understanding (MOU) with the State of California and particularly the California Energy Commission and California Public Utility Commission to work toward the development of this IGCC plant. We have funded a clean coal request for proposal (RFP) process with intention of drawing the best ideas from industry partnerships to advance the state of the art in clean coal technology.

We have established the School of Energy Resources at the University of Wyoming and will dedicate a portion of our time on the National Center for Atmospheric Research (NCAR) supercomputer to sequestration reservoir characterization. We have passed statutory incentives for the development of wind energy. We are exploring an exchange with a Chinese province focused on CO2 sequestration.

Summary

As you can see we are expending a good deal of money, time and talent in the pursuit of greenhouse gas management and will continue to do so. But please recognize this is just the tip if the iceberg and we need federal involvement in a serious way to really move forward in a meaningful way.

My recommendations for the Committee's consideration are three. First, continue to focus the debate on the proper, rational and achievable framework that leads to the monetization of carbon. However, let me be clear here, I am not urging continued inaction. The lack of a federal plan essentially paralyzes the other players, both private and public sector.

Secondly, focus short-term spending and federal underwriting on the nearly universally agreed upon activities of carbon capture and sequestration. With respect to capture, a better understanding of the technologies particularly the economics and power requirements is fundamental. Given the amount of material involved, a comprehensive study of the infrastructure requirements to move CO2 from source to sink is necessary. With respect to storage, continuation or acceleration of the multiple current sequestration projects which will put CO2 in quantity in the ground is essential.

Finally, the Congress should take up the issue of parsing the long-term liability of carbon storage. Serious investment in plants which will make use of carbon sequestration will likely not be forthcoming until this issue is settled.

It is my understanding that there have been over 105 hearings on this and the broader topic of energy independence in just the last eight months. I ask to you consider what specific information is still required to chart the course. For while I'm only one Governor, we will commit our resources towards obtaining the answers you need, so that we can effectively move forward now. The problem at hand is enormous, climate change does not wait for us and we cannot afford to delay.

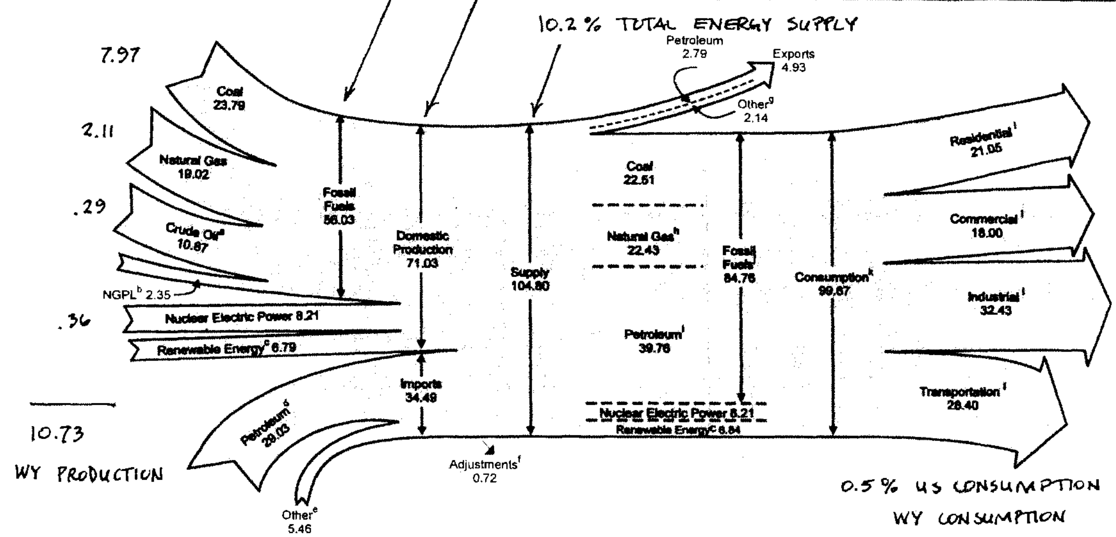
Mr. Chairman, thank you for your time and attention.

18.5 % DOMESTIC FOSSIL FUELS

Diagram 1. Energy Flow, 2006
(Quadrillion Btu)

15.1 % TOTAL DOMESTIC ENERGY PRODUCTION

10.2 % TOTAL ENERGY SUPPLY



[a] Includes lease condensate.
[b] Natural gas plant liquids.
[c] Conventional hydroelectric power, biomass, geothermal, solar/PV, and wind.
[d] Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.
[e] Natural gas, coal, coal coke, fuel ethanol, and electricity.
[f] Stock changes, losses, gains, miscellaneous blending components, and unaccounted-for supply.
[g] Coal, natural gas, coal coke, and electricity.
[h] Natural gas only; excludes supplemental gaseous fuels.
[i] Petroleum products, including natural gas plant liquids, and crude oil burned as fuel.
[j] Includes 0.06 quadrillion Btu of coal coke net imports.
[k] Includes 0.06 quadrillion Btu of electricity net imports.
[l] Primary consumption, electricity retail sales, and electrical system energy losses, which are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales. See Note, "Electrical Systems Energy Losses," at end of Section 2.

Notes: • Data are preliminary. • Values are derived from source data prior to rounding for publication. • Totals may not equal sum of components due to independent rounding.

Sources: Tables 1.1, 1.2, 1.3, 1.4, and 2.1a.

The CHAIRMAN. No, no. Again, you know, Mark Twain used to say that an expert is anyone who lives more than 500 miles away from a problem. And you, of course, live in Wyoming, so it is a Congressional expert that is the oxymoron, like jumbo shrimp or Salt Lake City nightlife. I mean, there is no such thing. [Laughter.]

So we need people like you, Governor, who come into town who actually are the experts to help us to understand these issues.

I am pleased to introduce our second witness, Mr. Michael Morris. He is the Chairman and CEO of American Electric Power. AEP is the largest electric utility in the United States, serving over five million consumers in 11 states, and it is also the largest consumer of coal in the United States. Under Mr. Morris' leadership, AEP has been an industry leader in the development of carbon capture and storage technology.

We welcome you, sir. Whenever you are ready, please begin.

STATEMENT OF MICHAEL MORRIS

Mr. MORRIS. Thank you very much, Mr. Chairman, and thanks for the opportunity to be here. I am intrigued by the questions that you have all racked up for us in your various introductory statements, and I know that, given the time that we will have to give comments and thoughts back and forth, this will be an extremely meaningful session.

I surely want to say hi to the Congresswoman from Michigan, who, while I was at Consumers Power for 12 years, had a lot of fun working with over the years, and you as well when I was at Northeast Utilities, Mr. Chairman.

I see this challenge not unlike the Ranking Member. It is, in fact, an opportunity. In your introductory comments of me, you mentioned 5.1 million customers. I have an obligation to make certain that there is adequate energy supply for those men and women in those industries, in those commercial operations, 24 hours a day, seven days a week, every day of the year. And for the most part, we do that. When weather intervenes, sometimes we aren't there when they want us, and that is very disturbing to them and understandably so.

Coal, as the Governor said, is an essential part, as many of you said in your opening comments, to the overall equation of how we will satisfy that demand across this entire country. Doing that with the respect for the environment is essential as well. To that end, we filed testimony to touch on many of those points, but let me subset on a couple of the specific questions that were sent to me by the Committee and by you.

The fact questions 3 and 4, "What is my company doing about this challenge?"—and our testimony is full of those kinds of issues, but, secondarily, question number 4, "When is a practical carbon capture and storage technology deployment going to be available for this country?"

We would believe that in the timeline in the latter half of the next decade we will have validated concepts that are already out in the marketplace, yet not out of the laboratory in the marketplace, to show that in fact, just as other flu gas issues or prior burn issues can be removed from the stream of carbon—of the coal fuel, we will have a chance to do that.

We intend, by 2009, at Appalachian Power in—that serves the states of West Virginia and Virginia—to do a 30-megawatt validation project on capture and storage there. We have worked with Battelle. We have subsurface storage actually at our Mountaineer site, and that would be our plan by 2009.

By 2011/2012, we will move that validation project out to Rogers County, Oklahoma, where at one of our major northeastern Public Service of Oklahoma stations we will capture up to 200 megawatts of carbon. There we will use it, as the Governor suggested, in enhanced oil recovery for the gas and oil fields in Oklahoma. We think that is an excellent way to go about doing that.

For the new plants—and those are both retrofit opportunities, which is essential for us to continue to keep the fleet out there for all of us in this country. For new plants, integrated gas combined cycle technology, ultra-supercritical technology, which we would hope to build also in Oklahoma with other partners, are part of the answer to use coal logically as we go forward.

So to the validation projects and the integrated gas combined cycle, we believe by the middle of next decade to the beginning of 2020 that technology will be there for us, and we as an industry, we surely as a company, will begin to deploy that as fast as we can. I think it is important to the notion of 150 coal plants to be built in some very short period of time.

The EIA unfortunately is always wrong in their forecast, and there is no way in the world we are going to build 30 or 40 nuclear stations, no way in the world we are going to build 150 coal-based generation stations in this country. Remember, in each and every of your states, we can't simply build whatever we would like. We can only build what the Public Utility Commission, Public Service Commission, or regulatory body will allow us to build.

The coal plants need to be built, and they, in fact, will be built between now and then. As to the notion of putting technology out there, what everyone will build at least will be coal capture-ready stations, if not coal capture deployed technology, because it isn't there yet. This is a very different timeline than the one that we shared a few decades ago when my company and my industry were very strong in the notion of "not now, not ever."

This is a willing industry, a willing company, a willing people, who simply want to have the timeline to allow the technology to develop, so that in fact we just don't get a political soundbyte but we get something that works.

To the gentlewoman from the Dakotas, I was part of the environmental study that—at American Electric Power Company—or, excuse me, at American Natural Resources when the gasification project was built. It has turned out to be an excellent idea. The day it came online it made gas for $8 a million BTUs into a $2 market, and everyone thought it was a terrible idea. Today, it does exactly as you suggest.

In the '60s, '70s, '80s, and '90s, we have used more electricity in this country than ever before every decade. The air and the water have gotten cleaner in each of those decades. If we are logical about how we do this, we can find an answer.

As to the global nature, it isn't U.S. warming, it is called global warming. We need to make certain that China, India, and other countries join us in this endeavor. What the unions and American Electric Power have put forward, and is being embraced at least at the principal committee in the House, and being embraced in writing in the Senate, is a concept that is WTO-compliant that ought to address that issue and cause them economically to want to do something.

Mr. Markey, in your opening comments you mentioned a number of plants being built here. They will be carbon capture-ready. The plants that are being built in China are not. That is a huge difference. This is a global issue, and there is no sense saddling the U.S. economy without addressing that global nature.

Thanks for the opportunity to be here. I look forward to the questions and answers.

[The prepared statement of Mr. Morris follows:]

Summary of Testimony of Michael G. Morris, Chairman, President, and CEO, American Electric Power before the House Select Committee on Energy Independence and Global Warming September 6 2007

American Electric Power (AEP) is one of the nation's largest electricity generators with over 5 million retail consumers in 11 states. AEP has a diverse generating fleet – coal, nuclear, hydroelectric, gas, oil and wind. But of particular note, AEP is one of the largest coal-fired electricity generators in the U.S.

Over the past decade, American Electric Power has implemented a portfolio of voluntary actions to reduce, avoid or offset greenhouse gases (GHG). During 2003-05, AEP reduced its GHG emissions by 31 million metric tons of CO_2 by planting trees, adding wind power, increasing power plant generating efficiency, retiring less-efficient units among other measures.

We also continue to invest in new clean coal technology that will enable AEP and our industry to meet the challenge of reducing GHG emissions longer term. This includes plans to build two new integrated gasification combined cycle (IGCC) plants and two, state-of-the-art, ultra-supercritical plants. These will be the first of the new generation of ultra-supercritical plants in the U.S. AEP plans to take the lead role in commercializing carbon capture technology. We signed a memorandum of understanding (MOU) with Alstom for post-combustion carbon capture technology using its chilled ammonia system. Starting with a "commercial performance verification" project in 2009 in West Virginia, we would move to the first commercial-sized project at one of our 450-megawatt coal-fired units at Northeastern Plant in Oklahoma by late 2012. This would capture about 1.5 million metric tons of CO2 a year, which will be used for enhanced oil recovery.

<u>AEP supports the adoption of an economy-wide cap-and-trade type GHG reduction program that is well thought-out, achievable, and reasonable.</u> We believe legislation can be crafted that does not impede AEP's ability to provide reliable, reasonably priced electricity to support the economic well-being of our customers, and includes mechanisms that foster international participation and avoids harming the U.S. economy. In contrast, imposing performance standards on new generation will place significant constraints on our ability and flexibility to adopt least-cost strategies under a market-based cap. Performance standards do not provide additional reductions or environmental benefits under a cap. In the end, cap-and-trade type legislation should include:

- A cap that applies to all sectors of the economy and covers all greenhouse gases;
- An unfettered cap-and-trade framework that maximizes flexibility and minimizes costs;
- AEP is not calling for an indefinite delay until advanced technology such as carbon capture and storage (CCS) is developed. However, as the requirements become more stringent during the next ten to twenty years, and we move beyond the ability of current technology to deliver those reductions, it is essential that requirements for deeper reductions coincide with the commercialization of advanced technology;
- Unrestricted use of real and verifiable domestic and international emissions offsets, such as methane capture from landfills, livestock, forestry and agricultural sequestration;
- Allowances allocated based on historic emissions to electric generators and other sources required to make reductions. At most, only a small number of the allowances (less than five percent) should be auctioned or set-aside for public benefit purposes; this is essential to minimize the cost burden to retail consumers;
- Recognition for companies that have voluntarily taken early actions/investments to mitigate emissions;
- Long-term public and private funding to develop commercially-viable technology solutions (*e.g.,* carbon capture and storage and other clean-coal technologies);
- Legislative provisions to eliminate the legal and regulatory barriers to the use of carbon capture and storage, nuclear, wind or other low or no-carbon technologies or processes;
- Regulatory pre-approval for utility recovery of costs of effective energy efficiency and demand-side management;
- A safety valve on the market price for purchasing allowances to be set at a level that protects the economy;
- Statutory provisions that address inequities that will result if the largest emitters in the developing world, who are manufacturing competitors with the U.S, fail to take comparable actions to cap or reduce their own emissions. If other countries refuse to reduce emissions but seek to continue to sell their goods in the U.S., our proposal would implement an appropriate trade measure to equalize the conditions of global trade. This measure could include a requirement that emission allowances accompany such imports, or border adjustment taxes that are functionally equivalent to America's domestic GHG initiatives, to be applied to products arriving from countries that do not limit their greenhouse gas emissions. Alternatively, the U.S. government could suspend or reduce the stringency of the domestic program until those countries join. (*See attached op-ed by Michael Morris, Chairman, President and CEO of AEP and Edwin Hill, International President of the IBEW.*)

Testimony of

Michael G. Morris

Chairman, President, and Chief Executive Officer

American Electric Power

Before the House Select Committee on Energy Independence and Global Warming September 6, 2007

Good morning Mr. Chairman and distinguished members of the House Select Committee on Energy Independence and Global Warming.

Thank you for inviting me here today. Thank you for this opportunity to offer the views of American Electric Power (AEP) and for soliciting the views of our industry and others on climate change technologies and policies.

My name is Mike Morris, and I am the Chairman, President, and Chief Executive Officer of American Electric Power (AEP). Headquartered in Columbus, Ohio, we are one of the nation's largest electricity generators -- with over 36,000 megawatts of generating capacity -- and serve more than five million retail consumers in 11 states in the Midwest and south central regions of our nation. AEP's generating fleet employs diverse sources of fuel – including coal, nuclear, hydroelectric, natural gas, and oil – and wind power. But of particular importance for the Committee members here today, AEP uses more coal than any other electricity generator in the Western hemisphere.

AEP Voluntary Climate Actions

Over the past decade, American Electric Power has implemented a broad portfolio of voluntary actions to reduce, avoid or offset greenhouse gas (GHG) emissions. In addition, we continue to invest in new clean coal technology plants and R&D that will enable AEP and our industry to meet the challenge of significantly reducing GHG emissions over the long term. For example, AEP is designing and will build two new generating plants using Integrated Gasification Combined Cycle (IGCC) technology in West Virginia and Ohio, as well as two highly efficient new generating plants using the most advanced (e.g., ultra-supercritical) coal combustion technology in Oklahoma and Arkansas. We have implemented 14 selective catalytic reactors (SCRs), and 10 Flue Gas Desulphurization units, with others currently under construction, and we are a leader in developing and deploying mercury capture and monitoring technology. In addition, we continue to invest in new clean coal technology plants and R&D that will enable AEP and our industry to meet the challenge of significantly reducing GHG emissions in future years. We are also playing a leading role in the FutureGen project, which, once completed, will be the world's first near-zero CO_2 emitting commercial-scale coal-fueled power plant. This plant will capture and sequester 90 percent of its (GHG) emissions.

Since joining the Chicago Climate Exchange and EPA Climate Leaders several years ago, AEP has voluntarily reduced its GHG emissions during 2003-05 by a total of 31 million metric tons of CO_2 equivalent. We did so by planting tens of millions of trees, adding several major wind generation projects, significantly increasing the generating efficiency of our larger coal-fired power plants, mothballing or retiring older and less efficient coal- and oil/gas-fired steam units, and achieving record levels of generation from our zero-emitting Cook Nuclear plant.

AEP's Major New Initiative to Reduce GHG Emissions

I have announced several major new initiatives to reduce AEP's GHG emissions and to advance the commercial application of carbon capture and storage technology. Our company has been advancing technology for the electric utility industry for more than 100 years. AEP's recent announcement continues to build upon this heritage. Technology development needs are often cited as an excuse for inaction. We see these needs as opportunities for action.

AEP has signed a memorandum of understanding (MOU) with Alstom, a worldwide leader in equipment and services for power generation, for post-combustion carbon capture technology using Alstom's chilled ammonia system. It will be installed at the 1300-megawatt Mountaineer Plant in New Haven, W.Va as a "30-megawatt (thermal) commercial performance verification" project in mid-2008 and capture up to 100,000 metric tons of carbon dioxide (CO_2) per year. Once the CO_2 is captured, we will store it. The Mountaineer site has an existing deep saline aquifer injection well previously developed in conjunction with Department of Energy (DOE) and Battelle. Working with Battelle and with continued DOE support, we will use this well (and develop others) to store and further study CO_2 injection into deep geological formations.

Following the completion of commercial verification at Mountaineer, AEP plans to install Alstom's system on one of the 450-megawatt coal-fired units at its Northeastern Plant in Oologah, Oklahoma. The system is expected to be operational at Northeastern Plant in late 2012, capturing about 1.5 million metric tons of CO_2 a year. The CO_2 captured at Northeastern Plant will be used for enhanced oil recovery.

AEP has also signed an MOU with Babcock and Wilcox to pursue the development of Oxy-coal combustion that uses oxygen in lieu of air for combustion. The Oxy-coal combustion forms a concentrated CO_2 post combustion gas that can be stored without additional post combustion capture processes. AEP is working with B&W on a "30-megawatt (thermal) pilot project." The results are due in mid-2007 and then these results will be used to study the feasibility of a scaled up 100 – 200MW (electric) demonstration. The CO_2 from the demonstration project would be captured and stored in a deep saline geologic formation or used for enhanced oil recovery application.

In March, AEP voluntarily committed to achieve an additional five million tons of GHG reductions annually beginning in 2011. We will accomplish these reductions through a new AEP initiative that will add another 1000 Mw of purchased wind power into our system, substantially increase our forestry investments (in addition to the 62 million trees we have planted to date), as well as invest in domestic offsets, such as methane capture from agriculture, mines and landfills.

AEP has also implemented efficiency improvements at several plants in its existing generation fleet. These improvements include new turbine blading, valve replacements, combustion tuning, and installation of variable speed drives on rotating equipment. Such improvements are currently reported through the Department of Energy's 1605 (b) program to the extent they produce creditable reductions in greenhouse gas emissions. However, we are limited in the efficiency improvements we can make due to the ambiguities in the existing New Source Review program, and support further clarification and reform of this program to encourage efficiency improvements.

AEP Perspectives on a Federal GHG Reduction Program

While AEP has done, and will do much more, to mitigate GHG emissions from its existing sources, we also support the adoption of an economy-wide cap-and-trade type GHG reduction program that is well thought-out, achievable, and reasonable. We believe legislation can be crafted that does not impede AEP's ability to provide reliable, reasonably priced electricity to support the economic well-being of our customers, and includes mechanisms that foster international participation and avoid creating inequities and competitive issues that would harm the U.S. economy. AEP supports reasonable legislation, and is not calling for an indefinite delay until advanced technology such as carbon capture and storage (CCS) is developed. However, as the requirements become more stringent during the next ten to twenty years, and we move beyond the ability of current technology to deliver those reductions, it is essential that requirements for deeper reductions coincide with the commercialization of advanced technology. The technologies for effective carbon capture and storage from coal-fired facilities are developing, but are not commercially engineered to meet production needs, and cannot be artificially accelerated through unrealistic reduction mandates. For these reasons, we do not believe that performance standards on new sources can or will meet our needs and/or the needs of our customers, regulators, and the nation, since these standards place significant constraints on ones ability and flexibility to adopt effective least-cost strategies without any additional environmental benefits.

A sound national policy for reducing GHG emissions, based on a cap-and-trade type approach, should include the following design elements:

- The cap should apply to all sectors of the economy and cover all greenhouse gases.
- An unfettered cap-and-trade framework should be used to maximize flexibility and minimize the costs of the program.
- The reduction levels should be gradually phased in over time to reflect the lead-time necessary for demonstrating and deploying new low-and zero-emitting technologies on a broad commercial scale. Setting reasonable and achievable emissions caps is critical to ensure that the power industry can provide reliable electricity and ensure the continued economic competitiveness for U.S. workers and industries.

- Minimize costs through unrestricted use of real and verifiable domestic and international GHG emissions offsets, such as methane capture from landfills, livestock and coal mines, forestry and agricultural sequestration and clean power development.
- As part of a comprehensive cap and trade system, all allowances should be allocated based on historic emissions without cost to the electric power sector and other sources that will be required to make reductions. At most, only a small number of the allowances (less than five percent) should be distributed through auctions or set-asides for general public benefit purposes. This approach is essential to minimize the cost burden to retail consumers, to safeguard competitiveness of U.S. industries, and to avoid harm to the U.S. economy.
- Recognition should be provided to those companies that have voluntarily taken early actions and investment to mitigate GHG emissions.
- Long-term public and private funding should be provided to develop commercially-viable technology solutions (*e.g.*, carbon capture and storage for new and existing plants and other clean-coal technologies).
- Legislative provisions should be included to eliminate the legal and regulatory barriers to the use of carbon capture and storage, nuclear, wind or other low or no-carbon technologies or processes.
- Regulatory pre-approval should be provided for utilities to recover the costs of effective energy efficiency and demand-side management programs.
- A safety valve for purchasing allowances should be included to establish a price ceiling and be set at a level that adequately protects the U.S. economy.

- Statutory provisions should be included for addressing inequities that will result if the largest emitters in the developing world, who are manufacturing competitors with the U.S, fail to take comparable action to cap or reduce their own emissions.

<u>All Greenhouse Gases Should be Covered, on An Economy-Wide Basis</u>

AEP believes mandatory emission reduction legislation must be premised upon a market-based cap-and-trade system that includes all significant emitting sectors of the U.S. economy. With regard to greenhouse gases and specifically CO_2 emissions, no one sector accounts for a majority of U.S. emissions. Instead, GHG emissions are ubiquitous, generated by multiple sectors, including electricity generation, transportation, various manufacturing processes, and residential and commercial fuel use. Adopting an economy-wide approach will improve the overall effectiveness of limiting GHG emissions nationally and expand opportunities to achieve those GHG reductions in a least-cost manner, while spreading the cost across the entire economy. The overall cost of the program will be lowered by enabling companies to take advantage of the most cost-effective reductions possible from all major source categories across the economy. An economy-wide approach prevents distortions driven by imposing disproportionate burdens on certain sectors while excluding others. In contrast, a sector approach – if limited to electric generating units and other large combustion sources – arbitrarily limits reduction obligations and costs to these sources. AEP urges that any cap-and-trade program not only be economy-wide, but also assign a compliance burden to each sector that is consistent with that sector's contribution to the problem.

Phased-in Timing and Gradually Increasing Level of Reductions Consistent with Technology Development

As a practical matter, implementing climate legislation is a complex undertaking that will require procedures for measuring, verifying, and accounting for GHG emission, as well as for designing efficient administration and enforcement procedures applicable to all sectors of our economy. Only a pragmatic approach with achievable targets and reasonable timetables – that does not require too many reductions within too short a time period – will succeed. Past experience with the Clean Air Act Amendments of 1990 (which involved a vastly simpler SO_2 allowance trading system for just the electric power sector), strongly suggests that a minimum of five years will be necessary to have the administrative mechanisms in place for full implementation of the initial GHG emission targets.

AEP also believes that the level of emissions reductions and timing of those reductions under a federal mandate must keep pace with developing technologies for reducing GHG emissions from new and existing sources. The technologies for effective carbon capture and storage from coal-fired facilities have not yet been perfected, and cannot be artificially accelerated through unrealistic reduction mandates.

While AEP and other companies have successfully lowered their average emissions and emission rates during this decade, further substantial reductions will require the wide-scale commercial availability of new clean coal technologies. AEP believes that the electric power industry can potentially manage much of the expected economic (and CO_2 emissions) growth over the course of the next decade (2010-2020) through aggressively deploying renewable energy, further gains in supply and demand-side energy efficiency, and new emission offset projects. As previously stated, AEP supports reasonable legislation, and is not calling for an indefinite delay of GHG reduction obligations until advanced clean coal technology is developed. However, as the reduction requirements become more stringent, and move beyond the ability of current technology to deliver those reductions, it is important that those stringent requirements coincide with the commercialization of advanced technology. This includes the next generation of low- and zero-emitting technologies. In the case of coal, this means demonstration and full-scale deployment of new IGCC units with carbon capture, new ultra-supercritical or oxy-coal plants with carbon capture and storage, as well as broad deployment of retrofit technologies for carbon capture and storage at existing coal plants. The next generation of nuclear technology will also play an important role in meeting significant reduction targets.

However, today's costs of new clean coal technologies with carbon capture and storage are much more expensive than current coal-fired technologies. For example, carbon capture and storage using current inhibited monoethanolamine (MEA) technology is expected to increase the total cost of electricity from a new coal fired power plant by about 65 percent and even the newer chilled ammonia carbon capture technology we plan to deploy on a commercial sized scale by 2012 at one of our existing coal-fired units will result in significantly higher costs. It is only through the steady and judicious advancement of these applications during the course of the next decade that we can start to bring these costs down, in order to avoid substantial electricity rate shocks and undue harm to the U.S. economy.

Additionally the MEA technology has limitations under existing plant retrofit conditions. CO2 capture requires a large volume of steam to regenerate the amine used to capture the CO_2. Review of several of our existing PC units indicates they can only supply enough steam from the power generation cycle to regenerate the amine necessary to capture about 50% of the CO_2, without jeopardizing the steam cycle.

In summary, AEP recommends a pragmatic approach for phasing in GHG reductions through a cap-and-trade program. The emissions cap should be reasonable and achievable. In the early years of the program, the cap should be set at levels that slow the increase in GHG emissions. Allowing for moderate emissions increases over the first decade is critical due to limitations on currently available GHG control options. The stringency of the cap would increase over time – first stabilizing emissions and then requiring a gradual, long-term decline in emissions levels. The cap levels should be set to reflect projected advances in new carbon-saving technologies. In the case of the electric power sector, additional time is necessary to allow for the deployment of new nuclear plants as well as the demonstration and deployment of commercial-scale gasification and advanced combustion facilities fully integrated with technologies for CO_2 capture and storage. Substantial GHG reductions should not be required until after the 2020 time frame.

Requiring much deeper reductions sooner would very likely harm the U.S. economy. For AEP and the electric sector, the only currently available strategy to achieve substantial absolute CO_2 reductions prior to 2020 without the full-scale deployment of new technologies will inevitably require much greater use of natural gas, in lieu of coal-fueled electricity, with the undesirable effects of higher natural gas prices and even tighter supplies.

Unrestricted Use of Real and Verifiable Emission Offsets of All Greenhouse Gases

GHG emissions and compliance costs will both be reduced, if all real and verifiable emission credits and offsets are included in any federal legislative program. Climate change is a global problem. Greenhouse gases emitted, avoided or reduced anywhere on Earth ultimately impact the entire globe. Artificially restricting reduction opportunities only increases the cost of compliance.

As an example, some project-based offsets are relatively low in cost because they involve high global warming potential (GWP) gases such as methane and nitrous oxides that can be captured with relatively little investment per CO_2 equivalent ton reduced. Forestry projects often provide lower cost reductions than direct reductions at industrial sources or power plants. In addition, many project-based offsets provide significant land use, aesthetic and other environmental benefits.

Viewed from a global perspective, any given reduction, anywhere, from any source, has the same benefit as any other – so the use of the most economically-prudent, real and verifiable offsets should be strongly encouraged, including offsets arising from initiatives involving forestry, agriculture, methane capture from livestock manure, landfills or coal mines, or other innovations.

Emission Allowances Should be Allocated Equitably in a Cap-and-Trade System with Limited Auctions

Under various proposed cap-and-trade systems, an emission allowance would permit the release of one ton of CO_2 or equivalent and are distributed in limited amounts up to the total GHG emissions cap. This limit on the supply of total allowances results in a market price being set for allowances based on the marginal control costs under the cap-and-trade program. Allocation of these allowances to companies equitably and efficiently is an important principle in allowing a cap-and-trade system to be successful.

If, for example, an electric utility generator under cost of service regulation is allocated emission allowances substantially equal to the GHG emissions permitted by legislation, the cost to consumers eventually is equivalent to the actual cost of reducing or offsetting GHG emissions to the level of the cap. The U.S. has already perfected just such a highly efficient allowance trading system, and it is now successfully being used to address Acid Rain and other national and regional domestic air quality issues. As a result, AEP strongly recommends that emission allowances be allocated to electric utility generators based on "input fuel" or emissions. Input-based allocations spread the reduction/cost burden evenly and equitably, by distributing emission allowances pro-rata based on historic emissions. So, all existing fossil fuel generating plants would face a similar effective percent reduction requirement. In this way, allowances are distributed to those companies who must bear the burden of reducing CO_2 emissions. Emission/fuel based allocation methods successfully allocated allowances under the Clean Air Act of 1990 (for SO_2), as well as EPA's recent Clean Air Interstate Rule (CAIR) and Clean Air Mercury Rule (CAMR) rules governing SO_2, NOx and Hg in the future.

Under this approach a high percentage of the available allowances (e.g., 95-100 percent) would be allocated to electric generators based upon their pro rata share of historical GHG emissions.

AEP supports the use of input fuel or emissions-based allocations among the sources actually emitting regulated pollutants and required to achieve emission reductions. Input fuel-based systems maintain the critical connection between the sources required to achieve reductions and the allowance system used to demonstrate compliance, and have a demonstrated history of successfully and substantially reducing overall costs of compliance through the use of this market mechanism. The allowances should be distributed to those companies who must bear this burden. In contrast, output-based allocation systems provide substantial windfalls for a few companies with significant amounts of nuclear, hydro and/or natural gas generation. Nuclear, hydro and renewables do not have any CO_2, SO_2, NOx or mercury emissions and thus they have no need for the permits for these emissions. Allocating allowances to nuclear and hydro serves only one purpose -- to force fossil fuel-fired generation to buy them back. This represents a direct income transfer from fossil generation to non-emitting sources.

Allocation of allowances to the electric power sector over time must also recognize the continuing and increasing electrification of our economy. As new innovative electro-technologies such as plug-in hybrid electric vehicles become a more significant part of the mix of options to meet future U.S. energy needs and to reduce our GHG emissions, allowance allocations will need to recognize the greater share of U.S. energy needs that electricity generators provide.

AEP supports auctioning five percent or less of the available allowances in order to set an initial market price to facilitate trading, reduce barriers to the entry of new sources, and provide incentives for technological advances and early action to mitigate emissions. However, AEP opposes any proposed cap and trade program with any significant auctions (or set-aside of allowances for public benefit purposes), since these would disproportionately increase compliance costs with no offsetting decrease in GHG emissions.

Auctioning allowances rather than allocating them to electric generators will simply increase electricity generating costs and electricity rates unnecessarily. Under cost of service regulation, the cost of auctioned allowance purchases would be – by necessity – passed on to consumers in addition to the direct costs of compliance. Under an auction, consumer costs and electricity prices would increase substantially more than under a system with no auctioned allowances.

In addition to increased electricity rates for consumers, auctioning a substantial number of emission allowances would cause a major redistribution of income, reduce market efficiency and impair companies' ability to make the needed reductions. Investment in compliance technologies would be forced to compete with large-scale investments needed by private companies to purchase auctioned allowances, even as coal-fired electricity generators make very large investments throughout the next decade to reduce SO_2, NOx and Hg emissions under existing and upcoming Clean Air Act regulatory requirements.

Finally, auctioning a substantial number of emission allowances will affect various regions of the country differently. States and regions in the U.S. that rely more heavily on coal-fueled power, including Michigan, North Carolina, Georgia, Ohio, West Virginia, Indiana, Kentucky, Tennessee, Iowa, Missouri, Oklahoma, Wisconsin, Minnesota, and most of the Western U.S. are likely to experience the largest cost and rate increases due to auctions. For these reasons, any decision to auction substantial number of allowances must compensate for the disproportionate impacts on America's coal-reliant states and regions if Congress is to minimize the economic hardships on specific states, regions, and the nation as a whole.

Recognition of Early Actions that Achieve Real and Verifiable GHG Emission Reductions

Any federal program needs to provide credit for real and verifiable early reductions made on a company-wide basis. Programs such as EPA Climate Leaders, DOE Section 1605(b) and the Chicago Climate Exchange among others provide the appropriate accounting and auditing mechanisms to ensure that the reductions are real and verifiable.

AEP is proud of its accomplishments in reducing its CO_2 and other GHG emissions voluntarily. We believe that early actors such as our company should be rewarded, and not penalized for being proactive in addressing their GHG emissions.

Congressional Action Must be Premised Upon that the Reality That Climate Change is caused by GHG Emissions on a Global Basis

We must keep in mind the context for our nation undertaking extraordinary efforts to limit our domestic GHG emissions. Humanity is confronting worldwide climate change; this is not purely a domestic issue. It would be unconscionable to pass legislation that imposes unilateral caps only upon

America's economy, while ignoring the fact that U.S. reductions will make little difference if other major emitting nations are not taking comparable action. Any reductions we make will be overtaken – literally swallowed up – by huge and rapidly increasing emissions arising from the largest emitters in the developing world. This would be flawed environmental policy and will accomplish very little to deal with global climate change.

Of equal importance, legislation must address the fact that imposition of emission limits by some, but not all, major emitting nations would adversely impact the competitive conditions of trade between nations. This could actually create perverse incentives to inappropriately drive environmentally-responsible American jobs to nations without emission limits, where their production costs would assuredly be less. This scenario would impact America's manufacturing sectors and workers alike – and the potential effects of such a non-global solution could, in a very real sense, undermine our competitiveness in our increasingly global economy.

These sort of practical concerns prompted Mr. Edwin D. Hill, International President of the International Brotherhood of Electrical Workers and me to collaborate in crafting an op-ed. The AEP/IBEW approach reconciles the environmental and economic nexus that frames the global climate issue -- "Trade is the Key to Climate Change" (see copy attached). In this article we offered recommendations on how trade considerations must be part of any U.S. legislation that also requires mandatory domestic emission reductions.

In this article we suggest that any U.S. legislation that would require mandatory U.S. emission reductions must also include a market mechanism that encourages other major GHG-emitting countries to reduce their emissions. If other countries refuse to reduce emissions but seek to continue to sell their goods in the U.S., our proposal would implement an appropriate measure to equalize the conditions of global trade. This measure could include a requirement that emission allowances accompany such imports, or border adjustment taxes that are functionally equivalent to America's domestic GHG initiatives, to be applied to products arriving from countries that do not limit their greenhouse gas emissions,. Alternatively, the U.S. government could suspend or reduce the stringency of the domestic program until those countries join.

In the best tradition of America's free market cap-and-trade policies, Ed Hill and I believe this approach offers the very real potential to equalize the conditions of global trade with regard to climate change, and to serve as a powerful impetus for other nations to meaningfully join a new global initiative. We are hopeful that all major emitting nations would find it prudent to participate rather than be compelled to pay border adjustment taxes or purchase significant numbers of allowances to offset GHG emissions arising from their production of exported goods and services, especially if they have the opportunity to also derive even greater benefits for their citizens and the world from cleaner development through treaty participation.

This approach would equalize the conditions of global trade with regard to climate change, and it would be a powerful incentive for nations to meaningfully participate in a new world-wide initiative to limit their GHG emissions.

Without an ironclad statutory backstop, the U.S. will have little leverage to negotiate with rapidly developing nations. If Congress were to fail to include these or similar provisions, it would fail to deal with climate change on a global scale because our own GHG emissions would be capped even as other nations' emissions increase and eclipse our own, further endangering our global environment and welfare. I believe American consumers, workers and businesses are ready, willing and able to do their part to address the risks presented by global climate change. But fair play and common sense dictate that we must not do this alone.

While Trade is the Key to Climate Change, Technology is the Answer

The primary human-induced cause of global warming is the emission of CO_2 arising from the burning of fossil fuels. Put simply, our primary contribution to climate change is also what drives the global economic engine.

Changing consumer behavior by buying efficient appliances and cars, by driving less, and by similar steps, is helping to reduce the growth of GHG emissions. However, these steps will never be nearly enough to significantly reduce CO_2 emissions from the burning of coal, oil and natural gas. Such incremental steps, while important, will never be sufficient to stabilize greenhouse gases concentrations in the atmosphere at a level that is believed to be capable of preventing dangerous human-induced interference with the climate system as called for in the U.S.-approved U.N. Framework Convention on Climate Change (Rio agreement).

For that, we need major technological advances to effectively capture and store CO_2. The Congress and indeed all Americans must come to recognize the gigantic undertaking and significant sacrifices that this enterprise is likely to require. It is unrealistic to assume, and wrong to argue, that the market will magically respond simply by the imposition of severe caps on CO_2 emissions. The result will not be a positive response by the market, but rather a severe impact on the economy. Not when what we are talking about, on a large scale, is the capture and geologic storage of billions and billions of tons of CO_2 with technologies that have not yet been proven anywhere in the world.

Carbon capture and storage (CCS) should not be mandated until and unless it has been demonstrated to be effective, and the costs have significantly dropped so that it becomes commercially available on a widespread basis. Until that threshold is met, it would be technologically unrealistic and economically unacceptable to require the widespread installation of carbon capture equipment. The use of deep saline geologic formations as the primary long-term geologic formations for CO_2 storage has not yet been sufficiently demonstrated. There are no national standards for permitting such storage reservoirs; there are no widely accepted monitoring protocols. Underscoring these realities, industrial insurance companies point to a lack of scientific data on CO_2 storage as one reason they are disinclined to insure early projects. In a nutshell, the institutional infrastructure to support CO_2 storage does not yet exist and will require years to develop. In addition, application of today's CO_2 capture technology would significantly increase the cost of an IGCC plant, calling into serious question regulatory approval for the costs of such a plant by state regulators. Further, recent studies sponsored by the Electric Power Research Institute (EPRI) suggest that application of today's CO_2 capture technology would increase the cost of electricity from an IGCC plant by 40 to 50 percent, and boost the cost of electricity from a conventional pulverized coal plant by up to 65 percent, which would again jeopardize state regulatory approval for the costs of such plants.

Despite these uncertainties, I believe that we must aggressively explore the viability of this technology in several first-of-a-kind commercial projects. AEP is committed to help lead the way, and to show how this can be done. For example, as described earlier in this testimony, AEP will install carbon capture controls on two existing coal-fired power plants, the first commercial use of this technology, as part of our comprehensive strategy to reduce, avoid or offset GHG emissions.

AEP is also building two state-of-the-art advanced ultra-supercritical power plants in Oklahoma and Arkansas. These will be the first of the new generation of ultra-supercritical plants in the U.S.

AEP is also advancing the development of IGCC technology. IGCC represents a major breakthrough in our work to improve the environmental performance of coal-based electric power generation. AEP is in the process of designing and constructing several of the earliest commercial scale IGCC plants in the nation.

IGCC technology integrates two proven processes – coal gasification and combined cycle power generation – to convert coal into electricity far more efficiently and cleanly than any existing power plants can. Not only is it cleaner and more efficient than today's power plants, but IGCC can also be retrofitted in the future for carbon capture at a lower capital cost and with less of an energy penalty than traditional power plant technologies, but only when the technology has been proven.

AEP is also a founding member of FutureGen, a groundbreaking public-private collaboration that aims squarely at making near-zero-emissions coal-based energy a reality. FutureGen is a $1.5 billion, 10-year research and demonstration project. It is on track to create the world's first coal-fueled, near-zero emission electricity and hydrogen plant with the capability to capture and sequester at least 90 percent of its carbon dioxide emissions.

As an R&D plant, FutureGen will stretch -- and indeed create -- the technology envelope. Within the context of our fight to combat global climate change, FutureGen has a truly profound mission – to validate the cost and performance baselines of a fully integrated, near zero-emission coal-fueled power plant.

The design of the FutureGen plant is already underway, and we are making great progress. The plant will be on-line early in the next decade. By the latter part of that decade, following on the advancements demonstrated by AEP, FutureGen and other projects, CCS technology should become a commercial reality.

It is then, and only then, that commercial orders will be placed on a widespread basis to implement CCS at coal-fueled power plants. That is, roughly around 2020. Widespread deployment assumes that a host of other important issues have been resolved, and there is governmental and public acceptance of CCS as the proven and safe technology that we now believe it to be. AEP supports rapid action on climate change including the enactment of well thought-out and achievable legislation so that our nation can get started on dealing with climate change. However, the complete transformation of the U.S. electricity system will take time, and we can't put policy ahead of the availability of cost-effective technology. The development of technology must coincide with any increase in the stringency of the program.

What will happen if the Congress does the opposite, and mandates deep reductions in the absence of a proven, viable technology? It is the proverbial road of good intentions, and only dangerous consequences can follow. The most immediate would be a dramatic -- and very likely costly -- increase in the use and price of natural gas by the utility sector, since there would be no other identifiable alternative. This would have significant adverse impacts on consumers and workers by driving up the cost of gas for home heating and cooking, and would further increase costs to any industry dependent upon natural gas as a feedstock, such as chemicals and agriculture with a further exporting of jobs overseas.

A huge challenge that our society faces over the remainder of this century is how we will reduce the release of GHG emissions from fossil fuels. This will require nothing less than the complete reengineering of the entire global energy system over the next century. The magnitude of this task is comparable to the industrial revolution, but for this revolution to be successful, it must stimulate new technologies and new behaviors in all major sectors of the economy. The benefits of projects like FutureGen will apply to all countries blessed with an abundance of coal, not only the United States, but also nations like China and India.

In the end, the only sure path to stabilizing GHG concentrations over the long term is through the development and utilization of advanced technologies. And we must do more than simply call for it. Our nation must prepare, inspire, guide, and support our citizens and the very best and the brightest of our engineers and scientists; private industry must step up and start to construct the first commercial plants; and our country must devote adequate financial and technological resources to this enormous challenge. AEP is committed to being a part of this important process, and to helping you achieve the best outcome at the most reasonable cost and timelines possible. Thank you again for this opportunity to share these views with you.

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Trade Is The Key To Climate Change

COMMENTARY

BY MICHAEL G. MORRIS AND EDWIN D. HILL

If there's one lesson to be learned from the Kyoto Protocol--an approach the U.S. Senate rejected in a 95-0 vote--it is that we cannot deal meaningfully with global climate change without simultaneously addressing the ramifications for trade and employment here at home. As the debate on climate change again heats up in Congress, it is time to address the interconnection between these global issues and replace the failed Kyoto approach with one that protects the environment and provides economic opportunities and jobs.

The United States should lead the effort to negotiate a successor treaty to Kyoto, which expires in 2012. The caps and provisions in a new treaty cannot cause serious harm to the U.S. economy and must have broad bipartisan support. It must address the fact that imposition of emission controls by some, but not all, major emitting nations disrupts the competitive trade balance between nations and inappropriately shifts jobs to countries without emission controls, where manufacturing costs will be less.

Accordingly, the new treaty should require that allowances--emissions credits--accompany exports from major emitting nations that have not joined a post-Kyoto global cap-and-trade framework or otherwise capped their emissions, in order to cover the emissions generated by the manufacture of those exports.

As a party to a post-Kyoto agreement, the United States would already be in compliance with this provision. Other major emitting countries, if they refuse to join a new treaty or cap their emissions, would, however, be required to provide emissions allowances for their exports to the United States or any complying nation.

In the best tradition of American free market cap-and-trade policies, this would equalize global trade with regard to climate change, and be a powerful incentive for nations to join a new global regime. Other major emitting nations would likely join rather than buy huge numbers of allowances, while deriving even greater benefits from cleaner development through treaty participation.

Similar trade provisions should form the basis for any legislation limiting domestic greenhouse emissions. This legislation would require a federal determination as to whether, by date certain, other major emitting nations have joined the global effort. If not, and in response, the legislation would automatically require that allowances accompany imports from such nations, or alternatively, an agency could suspend or reduce the stringency of the domestic program until those nations join.

Without such a legislative program, the U.S. would have little leverage to negotiate with rapidly developing nations. If Congress fails to include these provisions, it would abdicate its responsibility for dealing with climate change as a global problem because our own greenhouse gas emissions would be capped while other nations' emissions would rapidly increase and damage the environment.

Including such measures in any future treaty or domestic legislation would help break the impasse caused by Kyoto, which applied emissions caps only to industrialized nations. The Senate overwhelmingly rejected the Kyoto approach nine years ago. Our proposal addresses Kyoto's central flaw, and prevents non-participating nations' intransigence from holding the global environment hostage. It encourages major emitting countries to join us while ensuring that we are not hurt by cheaper exports from uncapped nations.

Ironically, even some Kyoto parties are now expressing similar concerns. Jacques Chirac, president of France, recently proposed that the next post-Kyoto climate treaty include a border tax on imports from nations lacking carbon controls. Peter Mandelson, the European Union Trade Commissioner, agrees that trade needs to be addressed, but believes that border taxes would be "highly problematic under current World Trade Organization rules and almost impossible to implement in practice."

Our proposal directly reduces greenhouse gases to diminish environmental harm. By contrast, border taxes don't do so. Because the use of allowances is required for both capped and uncapped nations, our proposal is more consistent with the WTO and superior to border taxes that apply only to uncapped exporters.

We welcome economic growth throughout the developing world. A more prosperous world benefits all humanity. However, we must also responsibly address the climate challenge posed by that growth. China's emissions will surpass America's in 2009. To unilaterally cap America's emissions, while ignoring other major emitting nations, is a fatally flawed approach, which would compromise our competitiveness, jeopardize American jobs, and harm the global environment.

Making the climate-trade linkage would empower the United States with the necessary carrots and sticks to lead a successful international solution. The old Kyoto approach failed. A new approach is long overdue.

Michael G. Morris is Chairman, President, and Chief Executive Officer of American Electric Power; Edwin D. Hill is International President of the International Brotherhood of Electrical Workers.

AMERICAN ELECTRIC POWER

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FOR IMMEDIATE RELEASE

AEP TO INSTALL CARBON CAPTURE ON TWO EXISTING POWER PLANTS; COMPANY WILL BE FIRST TO MOVE TECHNOLOGY TO COMMERCIAL SCALE

As climate policy advances, 'it's time to advance technology for commercial use,' CEO says

COLUMBUS, Ohio, March 15, 2007 – American Electric Power (NYSE:AEP) will install carbon capture on two coal-fired power plants, the first commercial use of technologies to significantly reduce carbon dioxide emissions from existing plants.

The first project is expected to complete its product validation phase in 2008 and begin commercial operation in 2011.

"AEP has been the company advancing technology for the electric utility industry for more than 100 years," said Michael G. Morris, AEP chairman, president and chief executive officer. "This long heritage, the backbone of our company's success, makes us very comfortable taking action on carbon emissions and accelerating advancement of the technology. Technology development needs are often cited as an excuse for inaction. We see these needs as an opportunity for action.

"With Congress expected to take action on greenhouse gas issues in climate legislation, it's time to advance this technology for commercial use," Morris said. "And we will continue working with Congress as it crafts climate policy. It is important that the U.S. climate policy be well thought out, establish reasonable targets and timetables, and include mechanisms to prevent trade imbalances that would damage the U.S. economy."

Morris will discuss AEP's plans for carbon capture during a presentation today at the Morgan Stanley Global Electricity & Energy Conference in New York. A live webcast of the presentation to an audience of investors will begin at 12:10 p.m. EDT and can be accessed through the Internet at http://www.aep.com/go/webcast. The webcast will also be available after the event. Visuals used in the presentation will be available at http://www.aep.com/investors/present.

AEP has signed a memorandum of understanding (MOU) with Alstom, a worldwide leader in equipment and services for power generation and clean coal, for post-combustion carbon capture technology using Alstom's Chilled Ammonia Process. This technology, which is being piloted this summer by Alstom on a 5-megawatt (thermal) slipstream from a plant in Wisconsin, will first be installed on AEP's 1300-megawatt Mountaineer Plant in New Haven, W.Va., as a 30-megawatt (thermal) product validation in mid-2008 where up to 100,000 metric tons of carbon dioxide (CO2) will be captured per year. The captured CO2 will be designated for geological storage in deep saline aquifers at the site. Battelle Memorial Institute will serve as consultants for AEP on geological storage.

Following the completion of product validation at Mountaineer, AEP will install Alstom's system on one of the 450-megawatt (electric) coal-fired units at its Northeastern Station in Oologah, Okla. Plans are for the commercial-scale system to be operational at Northeastern Station in late 2011. It is expected to capture about 1.5 million metric tons of CO2 a year. The CO2 captured at Northeastern Station will be used for enhanced oil recovery.

Alstom's system captures CO2 by isolating the gas from the power plant's other flue gases and can significantly increase the efficiency of the CO2 capture process. The system chills the flue gas, recovering large quantities of water for recycle, and then utilizes a CO2 absorber in a similar way to absorbers used in systems that reduce sulfur dioxide emissions. The remaining low concentration of ammonia in the clean flue gas is captured by cold-water wash and returned to the absorber. The CO2 is compressed to be sent to enhanced oil recovery or storage.

In laboratory testing sponsored by Alstom, EPRI and others, the process has demonstrated the potential to capture more than 90 percent of CO2 at a cost that is far less expensive than other carbon capture technologies. It is applicable for use on new power plants as well as for the retrofit of existing coal-fired power plants.

AEP has signed an MOU with The Babcock & Wilcox Company (B&W), a world leader in steam generation and pollution control equipment design, supply and service since 1867, for a feasibility study of oxy-coal combustion technology. B&W, a subsidiary of McDermott International, Inc. (NYSE:MDR), will complete a pilot demonstration of the technology this summer at its 30-megawatt (thermal) Clean Environment Development Facility in Alliance, Ohio.

Following this demonstration, AEP and B&W will conduct a retrofit feasibility study that will include selection of an existing AEP plant site for commercial-scale installation of the technology and cost estimates to complete that work. Once the retrofit feasibility study is completed, detailed design engineering and construction estimates to retrofit an existing AEP plant for commercial-scale CO2 capture will begin. At the commercial scale, the captured CO2 will likely be stored in deep geologic formations. The plant, with oxy-coal combustion technology, is expected to be in service in the 2012-2015 time frame.

B&W, in collaboration with American Air Liquide Inc., has been developing oxy-coal combustion, a technology that utilizes pure oxygen for the combustion of coal. Current generation technologies use air, which contains nitrogen that is not utilized in the combustion process and is emitted with the flue gas. By using pure oxygen, oxy-coal combustion excludes nitrogen and leaves a flue gas that is a relatively pure stream of carbon dioxide that is ready for capture and storage. B&W's and Air Liquide's collaborative work on oxy-coal combustion began in the late 1990s and included pilot-scale development at B&W's facilities with encouraging results, burning both bituminous and sub-bituminous coals.

The oxy-coal combustion process, as envisioned, uses a standard, cryogenic air separation unit to provide relatively pure oxygen to the combustion process. This oxygen is mixed with recycled flue gas in a proprietary mixing device to replicate air, which may then be used to operate a boiler designed for regular air firing. The exhaust gas, consisting primarily of carbon dioxide, is first cleaned of traditional pollutants, then compressed and purified before storage. B&W, working with Air Liquide, can supply the equipment, technology and control systems to construct this new value chain, either as a new application or as a retrofit to an existing unit.

The Alstom technology provides a post-combustion carbon capture system that is suitable for use in new plants as well as for retrofitting to existing plants. It requires significantly less energy to capture CO2 than other technologies currently being tested.

The B&W technology provides a pre-combustion boiler conversion option for existing plants that promotes the creation of a pure CO2 stream in the flue gas.

Both pre- and post-combustion technologies will be important for companies facing decisions on carbon reduction from the wide variety of coal-fired boiler designs currently in use.

AEP anticipates seeking funding from the U.S. Department of Energy to help offset some of the costs of advancing these technologies for commercial use. The company will also work with utility commissions, environmental regulators and other key constituencies in states that have jurisdiction over the plants selected for retrofit to determine appropriate cost recovery and the impact on customers.

"We recognize that these projects represent a significant commitment of resources for AEP, but they are projects that will pay important dividends in the future for our customers and shareholders," Morris said. "Coal is the fuel used to generate half of the nation's electricity; it fuels about 75 percent of AEP's generating fleet. By advancing carbon capture technologies into commercial use, we are taking an important step to ensure the continued and long-term viability of our existing generation, just as we did when we were the first to begin a comprehensive, system-wide retrofit program for sulfur dioxide and nitrogen oxide emissions controls. We have completed the sulfur dioxide and nitrogen oxide retrofits on more than two-thirds of the capacity included in the program and we are on schedule to complete all retrofits by shortly after the end of the decade.

"By being the first to advance carbon capture technology, we will be well-positioned to quickly and efficiently retrofit additional plants in our fleet with carbon capture systems while avoiding a potentially significant learning curve."

AEP has led the U.S. electric utility industry in taking action to reduce its greenhouse gas emissions. AEP was the first and largest U.S. utility to join the Chicago Climate Exchange (CCX), the world's first and North America's only voluntary, legally binding greenhouse gas emissions reduction and trading program. As a member of CCX, AEP committed to gradually reduce, avoid or offset its greenhouse gas emissions to 6 percent below the average of its 1998 to 2001 emission levels by 2010. Through this commitment, AEP will reduce or offset approximately 46 million metric tons of greenhouse gas emissions by the end of the decade.

AEP is achieving its greenhouse gas reductions through a broad portfolio of actions, including power plant efficiency improvements, renewable generation such as wind and biomass co-firing, off-system greenhouse gas reduction projects, reforestation projects and the potential purchase of emission credits through CCX.

American Electric Power is one of the largest electric utilities in the United States, delivering electricity to more than 5 million customers in 11 states. AEP ranks among the nation's largest generators of electricity, owning nearly 36,000 megawatts of generating capacity in the U.S. AEP also owns the nation's largest electricity transmission system, a nearly 39,000-mile network that includes more 765 kilovolt extra-high voltage transmission lines than all other U.S. transmission systems combined. AEP's utility units operate as AEP Ohio, AEP Texas, Appalachian Power (in Virginia and West Virginia), AEP Appalachian Power (in Tennessee), Indiana Michigan Power, Kentucky Power, Public Service Company of Oklahoma, and Southwestern Electric Power Company (in Arkansas, Louisiana and east Texas). AEP's headquarters are in Columbus, Ohio.

This report made by AEP and its Registrant Subsidiaries contains forward-looking statements within the meaning of Section 21E of the Securities Exchange Act of 1934. Although AEP and each of its Registrant Subsidiaries believe that their expectations are based on reasonable assumptions, any such statements may be influenced by factors that could cause actual outcomes and results to be materially different from those projected. Among the factors that could cause actual results to differ materially from those in the forward-looking statements are: electric load and customer growth; weather conditions, including storms; available sources and costs of, and transportation for, fuels and the creditworthiness of fuel suppliers and transporters; availability of generating capacity and the performance of AEP's generating plants; AEP's ability to recover regulatory assets and stranded costs in connection with deregulation; AEP's ability to recover increases in fuel and other energy costs through regulated or competitive electric rates; AEP's ability to build or acquire generating capacity when needed at acceptable prices and terms and to recover those costs through applicable rate cases or competitive rates; new legislation, litigation and government regulation including requirements for reduced emissions of sulfur, nitrogen, mercury, carbon, soot or particulate matter and other substances; timing and resolution of pending and future rate cases, negotiations and other regulatory decisions (including rate or other recovery for new investments, transmission service and environmental compliance); resolution of litigation (including pending Clean Air Act enforcement actions and disputes arising from the bankruptcy of Enron Corp. and related matters); AEP's ability to constrain operation and maintenance costs; the economic climate and growth in AEP's service territory and changes in market demand and demographic patterns; inflationary and interest rate trends; AEP's ability to develop and execute a strategy based on a view regarding prices of electricity, natural gas and other energy-related commodities; changes in the creditworthiness of the counterparties with whom AEP has contractual arrangements, including participants in the energy trading market; actions of rating agencies, including changes in the ratings of debt; volatility and changes in markets for electricity, natural gas and other energy-related commodities; changes in utility regulation, including the potential for new legislation or regulation in Ohio and/or Virginia and membership in and integration into regional transmission organizations; accounting pronouncements periodically issued by accounting standard-setting bodies; the performance of AEP's pension and other postretirement benefit plans; prices for power that AEP generates and sell at wholesale; changes in technology, particularly with respect to new, developing or alternative sources of generation; other risks and unforeseen events, including wars, the effects of terrorism (including increased security costs), embargoes and other catastrophic events.

BACKGROUND: American Electric Power's Actions to Address Climate Change

GHG Reduction Commitment

American Electric Power (AEP) was the first and largest U.S. utility to join the Chicago Climate Exchange (CCXSM) and make a legally binding commitment to gradually reduce or offset its greenhouse gas emissions to 6 percent below the average of 1998-2001 emission levels by 2010.

As a founding member of CCX, AEP committed in 2003 to reduce or offset its emissions gradually to 4 percent below the average of 1998-2001 emission levels by 2006 (1 percent reduction in 2003, 2 percent in 2004, 3 percent in 2005 and 4 percent in 2006). In August 2005, AEP expanded and extended its commitment to a 6 percent reduction below the same baseline by 2010 (4.25 percent in 2007, 4.5 percent in 2008, 5 percent in 2009 and 6 percent in 2010). Through this commitment, AEP expects to reduce or offset approximately 46 million metric tons of greenhouse gas emissions.

Operational Improvements

AEP has been able to reduce its carbon dioxide (CO2) emissions by improving plant efficiency for its fossil-fueled plants through routine maintenance and investments like turbine blade enhancements (installing new turbine blades) and steam path replacements that improve the overall heat rate of a plant and, in turn, reduce CO2 emissions. A one-percent improvement in AEP's overall fleet efficiency can reduce the company's greenhouse gas emissions by 2 million metric tons per year.

AEP has also reduced its CO2 emissions by improving the performance and availability of its nuclear generation. AEP's D.C. Cook Nuclear Plant in Michigan set plant records for generation and capacity factor in 2005. The plant had a capacity factor (energy generated as compared to the maximum possible) of 96.8 percent in 2005 and generated 17,471gigawatt-hours (GWH) of electricity. Additionally, AEP will invest $45 million to replace turbine motors in one unit at D.C. Cook in 2006, which will increase that unit's output by 41 megawatts.

As a member of the US EPA's Sulfur Hexafluoride (SF6) Emissions Reduction Partnership for Electric Power Systems, AEP has significantly reduced emissions of SF6, an extremely potent greenhouse gas, from 1999 levels of 19,778 pounds (a leakage rate of 10 percent) to 2004 emissions of 1,962 pounds (a leakage rate of 0.5 percent).

Managing Forests and Agricultural Lands for Carbon Sequestration

To reduce carbon dioxide (CO2) concentrations in the global atmosphere, AEP has invested more than $27 million in terrestrial sequestration projects designed to conserve and reforest sensitive areas and offset more than 20 million metric tons of CO2 over the next 40 years. These projects include protecting nearly 4 million acres of threatened rainforest in Bolivia, restoring and protecting 20,000 acres of degraded or deforested tropical Atlantic rainforest in Brazil, reforesting nearly 10,000 acres of the Mississippi River Valley in Louisiana with bottomland hardwoods, restoring and protecting forest areas in the Sierra Madres of Guatemala, and planting trees on 23,000 acres of company-owned land.

Deploying Technology for Clean-Coal Generation

AEP is focused on developing and deploying new technology that will reduce the emissions, including greenhouse gas emissions, of future coal-based power generation. AEP announced in August 2004 its plans to build a commercial-scale Integrated Gasification Combined Cycle (IGCC) plants to demonstrate the viability of this technology for future use of coal in generating electricity. AEP has filed for regulatory approval in Ohio and West Virginia to build a 629-megawatt IGCC plant in each of these states. The plants are scheduled to be operational in the 2010 to 2011 timeframe and will be designed to accommodate retrofit of technology to capture and sequester CO2 emissions.

Developing Technology for CO2 Capture and Storage

AEP's Mountaineer Plant in New Haven, W.Va., is the site of a $4.2 million carbon sequestration research project funded by the U.S. Department of Energy, the Ohio Coal Development Office, and a consortium of public and private sector participants. Scientists from Battelle Memorial Institute lead this climate change mitigation research project, which is designed to obtain data required to better understand and test the capability of deep saline aquifers for storage of carbon dioxide emissions from power plants.

AEP is a member of the FutureGen Alliance, who, along with the Department of Energy, will build "FutureGen," a $1 billion, near-zero emission plant to produce electricity and hydrogen from coal while capturing and disposing of carbon dioxide in geologic formations.

Additionally, AEP funds research coordinated by the Massachusetts Institute of Technology Energy Laboratory and the Electric Power Research Institute that is evaluating the environmental impacts, technological approaches, and economic issues associated with carbon sequestration. The MIT research specifically focuses on efforts to better understand and reduce the cost of carbon separation and sequestration.

Renewable Energy and Clean Power

AEP strongly supports increased renewable energy sources to help meet our nation's energy needs. AEP is one of the larger generators and distributors of wind energy in the United States, operating 311 megawatts (MW) of wind generation in Texas. The company also purchases and distributes an additional 373.5 megawatts of wind generation from wind facilities in Oklahoma and Texas. Additionally, AEP operates 2,285 megawatts of nuclear generation and 884 megawatts of hydro and pumped storage generation.

More than 125 schools participate in AEP's "Learning From Light" and "Watts on Schools" programs. Through these programs, AEP partners with learning institutions to install 1 kW solar photovoltaic systems, and uses these systems to track energy use and demonstrate how solar energy is a part of the total energy mix. Similarly, AEP's "Learning From Wind" program installs small-scale wind turbines to provide wind power education and renewable energy research at educational institutions.

Biomass Energy

Until the company sold the plants in 2004, AEP co-fired biomass in 4,000 MW of coal-based power generation in the United Kingdom (Fiddler's Ferry and Ferry Bridge). AEP has been evaluating and testing biomass co-firing for its smaller coal-fired power plants in the United States to evaluate potential reductions in CO2 emission levels.

Energy Conservation and Energy Efficiency

AEP is implementing "Energy Efficiency Plans" to offset 10 percent of the annual energy demand growth

in its Texas service territory. In 2003 alone, AEP invested more than $8 million to achieve over 47 million kilowatt-hours (kWH) of reductions from installation of energy efficiency measures in customers' homes and businesses. Total investments for the four-year program will exceed $43 million, achieving more than 247 million kWH of energy efficiency gains.

2005 EPA Climate Protection Award

In May 2005, the EPA selected AEP to receive a 2005 Climate Protection Award for demonstrating ingenuity, leadership and public purpose in its efforts to reduce greenhouse gases. EPA began the Climate Protection Awards program in 1998 to recognize outstanding efforts to project the earth's climate.

The CHAIRMAN. Thank you very much.

Our next witness is Mr. Carl Bauer. He is the Director of the Department of Energy's National Energy Technology Laboratory. A nuclear engineer by training, Mr. Bauer oversees much of the Federal Government's research and development efforts on coal-fired generation technologies and carbon capture and storage. He is recognized as one of the leading experts in this field. We welcome you today, Mr. Bauer.

STATEMENT OF CARL BAUER

Mr. BAUER. Thank you very much, Mr. Chairman, and members of the Committee. I appreciate the importance that this Committee has in addressing the future of the United States and the world from energy and the environmental impacts of its use and production.

The economic prosperity of the United States over the past century has benefitted from the abundance of fossil fuels found in North America. These fuels are important to our energy security and the global economic competitiveness we experience. However, these concerns of climate change and air pollution challenge our ability to continue to take full advantage of these resources.

Recently, countries like China have seen dramatic growth, as we have mentioned earlier and the Committee members have all recognized. But a point that you might not have seen just recently came forward. In the last quarter, China put online 30 gigawatts of coal-fired power generation.

That is four to five times more than we have built in this country in the last five years. That is a very important point. India is also putting things online, and we believe that the eastern European countries will also continue to depend on coal power generation as one of their mainstays. So this global climate change issue in CO_2 from coal-fired and fossil-fired plants is extremely important.

In 2004, the global anthropogenic CO_2 emission amounted to 27 billion metric tons. By 2030, global CO_2 emissions are projected at 43 billion metric tons per year. China and India and the other non-OECD Asian countries will contribute 57 percent of that. In comparison, the United States will—from coal-fired generation will contribute to 6.8 percent of that.

Nevertheless, because of these concerns of global climate change and the need to stabilize greenhouse gas emissions, the U.S. must consider rolling back CO_2 emissions to a level substantially below today's. Carbon capture and storage technologies offer a great opportunity to pursue these reductions, as the Committee has recognized in their opening statements.

Fortunately, the U.S. and Canada are blessed with an abundance of geologic storage capacity. At the current rate of energy production use, we could potentially store all of the associated CO_2 emissions in North America for a period of over several hundred years.

One scenario that DOE has looked at in terms of accelerating commercial application of carbon capture technology is to couple CO_2 capture from powerplants with enhanced oil recovery, as the Committee has recognized. This may represent the earliest and most economic—and I emphasize economic—project opportunities for a power company to address the technical and economic risks of investing in carbon capture technology.

In today's world of global commerce, there is presently no significant business incentive to deploy carbon capture technology. In order for the marketplace to more aggressively address our nation's need for effective, safe, permanent, and economic carbon mitigation options, we must move forward towards the following, I would suggest—an established regulatory framework for industry and its financial partners in order that they may do an assessment of the risk and the financial investments required; the development of accurate methods to calculate the allocation of risk and potential financial consequences associated with long-term liability, not decades but hundreds of years; an international agreement on patent and intellectual property protections, so those who can come up with the best ideas feel they have a chance to realize a financial return on their investments of their intellectual and financial capital; and the development of advanced technologies needed to deliver an economic option.

DOE's R&D program is aimed at providing the scientific and technological foundation for carbon capture and storage for both new and existing fossil fuel powerplants. And I say "fossil fuel"—as we move to more natural gas and more LNG, there is a recent study that just was released in Environmental and Energy Weekly that Carnegie Mellon has put forward.

The study on LNG suggests that the CO_2 related from the full production—and this is somewhat akin to what the Governor had mentioned about the production of natural gas even domestically—the release of CO_2 into the production of natural gas conversion to LNG, shipping, and then turning it back into gas in a pipeline, may wind up being just as much when you bring in the powerplant and transport as a coal-fired plant does in a CO_2 release.

Now, that is one study. There has been a few other studies similarly, but that again puts us in an awkward spot as fuel shifting being the only solution. We have got to find a portfolio of opportunities.

The program we are heading up with DOE is an opportunity that recently presented itself using coal and biomass and capturing and sequestering that. Recognizing that biomass is often considered as CO_2 neutral, because of the short cycle of plant life and the ability to withdraw through photosynthesis CO_2 from the atmosphere.

However, if biomass and coal are used together, and the biomass and coal resulting CO_2 are all captured and sequestered, you actually wind up with not only avoidance of release of CO_2 from coal, but an actual effective withdrawal of CO_2 from the inventory associated with the biological plant growth cycle.

NETL systems engineers have modeled this, and we believe that by co-feeding 11 percent biomass by energy value, with coal, through integrated gasification combined cycle plant, which would employ 90 percent capture and sequestration—you might call this coal biomass and IGCC—the net greenhouse gas emissions would be zero or possibly even negative. A similar theory applies for coal biomass liquids production, with CO_2 capture and sequestration.

To put it as an example, a nominal 500 megawatt plant consuming 900 tons per day of switchgrass and 5,000 tons per day of coal, and capturing 12,000 tons per day of CO_2, would yield a net zero life cycle carbon footprint, including not only the power generation but the upstream coal and biomass preparation and transport.

DOE's carbon sequestration is addressing these challenges through applied research, proof of concept technology evaluation and pilot scale testing, large-scale deployments, stakeholder involvement, and public outreach. And those last two are also important as a technological—because it is going to be done locally.

I realize I have taken my time, and I thank you for the opportunity, Mr. Chairman, and your patience with me.

[The prepared statement of Mr. Bauer follows:]

CARL O. BAUER

DIRECTOR OF NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY

BEFORE THE HOUSE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

HEARING ON "FUTURE OF COAL: CARBON CAPTURE AND STORAGE"

SEPTEMBER 6, 2007

Thank you Mr. Chairman and Members of the Committee. I appreciate this opportunity to provide testimony on the Department of Energy's (DOE's) development of Carbon Sequestration technologies to mitigate climate change.

The economic prosperity of the United States over the past century has benefited by the abundance of fossil fuels found in North America. The United States' fossil fuel resources represent a national asset that is important to our energy security and global economic competitiveness. However, concerns over climate change and air pollution challenge our ability to take full advantage of our fossil fuels resources.

In 2004, global anthropogenic CO_2 emissions amounted to 27 billion metric tons, of which United States' emissions represented 22 percent. The projected growth of total global annual CO_2 emissions by 2030 is forecasted to be 16 billion metric tons, resulting in total global CO_2 emissions of 43 billion metric tons. The United States' share of this growth is expected to be 12.7 percent, with the portion allocated to U.S. coal-fired power generation being 6.4 percent. The parallel share of global growth in CO_2 emissions for the same period from China, India, and other non-OECD (Organization for Economic Cooperation and Development) Asian nations is expected to be 57.2 percent.[1]

Recently, countries like China have seen dramatic growth in the use of coal as they grow their economy at a very rapid rate. China already uses more coal than the United States and its use will likely continue on a very steep curve well into the future. In fact, China is building approximately one major coal fired power plant every other week. It is also likely that economic growth in the countries of Eastern Europe will be fueled in part by coal. The advancement of carbon capture and storage technologies will not only have domestic benefits in energy security and addressing CO_2 emissions, but its advancement and deployment is an essential technology if we are to address long-term CO_2 emissions around the world.

Of the 43 billion metric tons of CO_2 emissions projected for 2030, the United States' share is expected to be 18.5 percent and U.S. coal-fired generation would represent 6.8 percent.[2]

Carbon capture and storage (CCS) technologies offer a great opportunity to reduce these potential emissions. Fortunately, the United States and Canada are blessed with an abundance of potential geologic storage capacity. At the current rate of energy production and use, we could potentially store all of the associated CO_2 emissions in North America for a period of 175 to 575 years, according to the range of geologic storage capacity estimates recently made by DOE's Regional Carbon Sequestration Partnerships (Partnerships). These results were recently published in the "*Carbon Sequestration Atlas of the United States and Canada*" that is available on our website at http://www.netl.doe.gov/publications/carbon_seq/refshelf.html.

[1] EIA's International Energy Outlook 2007
[2] EIA's Annual Energy Outlook 2007 and International Energy Outlook 2007

Geologic Storage Potential

In the *Carbon Sequestration Atlas of the United States and Canada*, DOE identified hundreds of years of storage potential in deep saline, depleted oil and gas, and unmineable coal seams. The over 3,500 billion metric tons of CO_2 storage capacity that exists throughout these regions represents a significant resource, capable of storing centuries of projected coal-fueled power plant carbon emissions. This assessment was performed by DOE and the Partnerships to summarize the completed Characterization Phase of the Regional Partnerships. The geological sequestration experts from the Partnerships, the National Carbon Sequestration Database and Geographical Information System (NATCARB), and the National Energy Technology Laboratory (NETL) created a uniform and consistent set of methodologies to determine the capacity for CO_2 storage in the United States and Canada and an Atlas from data generated by the Partnerships and other databases, including the United States Geological Survey (USGS). Carbon storage estimates will be updated in the future.

One scenario that DOE has looked at in terms of accelerating the commercial application of carbon capture technology is to couple CO_2 capture from power plants with an enhanced oil recovery (EOR) operation. This may help provide financial incentive for a power company to assume the economic and technical risk of investing in the utilization of carbon capture technology currently under development at an existing plant.

It is estimated that at a world oil price of $50 a barrel, with CO_2 priced at $40 a ton for the domestic EOR industry (the current price of CO_2 for EOR is significantly lower, around $20 a ton), there would be 5.0 gigatonnes of CO_2 capacity available for EOR to the lower-48-state market. This 5.0 gigatonnes would satisfy the sequestration needs of 30 gigawatts of coal-fired power demand for 30 years at an 80 percent capacity factor.[3] (At the current price of $20 a ton of CO_2, the sequestration capacity for EOR would be 47 gigawatts.) The capacity of the domestic EOR market to economically serve the demonstration needs of early large-scale sequestration projects can be seen to be more than adequate, and represents a unique U.S. advantage. It is estimated that advanced EOR technology, with CCS and other approaches applied, can increase U.S. reserves by 26 billion barrels over 20 years or more, from the current estimate of 22 billion barrels.

Market Barriers

In today's world of global commerce, there is no significant incentive to deploy carbon capture technology. The most prominent consequence of carbon capture in a world lacking a global regulatory framework is placing goods and services produced in one nation at a competitive disadvantage relative to others.

The United States can speed the deployment of CCS technologies here at home and set an example of leadership for the world. That leadership could bring us economic rewards in the new business opportunities it creates here and abroad, and it will provide important leverage to help speed engagement by critical countries like China and India.

In order for the marketplace to more aggressively address our Nation's need for effective, safe, permanent, and economic carbon mitigation options we must move toward:

- An established regulatory framework for industry and its financial partners in order that risk may be properly assessed in advance of investment.
- The development of accurate methods to calculate the allocation of risk and potential financial consequence associated with long-term liability issues, and to assess

[3] Various reports relating to regional U.S. enhanced oil recovery potential performed for DOE's Office of Fossil Energy by Advanced Resources International (ARI) of Washington, DC, 2005-2006

responsibility for those risks to contributing technology developers, performers, and investors.

- International agreement on needed patent and intellectual property protections to allow our Nation's best and brightest minds to examine CCS technologies, and to allow our domestic industries to protect and recover the costs of R&D needed to develop and take advanced technologies to commercialization. Particularly as these risks present themselves in unique ways in the developing nations and potential commercial markets of China and India.
- The development of the advanced technologies needed to deliver an economic option.

Perspective on U. S. Power Generation

Based on the Energy Information Administration's (EIA's) 2007 new capacity forecast, 145 gigawatts of new coal-based capacity will be added in the United States by 2030, while still maintaining most of the 300 gigawatts of generating capacity in the existing coal fleet. We have a fast-approaching opportunity to introduce a "new breed" of power plant – one that is highly efficient compared to existing coal plants, capable of producing multiple products, and has very low emissions rates. If we wanted to dramatically reduce our carbon emissions from coal power, there would also be demand for new technology that would permit efficient, cost-effective capture of CO_2 emissions from the existing fleet. DOE's R&D program is aimed primarily at providing the scientific and technological foundation for carbon capture and storage for both new coal-fueled power plants, but some of that technology is applicable to existing plants.

Today, proposed new coal-fired power plants, in permitting or under construction, represent 46 gigawatts. For perspective, over the past five years the U.S. has put into operation 3 gigawatts.[4]

The economics of CCS using today's available commercial technologies are an overwhelming disincentive to their widespread application. Yet, the large presently installed coal-fired fleet, which provides 50 percent of our Nation's power, is expected to account for approximately 77 percent of the cumulative power plant CO_2 emissions produced by the power sector through 2030. All coal plants, including those newly installed, will be responsible for 84 percent of cumulative power plant CO_2 emissions through 2030.[5] The impact on the Nation's cost of electricity depends significantly on whether goals for carbon reduction include carbon capture for not only the new builds but also the existing fleet of coal-fired plants. Significant reductions in carbon emissions can be achieved by including carbon capture in new installed coal power. However, since a majority of coal-based electricity generation in 2030 will still come from the currently existing assets, CO_2 control from those assets, if required, would be a substantial economic challenge.

A new opportunity has recently presented itself using coal with biomass and sequestration. NETL's system's engineers have modeled this technology on a limited life-cycle basis, and believe it may lead to carbon-neutral or even net-negative carbon balance electric power. By co-feeding 11 percent biomass by energy (15 percent biomass by weight) with coal through an Integrated Gasification Combined Cycle (IGCC) plant employing 90 percent capture and sequestration, a process referred to as Coal/Biomass-IGCC (CB-IGCC), NETL estimates that net-GHG emissions would be zero. By example, a nominal 500-megawatt net plant,

[4] Estimate made using Energy Velocity database, August 29, 2007
[5] EIA's Annual Energy Outlook 2007

consuming 900-tons per day (TPD) of switchgrass, 5,000-TPD of coal, and capturing 12,000-TPD of CO_2, if one takes credit for the switchgrass, would yield a net-zero life-cycle carbon footprint that includes not only the power island but also the upstream coal and biomass preparation and transport.[6]

At the NUON 250-megawatt IGCC plant in the Netherlands, they have successfully fed a mixture of coal and 30 percent (by weight) demolition wood into a high-pressure, entrained-flow gasifier. The 900-TPD of biomass is well within a reasonable economic limit of 5,000-TPD, as recently published in the NETL-United States Air Force report on coal-biomass to liquids. This technical option reflects the potential of CCS to enhance the carbon reduction benefits, intended by those States that have chosen to enact renewable portfolio standards on their electric suppliers, by allowing for negative (rather than neutral) CO_2 credits to be applied to biomass CO_2, to which CCS is applied.

Carbon Sequestration Technology Roadmap

DOE's coal RD&D program is focused on addressing the technical uncertainties and reducing the costs and risks associated with CCS from coal-based systems. Today's commercially available technology will add from 81 to 86 percent to the cost of electricity for a new pulverized coal plant, and from 32 to 40 percent to the cost of electricity for a new advanced gasification-based plant.[7]

By cost-effectively capturing CO_2 before it is emitted into the atmosphere and then permanently storing or sequestering it, fossil fuels could be used in a carbon-constrained world with reduced impact to economic growth. DOE is taking a leadership role in the development of

[6] Estimate performed by NETL's Office of Systems, Analyses and Planning
[7] Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity , U.S. Department of Energy/National Energy Technology Laboratory, DOE/NETL-2007/1281, Final Report, May 2007

CCS technologies by addressing cost-effective capture, geographical diversity, permanence, monitoring, mitigation and verification (MMV), permitting and liability, public acceptance, and infrastructure.

The Carbon Sequestration Program is addressing these challenges through applied research, proof-of-concept technology evaluation, pilot-scale testing, large-scale demonstrations, stakeholder involvement, and public outreach.

We have accelerated the scheduled dates for commercial readiness of CCS technologies by several years by expediting the large-scale field tests. The programs current technology roadmap and program plan is set to achieve the following goals on the timeline indicated:

- 2007: Initiate deployment of Regional Carbon Sequestration Partnerships.
- 2008: Establish MMV protocols; enable 95 percent of CO_2 stored to be credited.
- 2009: Inject 0.5 million metric tons CO_2 total at 1 or more large-volume field test sites.
- 2012: Complete pilot-scale operations from a combination of CO_2 capture, MMV and storage system component projects such that, when integrated into a systems analysis framework, will collectively meet the goals of 90 percent capture, 99 percent permanence, at no greater than 10 percent added cost of electricity.
- 2013: Equipment specifications and designs available to industry.
- 2020: Optimized sequestration technology ready for commercial deployment.

Reflecting on a historic precedent represented by the 1970 Clean Air Act, it required approximately 10 years to establish the key technologies that industry would employ to meet the requirements of the regulation, then an additional 10 years to approach the widespread deployment of applicable technologies. This timeframe is reflected in the goals of the accelerated roadmap presented above, even though the costs and magnitude of CCS have been only subjectively drawn, and may be much greater than those associated with Clean Air Act compliance.

Carbon Sequestration Program

DOE's Carbon Sequestration Program leverages basic and applied research with field verification to assess the technical and economic viability of CCS as a greenhouse gas mitigation option. The Program encompasses two main elements: Core R&D and Validation and Deployment. The Core R&D element focuses on technology solutions, including low-cost, low-energy intensive capture technologies, which can be validated and deployed in the field. Lessons learned from field tests are fed back to the Core R&D element to guide future R&D.

The key challenges the program is addressing are to demonstrate the ability to store CO_2 in underground geologic formations with long-term stability (permanence), to develop the ability to monitor and verify the fate of CO_2, and to gain public and regulatory acceptance. DOE's seven Regional Carbon Sequestration Partnerships are engaged in an effort to develop and validate CCS technology in different geologies across the Nation.

Collectively, the seven Partnerships represent regions encompassing 97 percent of coal-fired CO_2 emissions, 97 percent of industrial CO_2 emissions, and 97 percent of the total land mass, and essentially all of the geologic storage sites in the United States potentially available for sequestration. The Partnerships are evaluating numerous CCS approaches to assess which approaches are best suited for specific geologies, and are developing the framework needed to validate and potentially deploy the most promising technologies.

The Regional Partnership initiative is using a three-phased approach.

Characterization, the first phase, was initiated in 2003 and focused on characterizing regional opportunities for CCS, and identifying regional CO_2 sources and storage formations. The Characterization Phase was completed in 2005 and led to the current Validation Phase.

Validation, the second phase, focuses on field tests to validate the efficacy of CCS technologies in a variety of geologic storage sites throughout the United States. Using the extensive data and information gathered during the Characterization Phase, the seven Partnerships identified the most promising opportunities for storage in their regions and are performing widespread, multiple geologic field tests. In addition, the Partnerships are verifying regional CO_2 storage capacities, satisfying project permitting requirements, and conducting public outreach and education activities.

Deployment, the third phase, involves large-volume injection tests. This phase was initiated this fiscal year and will demonstrate CO_2 injection and storage at a scale necessary to demonstrate potential future commercial deployment. The geologic structures to be tested during these large-volume storage tests will serve as potential candidate sites for the future deployment of technologies demonstrated in the FutureGen Project as well as the Clean Coal Power Initiative (CCPI). The Department expects to issue a CCPI solicitation for carbon capture technologies at commercial scale in calendar year 2007.

DOE also recognizes the importance of the existing fleet of coal-fired power plants in meeting energy demand and possible future carbon constraints. Research is being pursued to develop technologies that dramatically lower the cost of capturing CO_2 from power plant stack emissions. This research, supported by the Office of Fossil Energy, is exploring a wide range of approaches that includes membranes, ionic liquids, metal organic frameworks, improved CO_2 sorbents, advanced combustor concepts, advanced scrubbing, and oxy-combustion.

Additionally, advanced research is being pursued on high-temperature materials, advanced sensors & controls, and advanced visualization software. These developments could provide significant efficiency improvements and cost reductions for both existing and future power plants, based on pulverized coal combustion.

Closing Remarks

Carbon sequestration can play an important role in mitigating CO_2 emissions under potential future stabilization scenarios. The United States is underlain by a large capacity of geologic formations amenable to CO_2 storage. DOE's Carbon Sequestration Program will continue to move sequestration technology towards commercial deployment when it is needed.

Mr. Chairman, members of the Committee, this completes my statement. I would be happy to answer any questions you may have.

The CHAIRMAN. Thank you. I appreciate it, Mr. Bauer, very much.

Now I am pleased to welcome Mr. David Hawkins, who is the Director of the Natural Resources Defense Council's Climate Center. Mr. Hawkins is a former Assistant Administrator of the EPA and has over 30 years of experience on air quality, climate change, and energy policy issues.

I have been a Congressman for 30 years. David Hawkins has been testifying on these issues for all 30 years up here. So there is nobody that knows more about this issue than you do.

David, whenever you are ready, please begin.

STATEMENT OF DAVID HAWKINS

Mr. HAWKINS. Thank you very much, Mr. Chairman. I have 12 points to make and 5 minutes to make them, so let me get started. The first is that coal use trends in the United States and globally, if continued, will make protecting the climate impossible. But coal is abundant and relatively low cost. So trying to convince world leaders to give up coal would take a long time, time that we do not have.

So a critical need is to keep new coal plants from being built unless they actually capture their CO_2. That is the only way we can reconcile these two imperatives. About 3,000 coal plants are now on the drawing board, new coal plants, globally around the world between now and 2030. That is less than a 25-year investment period.

Two-thirds of those are in plan for the developing world, and 40 percent of them are in China. Now, if these plants operate for 60 years, and they release all of their carbon dioxide to the atmosphere, the total cumulative emissions during that 60-year period would be 750 billion tons of carbon dioxide.

How do we put that number in perspective? Well, it is 30 percent more than all of the carbon dioxide released from coal use in human history, and that is from a 25-year period of investment from one technology. So we clearly have a problem that we need to address immediately.

Fortunately, carbon capture and geologic disposal technologies are ready for use today. Unfortunately, they are not being used in the power sector. What we need, as has been observed, is a policy framework that assures that carbon capture and disposal systems are used for new coal plants and gradually get used on all coal plants.

To do this we recommend a three-part policy package to assure that carbon capture and disposal gets deployed without additional delay. First, enactment of a comprehensive cap and trade system in the United States. We need a comprehensive system in order to get the cuts in greenhouse gas reductions that we need, and to provide the flexibility that will keep costs low.

Second, enactment of a low carbon generation obligation that applies to coal plant operators. This provision would assure that an increasing fraction of America's coal-fired electricity uses carbon capture and disposal, and that fraction would increase over time. Now, by making this obligation tradeable, the provision would spread the additional costs of those first carbon capture and disposal plants over the entire customer base of the United States rather than the single customer base of the company that happens to build the first one or two plants. We think that is an important way of keeping costs low as this technology is deployed.

Third, we recommend enactment of a new source performance standard for new coal plants. This will assure that we don't build any more new coal plants that release their carbon into the atmosphere. The first rule of holes is that when you are in one, stop digging. Well, building new coal plants that release their carbon into the atmosphere would just dig us deeper, and we can't afford that.

So by combining the new source standard with a low carbon generation obligation, we think we can assure a smooth transition away from coal plants that each today emit millions of tons to the atmosphere every single year.

We believe that Congress can and should act this year to pass legislation with features—with these features. And if you do this, we think that the world will take notice and that the opportunities that the Ranking Member Sensenbrenner spoke about will emerge, that we indeed can be a marketer of ideas and technology to the rest of the world. The world will follow. We have the power to change international practice in designing coal-fired powerplants. We don't have the time to wait.

Thank you very much for your attention.

[The prepared statement of Mr. Hawkins follows:]

David G. Hawkins

Director, Climate Center

Natural Resources Defense Council

Testimony

Before the
Select Committee on
Energy Independence and Global Warming
Unites States House of Representatives

Hearing on

The Future of Coal Under Carbon Cap and Trade

September 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, it has been used heavily by the world's largest economies to fuel economic growth. But we cannot solve the climate crisis unless we cut coal's global warming emissions dramatically. We have the tools to do this. Energy efficiency, increased reliance on renewables like wind, solar, and biomass, and capture of carbon dioxide from power and industrial coal plants followed by geologic disposal (CCD or CCS) can play a major role in harmonizing our economic, security and climate protection goals. But these tools will not be deployed at the required scale without adoption of new laws to cut global warming pollution. New coal plants forecast to be built globally in the next 25 years, if not equipped with CCD, will emit 30 per cent more carbon dioxide (CO_2) in their operating lives than has been released from all prior human use of coal. We cannot afford to delay enactment of policies to prevent this train wreck.

NRDC believes that a program combining an economy-wide cap and trade program with performance-based policies focused on reducing CO_2 emissions from coal use can be effective in protecting the climate and managing the transition to a cleaner energy future. While energy efficiency and renewable alternatives should be our primary tools, as requested by the Committee I will focus today on policies to speed deployment of CCD.

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. Government support of initial large-scale injection projects can help speed deployment and build confidence.

Testimony of David G. Hawkins

Director, NRDC Climate Center

Thank you for the opportunity to testify today on the subject of coal and carbon cap and trade. 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 economics largely with industrial sources powered by fossil fuel and those sources release billions of tons of carbon dioxide (CO_2) into the atmosphere every year. There is national and global interest today in capturing that CO_2 for disposal or sequestration to prevent its release to the atmosphere. 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.

The interest in CCD stems from a few basic facts. We now recognize that CO_2 emissions from use of fossil fuel result in increased atmospheric concentrations of CO_2, 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 the contribution to global warming from coal use, we can pursue efficiency and renewables to limit the total amount of coal we consume but for the coal we use we must deploy and improve systems that will keep the carbon in coal out of the atmosphere, specifically systems that capture carbon dioxide (CO_2) 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). Thousands of miles of streams are polluted by acid mine drainage. 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 (to say nothing regarding harms from other toxins the rule ignores). 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 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 in the air 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 opposes new coal plants that do not capture their CO_2 and supports rapid deployment of capture and disposal systems for any new coal sources. 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. 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 CO_2 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 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. 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 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 30% greater than the total CO_2 emissions from all previous human use of coal. Once emitted, this CO_2 pollution load remains in the atmosphere for centuries. Half of the CO_2 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. 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.

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 CO_2 emissions are adopted. This year in Congress serious attention is finally being directed to enactment of such measures and we welcome this committee's contribution to this effort.

I will now discuss the issues mentioned in the Committee's letter of invitation. Questions relating to the readiness of CCD technology for deployment are addressed in the Appendix to my testimony.

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 forecast that as much as 160 GW of new coal capacity might be build 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 61 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. NRDC and other organizations are challenging new coal plants and regulators and the financial community are increasingly questioning whether investing billions of dollars in high-carbon emitting projects makes any sense. 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 useful, it cannot substitute for the incentive that a genuine commercial market for CO_2 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 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 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. We believe such performance measures need to serve two purposes. First, assure that no new coal plants are built without operating CCD systems. New coal plants with uncontrolled CO_2 emissions will increase costs for others now or in the future or both. Second, provide a stimulus for early and significant deployment of CCD systems. These two purposes may appear to be the same but they are not. Prohibiting construction of new coal plants without CCD will not assure early deployment of CCD if no new coal plants are built for some time. And policies that do not require each new coal project to meet a performance standard will not necessarily prevent the construction of new coal plants that lack CO_2 controls. But a combination of performance measures can achieve both of these objectives.

First, we need 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 with a moderate amount of CO_2 capture. A similar standard is proposed in S.309, introduced by Senators Sanders and Boxer.

Second, we need 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 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. S. 309 also includes 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. NRDC believes that the obligation can and should start sooner and achieve a larger fraction of generation than is specified in S. 309 but the concept is a sound one.

These two measures work together to achieve a result that neither could accomplish alone. The new source performance standard prevents the construction of new coal plants without CCD, something that could happen with a low-carbon generation obligation by itself. The low-carbon generation because it can be met through trading with other coal-based generators, avoids placing the entire incremental cost of the first CCD units on the customers of the companies that build the plants. This cost spreading avoids significant rate impacts from implementation of the new source performance standard. The low-carbon generation obligation also assures that CO_2

pollution from America's coal power fleet, whatever the size of that fleet, is reduced at a predictable minimum rate—something that would not be assured with a new source performance standard by itself if the industry delayed construction of new coal plants.

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 CO_2. 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.

Finally, let me say a word about China and other developing coal-dependent economies. America became an industrial giant by using coal and countries like China and India are on a path to emulate that history. Both countries are interested in CCD technology but all indications are that they will wait to see what the U.S. does before making a commitment to this and the broader range of climate protection solutions we need. By showing leadership the U.S. can demonstrate seriousness of purpose that can be contagious. With our slower rate of new plant construction we can also deploy CCD on new plants with a much smaller impact on our economy. The experience that early deployment of CCD in the U.S. will provide will help bring down costs of the technology, thereby speeding its adoption in other countries. Nor is such a program altruism. By getting ahead of the curve with CCD and other climate protection technologies, the U.S. can become a leading global marketer of climate solutions, helping bring back our economy and providing living wages to more American workers.

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 CO_2 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 CO_2 emissions. 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. 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 CO_2 repositories.

A cap and trade program for greenhouse gases is essential to change the way we use coal but it does not assure in its early years the deployment of CCD technology. To achieve that objective, we need complementary policies that require minimum emission performance from new investments and a steady reduction in the average CO_2 emission rate of the U.S. coal power fleet.

Finally CCD is an important strategy to reduce CO_2 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 cleanest energy 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.

APPENDIX

Is CCD Ready for Broad Deployment?

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.

The CHAIRMAN. I just want to note it is an unusual moment where a witness has given back 30 seconds. Just doesn't happen that often. I just wanted to take note of it.

Let me recognize the next witness, Mr. Robert Sussman, who is a partner at the law firm of Latham & Watkins. Mr. Sussman is a former Deputy Administrator of the EPA during the Clinton administration, and is recognized as one of the leading environmental lawyers in the country.

We welcome you, sir. Whenever you are ready, please begin.

STATEMENT OF ROBERT SUSSMAN

Mr. SUSSMAN. Thank you, Mr. Chairman. It is a pleasure to be here today. I am presenting my testimony on behalf of the Center for American Progress, a non-partisan research and educational institute dedicated to promoting a strong, just, and free America. The Center has recently published two reports on carbon capture and sequestration, which I wrote, along with Ken Berlin, one of my colleagues. And what I would like to do today is to highlight the conclusions to these reports, which are attached to my written testimony and hopefully will be in the record for this hearing.

What we have heard from several witnesses is that the challenge posed by a dramatic increase in greenhouse gas emissions as a result of new coal plants is serious and urgent. If these plants do not control their emissions, the consequence will be to add many millions of tons of carbon dioxide to the atmosphere. And this growth in emissions will make it very, very difficult to move in the direction that many of us recognize is imperative, which is to reduce emissions, ultimately on the order of 70 to 80 percent by 2050.

The most promising, and as best I can tell the only, path to control CO_2 emissions from new coal plants is carbon capture and storage. The task facing Congress is to maximize the likelihood that CCS is widely deployed on an expeditious but realistic timetable and at a reasonable cost. The stakes are very high. If we succeed at this task, we will assure coal a secure place in the future U.S. energy mix. If we fail, coal's historic role as a vital energy resource in this country will be at risk.

And I want to underscore that point, because there is I think growing evidence that coal faces a very uncertain future in the United States without carbon capture and storage. Two years ago, there were rosy predictions of a resurgence of coal, but today there is growing public opposition to new coal plants all around the country. Legal and political challenges to these plants are routine.

In a remarkable development, we saw private equity investors taking over TXU, a large Texas utility, announce that they would cancel 8 out of 11 proposed coal plants if their buyout was consummated. Recently, in California and Florida, we have seen some significant barriers erected to the construction of new coal plants.

And recognizing these trends, it is interesting that in July Citigroup downgraded the stocks of coal companies across the board, maintaining, and I quote, that "prophecies of a new wave of coal-fired generation have vaporized while clean coal technologies remain a decade away or more." These trends I think underscore the urgency of this challenge, and also the very important solution that timely CCS deployment can provide.

Let me turn to cap and trade programs and to the very important question of whether the cap and trade proposals that are now on the table in Congress will lead to timely deployment of CCS. Unfortunately, our analysis indicates that the initial stages of cap and trade programs are not likely to create carbon prices high enough to eliminate the cost differential between new coal plants with CCS and those without it.

This would mean that new coal plant owners are unlikely to install CCS systems until the emission camps for these programs become sufficiently stringent to increase the price of CO_2——

The CHAIRMAN. Mr. Sussman.

Mr. SUSSMAN [continuing]. Allowances to at least $30 per ton. This will probably not occur until 2030, and maybe even later.

The CHAIRMAN. Mr. Sussman, I apologize, sir, but your time has expired.

Mr. SUSSMAN. Okay.

The CHAIRMAN. So you will have plenty of time in the question and answer period, I am sure.

Mr. SUSSMAN. Okay. Thank you.

The CHAIRMAN. Okay. Great. Thank you.

[The prepared statement of Mr. Sussman follows:]

STATEMENT OF ROBERT M. SUSSMAN AND KEN BERLIN
On behalf of the Center for American Progress

Before the

U.S. House of Representatives Select Committee on Energy Independence and Global Warming

Hearing on
The Future of Coal under Carbon Cap and Trade
September 6, 2007

We appreciate the opportunity to present testimony before this Committee on how our nation can best deploy Carbon Capture and Storage (CCS) technologies to reduce the carbon footprint of coal-fired power plants. Our testimony is being offered on behalf of the Center for American Progress (CAP), a non-partisan research and educational institute dedicated to promoting a strong, just and free America that ensures opportunity for all.

Robert M. Sussman is a partner at the firm of Latham & Watkins LLP and Ken Berlin is a partner at the law firm of Skadden, Arps, Slate, Meagher & Flom LLP. Both of us have long experience working on climate change and energy policy. Mr. Sussman was Deputy Administrator of the Environmental Protection Agency during the first part of the Clinton Administration. Mr. Berlin is a past Chairman of the Board of the Environmental Law Institute. More detailed biographies for both of us are attached. Our testimony reflects our personal views and those of CAP, not necessarily the views of our law firms or clients.

Summary

A major challenge in addressing the risk of global warming is the potential for a dramatic increase in greenhouse gas (GHG) emissions as a result of a new generation of coal-fired power plants. This challenge exists both in the United States, where abundant coal reserves have created heightened interest in the construction of new coal plants, and in developing countries such as China and India, where demand for energy is growing at a rapid pace and coal-fired generation holds the most potential for meeting these increasing energy needs. Fortunately, there is a potential pathway that would allow continued use of coal as an energy source without magnifying the risk of global warming. CCS technology would enable power plants to capture carbon dioxide (CO_2) emissions from coal-fired plants before they are released into the environment and then to store the captured CO_2 safely in underground geologic formations.

The task facing Congress as it develops global warming legislation is to maximize the likelihood that CCS is widely deployed on an expeditious but realistic timetable and at a cost which is reasonable for the affected industries and electricity consumers. Accomplishing this task successfully will assure coal – a low-cost domestic fuel available in ample quantities – a secure

place in the future U.S. energy mix without exacerbating global warming. Failure would mean that new coal plants add greatly to overall CO_2 emission levels, burdening other sources with greater reduction obligations and jeopardizing attainment of emission reduction targets. If – as is likely – these outcomes are unacceptable to large segments of the public and many policymakers, coal's historic role as a vital energy resource for the electricity supply sector and the U.S. economy would be greatly diminished.

To examine different policy tools for achieving widespread CCS adoption at new plants, we wrote a report published by the Center for American Progress (CAP) in May of this year, *Global Warming and the Future of Coal: the Path to Carbon Capture and Storage.* Last week, CAP published a follow-up report, *The Path to Clean Coal: Performance Standard More Effective than Bonus Allowances.* This new report augments our earlier analysis by examining the bonus allowance set-aside provisions in the Low Carbon Economy Act of 2007, S. 1766. Copies of these reports are attached. Their conclusions and recommendations are fully supported by CAP.

Our analyses conclude that, in their initial stages, the cap-and-trade programs under consideration by Congress are not likely to create carbon prices high enough to eliminate the cost differential between new coal plants with CCS and those without it. As a result, new coal plant developers are unlikely to capture and sequester their emissions until 2030 at the earliest and perhaps not until later. To accelerate CCS deployment, we recommend that Congress adopt an emission performance standard for all new coal plants pegged to the capture efficiency of available technology. This standard would apply to new plants for which construction begins after the legislation takes effect (presumably in 2008) and would provide these plants with a phase-in period to allow for further testing and improvement of the technology before fully implementing it. Under this timeline, CCS systems at covered plants would need to meet the performance standard in 2016 or within four years after the plant becomes operational, whichever occurs later.

An emission performance standard would have several important benefits. It would: :

- Minimize the risk that substantial emissions growth from new coal plants jeopardizes overall emission reduction efforts, particularly as more stringent caps are triggered in the later years of a carbon control regime.

- Overcome the "CCS cost gap" that will prevent deployment until at least 2030 and perhaps even longer under anticipated cap-and-trade legislation.

- Send a clear signal to plant developers and investors that CCS systems are an essential feature of all new coal plants, spurring innovation and cost-reduction by technology vendors and utilities and concentrating public and private resources on the remaining technical, economic and regulatory hurdles to CCS implementation.

- Provide a path toward public acceptance of new coal plants which enables coal to play a secure and important role in the future energy mix.

- Position the U.S. as a leader in developing CCS technology and thereby speed its adoption by the rest of the world.

We are *not* proposing an emission performance standard for existing coal-fired power plants, which do not threaten the same increase in overall CO_2 emissions as new plants which lack CO_2 controls. In our view, existing plants – like other large CO_2 emitters – should be subject to an economy-wide cap-and-trade program which progressively lowers national greenhouse gas emissions. Retrofitting these plants with CCS is an important emission reduction option but the costs and technical challenges it poses are not yet fully understood. At least initially, CCS should not be a preferred compliance strategy for existing plants but should be considered along with other options based on cost-effectiveness.

Our reports recognize that, at the current stage of technology development, CCS-equipped plants are significantly more costly than conventional plants and may well be uneconomic if there is no commercial value to the CO_2 stream which is captured. Closing this cost gap is essential so that (1) investors have incentives to build plants with CCS, (2) coal remains competitive with other fuels, and (3) consumers do not suffer significant electricity price increases. Accordingly, we propose a package of financial assistance that would initially offset 20 percent of total construction costs and a portion of ongoing operating costs. Revenues for this package might be derived from the proceeds of allowance auctions under cap-and-trade legislation, from a national "wires charge" on electricity sales, or from a mix of traditional financial instruments (loan guarantees, tax credits and grants).

This framework for deploying CCS at new coal plants is ambitious and will only be workable with a concerted national commitment to create a sound legal and technical foundation for CCS. Along with a program of large-scale testing, Congress must assure that a regulatory regime is in place for CO_2 transportation and storage as soon as possible. It must also clarify who bears long-term liability for maintaining and operating sequestration sites – a vitally important issue to industry and a potentially serious hurdle to CCS deployment if it is not resolved.

The Impact of New Coal Plants on the Success of GHG Emission Reduction Efforts

Why is it urgent to address new coal plants under climate legislation?

For the last 15 years, most new power plants built in the U.S. have been fueled with natural gas. In the last few years, however, coal has again emerged as a fuel of choice for the power sector as natural gas prices hit historically high levels worldwide and as demand for natural gas overtakes available supplies. In the U.S., coal is abundant, representing 27 percent of the world's known reserves,[1] and is less subject to price volatility and supply constraints than petroleum and natural gas. Because demand can be met from domestic sources, coal also offers important energy security benefits to the United States. In contrast, U.S. imports of natural gas are rising, requiring construction of controversial LNG terminals and increasing dependency on major natural gas producers like Russia and Iran with interests hostile to those of the U.S.

While only 11 gigawatts of new coal-fired plants were built in the U.S. from 1991 to 2003, and virtually none from 2001 to 2005,[2] the National Energy Technology Laboratory (NETL) of the

U.S. Department of Energy (DOE) has estimated that 145 gigawatts of new coal-fired plants will be built in the U.S. by 2030.[3] Utilities and other power plant developers have already announced plans to build 151 coal-fired plants with a capacity of 90 gigawatts.[4] Outside the U.S., the projections are more dramatic. Estimates of the worldwide total new construction of coal-fired plants by 2030 are around 1,400 gigawatts.[5]

Few of these new plants in the U.S. are likely to replace existing less efficient coal-fired plants. The Energy Information Administration (EIA) predicts that by 2030 electricity demand in the U.S. will increase by approximately 40 percent,[6] creating a need for increased power generation, and estimates that only about 3.6 gigawatts of coal power plants will be decommissioned by 2025.[7] In the developing world, where economic growth will be higher than in the U.S., almost all of the new coal-fired plants will represent an expansion, rather than a replacement, of capacity to meet soaring energy demand. China, for example, has the world's third largest coal reserves,[8] and is in the process of implementing a massive increase in coal-fired generation to meet growing energy needs.[9]

A major expansion of worldwide coal generation would dramatically increase greenhouse gas emissions. A new 1,000 megawatt (1 gigawatt) coal power plant using the latest conventional pulverized coal technology produces about 6 million tons (5.4 million metric tons) of CO_2 annually.[10] In the absence of CO_2 emission controls, the new coal plants projected to be built globally would generate as much as 8.4 billion additional tons (7.6 billion metric tons) of CO_2 each year (assuming 1,400 gigawatts of new coal-fired plants are constructed). This represents an increase of approximately 30 percent over current total annual world emissions of 25 billion metric tons of CO_2 from the consumption of fossil fuels.[11] Worldwide emissions from these new plants between now and 2030 would be equal to 50 percent of all emissions from all power plants during the past 250 years.[12]

In the United States alone, 870 million tons of CO_2 (790 million metric tons) would be emitted if all of the currently proposed coal plants are built and do not control their emissions.[13] This compares to 2005 annual emissions in the U.S. of about 6 billion metric tons of CO_2 and 7.15 billion metric tons of CO_2 equivalent greenhouse gases from *all* sources.[14] Moreover, new coal-fired plants, once built, will have a projected lifespan of up to 60 years. There will be powerful resistance to retiring them before investors have earned an acceptable return on their investment. These plants would therefore be high CO_2 emitters for decades to come.

Perhaps in the early years of emission reduction efforts, the increased emissions from new coal plants might be offset by a combination of reductions from existing sources and other low carbon activities like methane recovery. But over time, as emission caps become more stringent, with reduction targets of 20, 30 and even 70 percent of current levels by 2050, the added emissions from uncontrolled new coal plants will make it increasingly difficult, if not impossible, to attain overall emission reduction goals.

Will all of the proposed coal plants in fact be built in the absence of climate legislation?

In the U.S., there is growing public opposition to new coal plants, and legal and political challenges to these plants are now routine. The recent proposal by private equity investors to cancel eight coal plants announced by Texas utility TXU Corp. is evidence that public concerns are influencing investment decisions. [15] States like Florida and California are adopting policies which discourage new coal plants because of their climate change impacts.[16] Moreover, with the Supreme Court recently holding that CO_2 is a "pollutant" that can be regulated under the Clean Air Act, activists now argue that new plants cannot be permitted unless emission control technologies are installed to address climate concerns. Recognizing these trends, in July, Citigroup analysts downgraded the stocks of coal companies across the board, maintaining that "prophesies of a new wave of coal-fired have vaporized, while clean coal technologies . . . remain a decade away, or more." [17]

Some plant developers are persisting in the face of these obstacles and a number of new plants are on track to be built on schedule. However, the total number of new plants will probably be substantially smaller than projected a few years ago. Many of those that are built will probably be Integrated Gasification Combined Cycle (IGCC) facilities, which are viewed as offering more cost-effective opportunities for installing CCS systems than pulverized coal (PC) units and enjoy a higher level of public acceptance. Nonetheless, the odds that these facilities will actually capture and store their emissions in their early years of operation are small.

The slowdown in new coal plant construction is not necessarily a positive development. One consequence may be a delay in adding new generation capacity nationwide, which could hurt grid reliability and increase the cost of peak generation as demand for power grows. Another consequence may be to increase reliance on natural gas generation despite price and energy security concerns. It may therefore be in the national interest to adopt a policy framework which eases anxiety about coal plants and creates a regulatory environment that maximizes public acceptance of new coal generation in a carbon constrained world. From this standpoint, timely CCS deployment may reinvigorate the prospects for an expansion of coal capacity in the U.S.

Near-term Prospects for CCS Deployment

There is generally optimism about the feasibility and safety of large-scale capture and underground injection of CO_2 generated by new coal power plants, tempered by a recognition that the technology is evolving and more demonstration projects are needed to lay the groundwork for widespread CCS deployment.

Geological Sequestration

During CCS operations, CO_2 is compressed to a supercritical liquid, transported by pipeline to an injection well and then pumped underground to depths sufficient to maintain critical pressures and temperatures. The CO_2 seeps into the pore spaces in the surrounding rock and its escape to the surface is blocked by a caprock or overlaying impermeable layer. In some types of formations, the CO_2 may dissolve in water and react with minerals in the host rock to form carbonates, becoming permanently entrained. Long-term sequestration of CO_2 is possible in depleted oil and gas reservoirs, unminable coal seams, basalt structures, and deep saline aquifers. The latter are believed to be ubiquitous at depths generally below one kilometer and are estimated to underlie at least one-half of the area of inhabited continents.[18] These deep saline formations have the greatest capacity to store CO_2 and would play a critical role in any large-scale CCS program.

There is considerable experience in the U.S. with underground injection of liquids and gases.[19] Over 100,000 technically sophisticated and highly monitored injection wells are currently employed to pump fluids as much as two miles below the earth's surface.[20] U.S. CO_2 pipeline transmission is also well-established, with CO_2 pipelines in use since the early 1970s, the longest of which runs for approximately 500 miles.[21]

Similarly, CO_2 has long been pumped into the ground in oil and gas fields to improve extraction of these fuels. CO_2 injection has occurred extensively in the Permian Basin of West Texas and East New Mexico, plus several other areas of the U.S. and Canada, as part of enhanced oil recovery (EOR) operations. Currently 71 active CO_2-EOR projects inject, use and store 43 million tons/year of CO_2, 11 million tons/year (9.9 million metric tons/year) of which comes from industrial sources.

Of particular note is EnCana's CO_2-EOR sequestration project in the Weyburn Field of Saskatchewan, Canada. The CO_2 is created in North Dakota and goes through a 200-mile pipeline to reach the Weyburn Field. The EnCana project in combination with the nearby Apache project currently injects 2.5 million metric tons of CO_2 annually into the Weyburn Field and expects to sequester a total of 51 million metric tons of CO_2 by project end.[22] Overseas, the two most visible CO_2 capture and storage projects (not involving CO_2-EOR) are at the Siepner Field in the North Sea by Norway's Statoil ASA and the InSala Field in Algeria by Britain's BP plc. Each of these projects currently injects about 1 million tons of CO_2 per year into a saline formation either above or below the producing natural gas reservoir.

The large scale sequestration projects now underway provide reassuring evidence that leakage from CO_2 storage formations is unlikely. Long-term experience with EOR in oil and gas fields is also reassuring. The geology of these fields is well-known and their sealing potential well-established; they have been storing oil and gas for millions of years.[23] Despite the importance of additional testing, experts are confident that large-scale sequestration will be safe, feasible, and cost-effective. Thus, after reviewing the key questions of subsurface engineering and surface safety associated with carbon sequestration, a recent MIT study concludes:

> There do not appear to be unresolvable open technical issues underlying these questions. Of equal importance, the hurdles to answering these technical questions well appear manageable and surmountable. As such, it appears that geological carbon sequestration is likely to be safe, effective, and competitive with many other options on an economic basis.[24]

Available data also provide confidence that there is ample underground capacity in the U.S. and most other areas of the world to sequester the CO_2 output from projected levels of fossil fuel combustion. DOE recently released its first Carbon Sequestration Atlas of the United States and Canada based on a preliminary survey of potential sequestration reservoirs by its seven regional sequestration partnerships. The Atlas concludes that approximately 3,500 billion tons of CO_2 storage capacity exists in North America (mostly in deep saline formations) at diverse locations across the country.[25] A 2006 report by the Battelle Institute on U.S. sequestration capacity reaches remarkably similar conclusions, estimating total U.S. capacity of 3,900 gigatons of CO_2 and finding that usable formations underlie parts of 45 states and two thirds of the land mass of the contiguous 48 states.[26] This capacity would be sufficient to store the CO_2 emissions of the 145 projected new coal plants in the U.S. for several centuries. A third report published in 2005 by the Intergovernmental Panel on Climate Change, entitled *IPCC Special Report on Carbon Dioxide Capture and Storage,* likewise concluded that there is considerable worldwide geological storage capability for CO_2.[27] The IPCC also concluded that it is likely that the CO_2 retained in underground formations will likely exceed 99 percent of the quantity injected over 1,000 years.[28]

It is widely agreed that a comprehensive survey of storage capacity is needed to improve the accuracy of existing estimates. Notwithstanding uncertainties in estimation, there is little doubt that most regions of the U.S. are endowed with ample geological formations suitable for sequestration. Thus, underground CO_2 storage opportunities are likely to be within close proximity (zero to 250 miles) to the majority of coal plants that would be built, although some coal-dependent states may need to transport CO_2 for longer distances in order to sequester it.[29]

CO_2 Capture Technology

The separation and capture of CO_2 at large coal-fired power plants pose larger economic and technical challenges than the transportation and sequestration of CO_2 and account for the bulk of the costs of CCS. The dominant coal generation technology in the world today is pulverized coal (PC), in which coal is ground to fine particles and then injected into the furnace with combustion air; the flue gas from the boiler contains CO_2 and other combustion byproducts, which are treated to remove certain pollutants (nitrogen oxides or NO_x, and sulfur dioxide or SO_2) and then released to the air. The CO_2 can be captured from the flue gas following combustion at these plants by absorption into an amine solution, from which the absorbed CO_2 is then stripped via a temperature increase and cooled, dried, and compressed into a supercritical liquid.

IGCC plants are able to capture CO_2 emissions more cost-effectively than PC plants using current technology because IGCC technology does not rely on direct combustion but instead converts the carbonaceous feedstocks, by way of gasification, into a clean gas called syngas. A phase shifter can be used to convert carbon monoxide gas to carbon dioxide in the presence of steam at the end of the syngas refining stage and to separate the CO_2 stream from the syngas before combustion. Because CO_2 concentrations are higher and pressure is lower when CO_2 is captured pre-combustion, the energy required for CO_2 separation is smaller for IGCC units than for PC units. The carbon capture rate at IGCC plants is currently believed to be around 85 percent.

Although CO_2 capture is relatively straightforward technically, it poses a major economic challenge. Because of higher capital costs, greater fuel utilization, and lower electricity output, coal plants that capture CO_2 are projected to be more expensive producers of electricity than plants without capture capability. Carbon capture is estimated to account for 83 percent of the total cost of CCS systems, with transportation and storage accounting for only 17 percent of such costs.[30] Table 1 summarizes the results of three recent studies that estimate the economic and performance impacts of adding carbon capture technologies to IGCC and Supercritical Pulverized Coal (SCPC) plants.[31] As Table 1 illustrates, although capture costs will be high with both technologies, IGCC is currently perceived to have a marked advantage over SCPC:

Table 1: Estimated Economic Impacts of Adding Carbon Capture & Sequestration

	IGCC Plants			**SCPC Plants**		
	MIT Study	**Wisconsin Report**	**EPA Report**	**MIT Study**	**Wisconsin Report**	**EPA Report**
Increase in Capital Costs (%)	32%	35%	47%	61%	60%	73%
Decrease Total Efficiency (%)	19%	NA	14%	24%	NA	29%
Increase in Cost of Electricity ($ / MWh)[32]	NA	$ 18	$ 18	NA	$ 33	$ 35
Increase in Cost of Electricity (%)	25-40%	30%	37.5%	60-85%	60%	67%
Cost of Preventing CO_2 emissions ($ per ton)	$ 24	$ 30	$ 28	$ 40	$ 45	$ 51

With the heightened interest in CCS, considerable work is underway in the private sector to improve pre-and post-combustion capture technologies as well as develop a promising oxycombustion capture process for use with PC plant designs. These improvements – which have projected times to commercialization of 5-12 years according to DOE[33] – have the potential to significantly lower the energy penalty (and hence the cost of electricity increase) of carbon capture.

Incentives for CCS Under Cap-and-Trade Programs

The critical question examined in our report *Global Warming and the Future of Coal* is which policy tools will best promote deployment of CCS in an expeditious but realistic timeframe. Our principal conclusion is that, in their initial stages, cap-and-trade programs are not likely to create carbon prices high enough to eliminate the cost differential between new coal plants with CCS and those without it. This would mean that new coal plant developers are unlikely to adopt CCS systems until the emission caps for these programs become sufficiently stringent to significantly increase the price of carbon – probably not until 2030 and perhaps later.

There are considerable uncertainties in any analysis of this type, including predicting the future price of carbon under various legislative scenarios as well as projecting the future costs of CCS and other power generation technologies. Nonetheless, it is instructive to examine the "CCS cost gap" under two recent cap-and-trade proposals:

- S. 280, introduced earlier this year by Senators McCain and Lieberman, would cap emissions at 2004 levels in 2012, 1990 levels in 2020 and 22 percent below 1990 levels starting in 2030. A recent analysis by the Environmental Protection Agency (EPA) found that CO_2 allowance prices (in 2005 dollars) would be \$13-15 per ton in 2015, \$16-20 per ton in 2025 and \$27-32 per ton in 2030.[34] EIA projected similar allowance prices (assuming substantial access to international and domestic offsets) in its own analysis of S. 280. [35]

- S. 1776, introduced by Senator Bingaman and co-sponsors, would reduce emissions to 2006 levels by 2020 and 1990 levels by 2030. Covered entities would need to submit allowances corresponding to the amount of CO_2 they emit or make payments into a special fund at a fixed price for each ton of CO_2 emitted. This "technology accelerator payment" (often described as a safety valve) would start at \$12 per metric ton of CO_2 equivalent in 2012 and increase by 5 percent per year above the rate of inflation. An analysis by the National Commission on Energy Policy (NCEP) concludes that the safety valve price will probably not be triggered and that, instead, allowance prices will likely be \$5.40 per ton in 2012 and just under \$24 per ton in 2030.[36]

As shown in Table 1, three recent studies conclude that IGCC plants with CCS systems would capture and sequester their emissions at a cost of around \$30 per ton; other recent estimates indicate that the cost is closer to \$40 per ton.[37] PC plants with CCS would remove CO_2 at \$40-50 per ton. At these cost levels, it would not be economic to capture and sequester emissions before 2030 under S. 280 or S. 1776. Instead, it would be less costly to build an uncontrolled coal plant and purchase allowances or offsets to cover its emissions. As EPA concluded in its analysis of S. 280, "while CCS is available in 2015, carbon prices rise to a high enough level to make CCS cost-competitive in ~ 2030." [38]

Even if the price of CO_2 allowances reaches a level at which CCS is cost-competitive, there would still be no assurance that new coal plants are equipped with CCS. Given a choice between building an uncontrolled plant and one with CCS at roughly equivalent compliance costs, developers may opt for the traditional technology as opposed to more innovative CCS. This is because there will be non-price barriers to building plants with CCS, including the reluctance of conservative utility executives to invest in new and uncertain technologies, the lower operational and financial risks of building conventional coal plants and the belief that second generation plants are more economical and reliable than first generation plants. Because of these perceived risks, developers could opt for conventional plants even though their nominal costs are no lower and (maybe even higher) than those of plants with CCS systems. In this event, the price of CO_2 allowances might need to reflect a "risk premium" above the cost per ton of CCS plants in order to entice reluctant investors. This could delay widespread CCS deployment beyond 2030, although individual CCS plants could still be economically viable where the captured CO_2 has commercial value – for example, when used in EOR.

An Emission Performance Standard for New Coal Plants

Global Warming and the Future of Coal concludes that the most effective strategy for closing the "CCS cost gap" is to adopt an emissions performance standard for new coal plants, while including existing coal plants in an economy-wide cap-and-trade program.

An emissions performance standard would require new plants to capture CO_2 emissions at the level achievable through the best performing CCS technology (currently in the range of 85 percent). The standard could be expressed as a ratio of the emissions rate to electricity output (CO_2 emissions per kWh), or as a percentage of total CO_2 generated. The standard could initially be applied to new coal plants but later extended to other new large fossil fuel combustion facilities (such as natural gas power plants).

The Phase-in Process for a Performance Standard

Under our proposal, an emissions performance standard requiring CO_2 capture and storage would not take effect immediately upon enactment of legislation. Rather, there would be a phase-in process because of the need for additional practical experience with large-scale sequestration, further technical refinement and cost-optimization of capture technologies, and creation of an effective legal and regulatory framework for long-term underground CO_2 storage. Assuming that legislation is enacted in 2008, all plants beginning construction thereafter would be subject to the emission performance standard but would not be required to begin capturing and sequestering their emissions until 2016 at the earliest. As a rule of thumb, all new plants would have at least four years lead-time from initial operation before complying with the standard. For example, a plant beginning operation in 2012 would start complying by 2016, while one beginning operation in 2016 would start complying by 2020. Over time, the four-year shakedown period would be reduced as experience with CCS grows. For example, by 2025, plants might get only one year after beginning to produce electricity before CCS systems must be up and running.

We recognize that a target date of 2016 for implementing CCS at all new coal plants is challenging. However, there is a growing consensus that CCS systems will be ready for widespread commercial deployment by 2020 if not earlier.[39] Thus, requiring CCS operation starting in 2016 would be an ambitious but achievable goal which underscores the national commitment to controlling emissions from new coal plants.

To the extent some utilities consider a 2016 compliance date overly aggressive, our report proposes giving plant developers a limited option (from 2008 to 2011) to begin constructing traditional coal plants that do not capture and sequester CO_2 provided they offset on a one-to-one basis their CO_2 emissions by one or more of the following steps:

- Improving system-wide efficiency and lowering CO_2 emissions at existing plants
- Retiring existing coal or natural gas units that generate CO_2 emissions
- Constructing previously unplanned renewable fuel power plants representing up to 25 percent of the generation capacity of the new coal plant.

Similar approaches have been announced recently by utilities building new coal plants.[40]

Benefits of an Emission Performance Standard

An emission performance standard would have several important benefits.

First, early across-the-board application of CCS – the most promising and perhaps only viable emission control technology for new coal plants – would minimize the risk that substantial emissions growth from these plants jeopardizes overall emission reduction efforts, particularly as more stringent caps are triggered in the later years of a carbon control regime.

Second, by providing an expedited timetable for implementing CCS, an emission performance standard would overcome the "CCS cost gap" that will prevent deployment until at least 2030 and perhaps even longer under anticipated cap-and-trade legislation. With a firm 2016 target date for implementation, a performance standard offers an element of certainty that would otherwise be lacking under a cap-and-trade program, where multiple uncertainties (such as the price of allowances, the cost of CCS and the reluctance of conservative utilities to invest in innovative technologies without a "risk premium") make the timing and scope of CCS implementation difficult to predict or control.

Third, a national target date for capturing and storing CO_2 at new plants would send a clear signal to plant developers and investors that CCS systems are a required feature of all new coal plants. This would spur innovation and cost-reduction by technology vendors and utilities by concentrating resources on the remaining technical, economic and regulatory hurdles. It would also provide public utility commissions (PUCs) with a stronger basis for authorizing CCS-equipped plants; otherwise, PUCs could conclude that conventional cost plants are less costly and risky for ratepayers until the price of carbon increases substantially.

Fourth, plants with CCS would enjoy public acceptance and would not carry the stigma of uncontrolled plants with high CO_2 emissions. Thus, resistance to new coal generation, which is now derailing many proposed plants, would abate, enabling coal to play a more secure role in the national energy mix.

Finally, it is in the economic interest of the U.S. to take the lead in developing CCS technology and thereby speed its adoption by the rest of the world. Successfully deploying CCS in the U.S. will create domestic jobs and give U.S. companies that develop these systems a leadership position in satisfying the demand for clean coal in other countries, helping them capture a major share of the billions of dollars that will be spent worldwide on coal plants between now and 2030.

Retrofitting of Existing Coal Plants

The emission performance standard would *not* apply to existing coal-fired power plants. These facilities do not pose the same risk of dramatically increasing overall CO_2 emissions over several decades as new uncontrolled plants. Thus, the logic of requiring the best available control technology carries less weight for existing plants than for new ones. At the same time, existing plants obviously need to be controlled and – like other large CO_2 emitters – should be subject to an economy-wide cap-and-trade program which progressively lowers national greenhouse gas emissions. Retrofitting these plants with CCS should be an important emission reduction option under this program but not a required compliance strategy since the costs and technical challenges of CCS retrofits are not yet fully understood and other reduction strategies (including energy efficiency and renewable energy technologies) may be more cost-effective.

Drawbacks of CCS Incentive Programs

In our two reports, we compare the certainty of an emission performance standard with other approaches that that create incentives for the construction of CCS plants but do not require adoption of CCS technology. One such approach is the program of bonus allowances that would be authorized by Senator Bingaman's bill, S. 1766. This program would use bonus allowances to offset the cost differential between plants with CCS and uncontrolled coal plants and thereby attempt to persuade utilities to build CCS plants although they are not required to do so.

We demonstrate in *The Path to Cleaner Coal* that the emission performance approach is more effective and less costly than a bonus allowance program for a number of reasons. First, because their value depends on future market conditions, bonus allowances are an imprecise tool that could either provide inadequate incentives to plant developers or overshoot the mark and provide them with unjustified windfalls. Second, because CCS would not be required, bonus allowances would not only need to close the cost gap between plants with and without CCS systems but include a premium to overcome non-price barriers such as industry reluctance to assume the risk of new technologies. This would inflate costs unnecessarily, as our analysis of S. 1766 shows. Finally, utilities will probably not sell bonus allowances in the open market but use them to offset emissions from existing plants or even from new plants without CCS systems. This would delay emission reductions from the utility sector, put upward pressure on allowance prices and increase emission reduction obligations and costs for other industrial sectors.

Offsetting Economic Impacts

An emissions performance standard would increase the price of electricity because of the reduced plant efficiency and increased construction and operational costs associated with carbon capture technology. As shown in Table I, this increase is estimated by the state of Wisconsin, MIT, and EPA to be on the order of 20 percent to 40 percent for IGCC plants with CCS units and considerably higher for CCS-equipped SCPC units.[41]

The predicted higher costs of electricity from plants with CCS units may be ameliorated by several factors. First, for some power plants, the injection of CO_2 in oil or gas wells will increase production of these fuels, creating a revenue stream that partially or totally offsets the increased costs of capture and storage. Second, with advances in technology, IGCC and PC plants will achieve an even greater energy efficiency advantage over conventional PC plants now in service, offsetting a greater portion of the loss of efficiency from carbon capture. Third, the technology for capturing carbon will itself become more cost effective, imposing less of an efficiency penalty on electricity generation. (Experience with other emission reduction programs has shown that, because of technological innovation, actual compliance costs turn out to be lower than predicted by government or industry before-the-fact). Finally, in the initial years, new plants would provide only a relatively small portion of the power generated by the utility sector, with the balance coming from lower-cost existing plants. Thus, when spread across the entire U.S. rate base, the increases in electricity rates would be negligible.

Nonetheless, a strong case can be made for coupling an emission performance standard with a program of financial assistance to utilities that closes the cost gap between CCS systems and non-CCS generation. Without financial assistance, the combination of a declining cap for existing plants and a CCS requirement for new plants would disproportionately burden power generation systems that rely heavily on coal. Since the benefits of CCS systems in preventing CO_2 emissions will be realized by all regions, the costs should arguably be borne equally at the national level and not be imposed solely on regions that produce or use coal. Moreover, there is a strong national imperative to develop CCS technologies as quickly as possible so that CCS plants can play a role in meeting energy demand growth and start replacing older inefficient coal-fired plants in a carbon-constrained world. Programs that reduce the financial risks and uncertainties of building CCS plants in the early years can secure commitments from otherwise reluctant investors and assure that coal remains a vital and viable part of the national fuel mix.

Global Warming and the Future of Coal recommends providing plant developers with a package of financial incentives, including tax credits and grants, that cover the added costs of building and operating coal-fired power plants with CCS systems under a cap-and-trade program. The size of these incentives would reflect the difference between the prevailing CO_2 allowance price and the cost per ton of capturing and storing plant emissions. As this difference narrows because of rising allowance prices or reductions in the costs of CCS, the level of financial assistance to the plant developer would decline proportionately. Thus, plants built in the early years would receive more assistance than plants built later on.

A number of the proposed climate bills require the auctioning of emissions allowances, with the auction revenues used to fund new technologies or to offset the costs to industries and consumers of climate-related requirements. One use for auction revenues could be to offset the higher costs of coal plants that employ CCS systems. Under a cap-and-trade program, owners of existing coal plants would be heavy allowance purchasers because of their large CO_2 emissions. Redistributing auction revenues to these owners if they build low carbon coal plants would serve the dual purposes of reducing their need for allowances (by helping to retire high-emitting plants) and providing economic relief to their customers (by cushioning them from increases in the cost of electricity).

As an alternative to auction proceeds, an incentive program for CCS plants could be funded by a uniform per kilowatt "wires charge" on retail electricity sales implemented at the federal level or by diverting a portion of general tax revenues. Phasing out existing federal subsidy programs for "clean coal" could reduce the overall demand on these funding sources.

As a starting point for discussion, *Global Warming and the Future of Coal* proposes that financial incentives for CCS plants should initially cover 20 percent of total construction costs (including the base-plant and add-on CCS capability) plus an ongoing subsidy for operating costs. This 20 percent cost recovery would be available for all new coal plants for which construction is commenced between now and 2012. The share of construction costs eligible for recovery would then begin dropping until the incentives are phased out. The cost of such a program would likely be in the range of $36 billion spread over 18 years, or about $2 billion a year, based on projections that 80 gigawatts of new coal-fired capacity with CCS systems will be built between now and 2025. Additional subsidies to cover operating costs would be available to the extent these costs exceed the costs of power from a plant that does not capture and sequester emissions. This subsidy might take the form of a $/kW production tax credit which is adjusted over time.

We welcome feedback on our proposal and encourage further analysis and modeling to determine how best to design a program of financial incentives that closes the CCS "cost gap" and stimulates investments in new CCS-equipped plants but is cost-effective and narrowly targeted.

Creating the Legal and Technical Foundation for CCS

Importantly, a national target date for capturing and storing CO_2 at new coal plants will not be achievable without a parallel effort to create a durable and credible legal and technical foundation for CCS. This is a job for Congress and it should receive the highest priority.

Energy legislation passed earlier this year in both bodies would significantly accelerate the research and development programs required for CCS to be successfully deployed on a widespread basis. As recommended in the MIT report, this legislation would authorize a small number of federally funded demonstration projects for different carbon capture technologies at IGCC and PC plants.[42] It would also authorize, in keeping with another MIT recommendation, a concerted demonstration program to determine the large-scale viability of different types of underground storage repositories and to assess the likelihood and scale of CO_2 leakage. Finally, a comprehensive inventory of potential storage reservoirs, building on existing DOE efforts, would be conducted.

Congress has made less progress in providing new authority and funding to EPA to develop a regulatory regime that establishes guidelines for sequestration site investigation, selection and permitting, monitoring of emissions and modeling of underground CO_2 migration and issuance of permits to entities responsible for CO_2 transportation and storage. This gap should be closed as soon as possible, perhaps before comprehensive climate legislation is enacted.

Since CO_2 injection at most sites will end after two or three decades, clearly defined liability and ownership rules will be required to delineate who bears long-term responsibility for effective CO_2 storage and remedial action if leaks occur at these sites. Some states, such as Texas, have decided to transfer ownership of post-injection sites to government bodies, but most other states have yet to set liability rules. Congress must develop a national liability framework for CCS sites as soon as possible. The absence of such a framework has created – and will create – substantial impediments to investment in CCS, notwithstanding general agreement that the risks to health and the environment of long-term CO_2 storage are probably negligible.

Conclusion

Bold action by the U.S. Congress to put in place an emission performance standard for new coal-fired power plants would demonstrate leadership in addressing global warming and build a technological and regulatory foundation that countries such as China and India could emulate as they attempt to tackle the risk of global warming without stifling economic growth. It would speed development and deployment of CCS technology in the U.S. and around the globe and prevent emissions growth that would jeopardize attainment of emission reduction goals. Finally, an emission performance standard that requires CCS systems for all new coal plants would assure coal a secure and important role in the future U.S. energy mix by establishing a clear path forward for coal in a carbon constrained world.

Again, we appreciate this opportunity to present our views to the Committee.

Endnotes

1 The Nat'l Coal Council, Coal: America's Energy Future, at xii, (March 2006), *available at* http://nationalcoalcouncil.org/report/NCCReportVol1.pdf. In 2005, U.S. coal consumption totaled 1.1 billion short tons. Energy Info. Admin., U.S. Coal Supply and Demand: 2005 Review, at 7 (April 2006), *available at* http://www.eia.doe.gov/cneaf/coal/page/special/feature05.pdf. In 2004, the United States accounted for nearly 20 percent of global demand, second only to China (approximately 34 percent). Int'l Energy Agency, World Energy Outlook 2006, at 127 (Nov. 2006) (hereafter WEO 2006 report). The demonstrated coal reserve base – approximately 500 short billion tons – is projected to last for over 100 years, even at elevated consumption levels. The Nat'l Coal Council, Coal: America's Energy Future, at 2 (March 2006), *available at* http://nationalcoalcouncil.org/report/NCCReportVol1.pdf.
2 Ben Yamagata, Clean Coal Opportunities in Electric Power Generation (February 8, 2006) (unpublished PowerPoint presentation of the Coal Utilization Research Council) (on file with authors).
3 DOE Nat'l Energy Tech. Lab., Tracking New Coal-Fired Power Plants: Coal's Resurgence in Electric Power Generation (May 1, 2007) (unpublished PowerPoint presentation) (on file with authors), *available at* http://www.netl.doe.gov/coal/refshelf/ncp.pdf [hereinafter, the NETL Tracking Report].
4 *Id.*
5 WEO 2006 report, *supra* note 1, at 493; Yamagata, *supra* note 2 (estimating 1400 gigawatts based on data from the International Energy Agency and Platt's database).
6 Energy Info. Admin., Annual Energy Outlook 2007, at 82, *available at* http://www.eia.doe.gov/oiaf/aeo/pdf/trend_3.pdf.
7 Energy Info. Admin., International Energy Outlook 2005, at 51, *available at* http://www.stat-usa.gov/miscfiles.nsf/85e14050560010 7b852566490063411d/d0d08407366b117d85257157006fae32/$FILE/IEO2005_ch007.pdf.
8 Energy Info. Admin., Energy Information Sheets: Coal Reserves (Aug. 2004), *available at* http://www.eia.doe.gov/neic/infosheets/coalreserves.htm.
9 Coal currently accounts for two-thirds of China's primary energy supply. Although the government has indicated its desire to decrease its coal usage, China is still predicted to drive over half of the growth in worldwide coal supply and demand in the next 25 years and coal will likely account for more than 50 percent of the country's energy supplies in the year 2030. *See* James Katzer et al., The Future of Coal: Options for a Carbon-Constrained World MIT Interdisciplinary Study (2007) (hereafter The MIT Study) at 63. *See also* The Fourth Assessment Report, Working Group III, Summary for Policy Makers (May 5, 2007). Prepared by the Intergovernmental Panel on Climate Change (stating that two-thirds to three-quarters of the increase in energy CO_2 emissions between 2000 and 2030 is projected to come from developing countries (e.g. those that are not "Annex I" countries or parties as defined in the IPCC report) [hereinafter, IPCC Fourth Assessment Report].
10 Robert Socolow, "Can We Bury Global Warming?," *Scientific American*, July 2005, at 50. *See also* The MIT Study, *supra* note 9, at ix (stating one 500 megawatt coal-fired power plant produces approximately 3 million tons per year of CO_2).
11 See WEO 2006 Report, *supra* note 1 at 73. The total world emissions figure is for CO_2 emissions from the consumption of fossil fuels only and relates to the year 2003.
[12] Socolow, *supra* note 10, at 52 (estimating that coal plants accounted for 542 billion tons of CO_2 emissions from 1751-2002 and will account for 501 billion tons of CO_2 from 2002-2030).
13 Energy Info. Admin., Emissions of Greenhouse Gases in the United States 2005, at 13 and ix (Nov. 2006), available at ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057305.pdf [hereinafter EIA 2006 Report].
14 *Id.* at 29.
[15] TXU initially proposed building 11 traditional coal-fired plants in Texas. In light of strong public opposition to the plants, TXU later cancelled plans for eight of these plants as part of the terms of a

buyout deal with a private equity group led by Kohlberg Kravis Roberts and the Texas Pacific Group. It subsequently announced plans to build two IGCC plants in Texas. Kurt Fernandez, "TXU, Buyout Partners Announce Plans for Two Carbon Dioxide Capture Plants," *BNA Daily Environment Report*, Mar. 12, 2007, at A-9.

[16] California has adopted legislation making it effectively impossible to enter into new contracts importing electricity from coal plants lacking CCS. With the support of Governor Crist, regulators in Florida have rejected a number of proposed coal plants and utilities are now looking to other forms of generation to meet demand growth.

[17] As quoted in *Coal Rush Reverses, Power Firms Follow*, by Steven Mufson, Washington Post, September 4, 2007.

[18] Robert H. Williams, "Climate-Compatible Synthetic Liquid Fuels from Coal and Biomass with CO_2 Capture and Storage," Princeton Envtl. Inst., Princeton Univ., at 7 (Dec. 19, 2005) (unpublished PowerPoint presentation) (on file with authors), *available at* http://www.climatechange.ca.gov/documents/2005-12-19_WILLIAMS.PDF.

[19] Except as otherwise indicated, the facts about sequestration were provided by Vello Kuuskraa of Advanced Resources International, Inc. ARI is the lead consultant on the EnCana project described in the text.

[20] EPA Underground Injection Control Program, http://www.epa.gov/safewater/uic/whatis.html (last visited March 27, 2007).

[21] *See* http://www.kindermorgan.com/business/co2/transport_cortez.cfm.

22 Email from Vello Kuuskraa, President, Advanced Resources Int'l, to Kenneth Berlin, Partner, Skadden, Arps, Slate, Meagher & Flom LLP (Apr. 30, 2007) (on file with authors).

[23] Jon Davis, "Gasification and Carbon Capture and Storage: The Path Forward," Contributing Paper (Pew Center/NCEP 10-50 Workshop) at 1.

[24] The MIT Study, *supra* note 9, at 43.

[25] The Nat'l Energy Tech. Laboratory, Carbon Sequestration Atlas of the U.S. and Canada (March 2007), available at www.netl.doe.gov/publications/carbon_seq/atlas/index.html [hereinafter, The NETL Sequestration Atlas.

[26] Battelle Joint Global Change Research Institute, Carbon Dioxide Capture and Geologic Storage: A Core Element of a Global Energy Technology Strategy to Address Climate Change, at 26-27. (April 2006) [hereinafter the Battelle Report].

[27] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, at 11 (Ogunlade Davidson et al. eds., 2005). Both the NETL Sequestration Atlas, *supra* note 30 and the Battelle Report, *supra* note 26, provide higher estimates of CO_2 storage capacity than IPCC. For example, Battelle estimates worldwide storage capacity of 11,000 gigatons. More definitive inventories in the United States and globally will enable this range of uncertainty to be narrowed considerably. For comparison purposes, fossil fuel CO_2 emissions from 1400 gigawatts of new IGCC plants would total 8.4 billon tons per year (at 6 million tons per gigawatt). *See* Socolow, *supra* note 10, at 50 and the MIT Study, *supra* note 9, at ix.

[28] IPCC Special Report on Carbon Dioxide Capture and Storage, *id.* at 31.

[29] A Duke University study, for example, recommended that the most cost-effective way for North Carolina to sequester CO_2 was to build a pipeline that would run 2250 miles and support a CO_2 flow rate of 57 million metric tons of CO_2 per year, sufficient to handle captured emissions from 11 gigawatts of new coal-fired plants. The pipeline alone is estimated at a cost of $5 billion, and according to the study would be cost effective at a CO_2 price of $29 per ton. Eric Williams, et al., *Carbon Capture, Pipeline and Storage: A Viable Option for North Carolina Utilities?* (Working Paper, March 2007), Nicholas Institute for Environmental Policy Solutions and Center on Global Change, Duke Univ. [hereinafter, The Duke Study]. See also Chris Holly, "*Clean Coal's Future in North Carolina Hangs On Big Pipe*, 35 The Energy Daily 71, 1-2 (Apr. 16, 2007) A price of $29 per ton of CO_2 is consistent with other estimates described in the text of the cost at which CCS becomes competitive.

30 MIT estimates the cost of CO_2 capture and pressurization at about $25 a ton and CO_2 transportation and storage at about $5 a ton. The MIT Study, *supra* note 9, at xi.
31 The MIT Study, *supra* note 4, at 30, 36; Mark Meyer et al., *Integrated Gasification Combined-Cycle Technology Draft Report*, Dep't of Nat. Res. Pub. Serv. Comm'n of Wisc. (June 2006), at 31-33 [hereinafter, the Wisconsin Report]; EPA, Environmental Footprints and Costs of Coal-based Integrated Gasification Combined Cycle and Pulverized Coal Technologies, at 5-11 – 5-12 (July 2006) [hereinafter, The EPA Report].
32 The efficiency of IGCC plans is now lower with Western subbituminous and Texas lignite coals, at least with some gasification technologies. As a result, the MIT report indicates that the cost differential between IGCC and SCPC narrows when these coals are used. The MIT Study, *supra* note 9, at 36-37.
[33] Carl Bauer, NETL Office of Fossil Energy, *CO_2 Capture Technology : Options and Experiences*, August 8, 2007 PPT presentation (on file with authors).
[34] US Environmental Protection Agency, *EPA Analysis of the Climate Stewardship and Innovation Act of 2007, S. 280 in 110th Congress* at 24 (July 16, 2007) [hereinafter, EPA Analysis].
[35] EIA, *Energy Market and Economic Impacts of S. 280, the Climate Stewardship and Innovation Act of 2007* (July 2007).
[36] National Commission on Energy Policy, *Impacts of the Low Carbon Economy Act of 2007* (July 11, 2007).
[37] Standard and Poors, S&P Viewpoint, *Which Power Generation Technologies Will Take the Lead In Response to Carbon Controls?* (May 11, 2007).
[38] EPA Analysis, *supra* note 34, at 3.
[39] Testimony of Brian Hannegan, *Future of Coal: Hearing Before the S. Comm. On Energy and Natural Resources*, 110th Cong. at 3 (March 22, 2007).
[40] An example is a March 2007 settlement agreement between Kansas City Power and Light and the Sierra Club relating to its 850 megawatt coal-fired plant under construction in Missouri. The agreement requires Kansas City Power and Light to offset the 6 million tons of CO_2 emissions from the new plant by installing 400 megawatts of new wind power, implementing measures to save 300 megawatts of energy demand and closing or upgrading an older coal-fired plant. Steven Mufson, "Electric Utility, Sierra Club End Dispute: Kansas City Power & Light Agrees to Offset New Coal-Fired Plant's Emissions, *The Washington Post,* March 20, 2007, at D03.
[41] *See* The Wisconsin Report, *supra* note 32 at 32 (estimating that costs would increase to over $75 per MWh of energy generated with carbon capture, compared to between $50 and $60 per MWh without carbon capture); The MIT Study, *supra* note 9, at 36 (estimating that the costs for IGCC with carbon capture will be 30 percent to 50 percent over that of SCPC without carbon capture and 25 percent to 40 percent higher than IGCC without carbon capture); The EPA Report, *supra* note 32, at 5-11 (estimating $66 per MWh for IGCC with carbon capture versus $48 per MWH for IGCC without capture and $51 for SCPC without capture).
[42] The MIT Study, *supra* note 9, at 100. Consistent with the MIT report, federal financial support for IGCC units without CCS would be phased out because IGCC already has strong commercial backing and the adoption of a generation performance standard requiring CCS will change the economics of new coal plants in IGCC's favor. *Id.*

The CHAIRMAN. And our final witness is Mr. Stuart Dalton, who is Director for the Generation sector of the Electric Power Research Institute. Mr. Dalton is a leading expert on coal-fired generation and carbon capture and storage. Among other efforts in this sphere, Mr. Dalton led EPRI's contribution to the National Coal Council's report on CCS and the Coal Utilization Council's—Research Council's technology roadmap.

We welcome you, sir. Whenever you are ready, please begin.

STATEMENT OF STUART DALTON

Mr. DALTON. Thank you, Mr. Chairman, members of the Committee. I appreciate the opportunity to speak today before the Committee. We believe that the—through the development and deployment of advanced coal plants with integrated CO_2 capture and storage coal power can be part of the solution to addressing both our growing energy needs, needs for energy independence, and for the global climate change concerns. However, we believe a sustained RD&D program at greater levels of investment and resolution of legal and regulatory unknowns for long-term CO_2 storage will be required to achieve the technologies.

In direct response to a couple of the questions that were posed earlier by the Committee, I would suggest that if you use today's technology it would probably increase the cost of a conventional pulverized coal plant, assuming you were scaling up with current technology and took that risk, by some 60 to 80 percent increase in the wholesale cost of power.

And if you put it on a gasification plant using today's technology, that might be a 40 to 50 percent increase in wholesale cost of power. That is to the how much question.

As to the when question, certainly it is heavily debated. We have heard different comments on when, but three to five years to build it, three to five years to inject, and three to five years to monitor adds up to a significant amount of time. And that is one of the questions is: when could these be built and proven in operation?

We have a program that has been developed with about 60 organizations from five continents working, which has laid out an RD&D program to move the technology forward. We see crucial roles for industry and governments worldwide in aggressively pursuing carbon capture and storage.

A couple of key points from my written submission. Advanced coal technology powerplants, with the integrated capture and storage, will be crucial to the U.S. The availability of advanced technologies could dramatically reduce the projected increases in cost of wholesale electricity under a carbon cap, thereby saving the U.S. economy as much as $1 trillion by 2050 in our estimation.

The program has identified pathways to demonstrate by 2025 a portfolio of attractive, highly efficient power, and integrated technologies. We see that with an aggressive program multiple large-scale capture and storage demonstrations by the middle of next decade, and some commercial applications starting around 2020.

It will take additional sustained efforts past the first applications to take the test technology down the learning curve in cost. We have identified RD&D that is in the testimony of $8 billion between now and 2017, and $17 billion by 2025, needs to begin immediately to fully test that scale. We believe that the House Bill 3221 appears to be consistent with some of these recommendations.

Major non-technical barriers must be addressed as well, such as CO_2 storage and liability. Potential sale of CO_2 to EOR may help some of the early applications in specific localities, as we have heard. But we believe ultimately that the primary economic driver will be the value of carbon emissions that results from any future climate policy.

We have just produced a study—I hold it in my hand—Electricity: The Power to Reduce CO_2 Emissions, and a companion study earlier this year, Electricity Technology in a Carbon-Constrained Future. Emissions over the next 25 years could be reduced in our estimation. The study shows the largest single contributor is reduction by CCS technologies. It also showed that generation efficiency enhancements can contribute significantly. Those two are the actual largest contributors to reduction in CO_2 in this study.

It shows that U.S. generation mix based on a full portfolio of technologies, including advanced coal technologies, integrated with CCS, and advanced lightwater reactors, results in a wholesale reduction of cost of $1 trillion with a stronger manufacturing economy. The portfolio aspect is critical, because no single advanced coal technology or any generating technology has clear-cut economic advantages in each region, with each coal, and across the range of applications.

We want to see how we can minimize economic disruption, and that, we believe, lies in the full portfolio of technologies. The four areas are: increasing efficiency and reliability of integrated gasification combined cycle powerplants, as well as cost reductions; increasing thermodynamic efficiency of coal-fired powerplants, as was said by Mr. Morris; improving technologies for capture of CO_2; reliable, acceptable technologies for long-term storage; and providing the financial mechanisms to share risk.

In short, a comprehensive program is what is needed. We thank you for the opportunity.

[The prepared statement of Mr. Dalton follows:]

Testimony

The Future of Coal Under Carbon Cap and Trade

Hearing of the Select Committee on Energy Independence and Global Warming

U.S. House of Representatives

Stuart Dalton
Director, Generation
Electric Power Research Institute

September 6, 2007

Introduction

Thank you, Mr. Chairman, Ranking Member Sensenbrenner, and Members of the Committee. I am Stuart Dalton, Director of Generation for the Electric Power Research Institute (EPRI), a non-profit, collaborative R&D organization. EPRI has principal locations in Palo Alto, California, Charlotte, North Carolina, and Knoxville, Tennessee. EPRI appreciates the opportunity to provide testimony to the Committee on the topic of the future of coal under carbon cap and trade.

Coal is the energy source for half of the electricity generated in the United States. Even with the aggressive development and deployment of alternative energy sources, numerous forecasts of energy use predict that coal will continue to provide a major share of our electric power throughout the 21st century. Coal is a stably priced, affordable, domestic fuel that can be used in an environmentally responsible manner. Criteria air pollutants from all types of new coal power plants have been reduced by more than 90% compared with plants built 40 years ago. Through the development and deployment of advanced coal plants with integrated CO_2 capture and storage (CCS) technologies, coal power can become part of the solution to satisfying both our energy needs and our global climate change concerns. However, a sustained RD&D program at heightened levels of investment and the resolution of legal and regulatory unknowns for long-term geologic CO_2 storage will be required to achieve the promise of clean coal technologies. The members of EPRI's *CoalFleet for Tomorrow*® program—a research collaborative comprising more than 60 organizations representing international power generators, equipment suppliers, government research organizations, coal and oil companies, and a railroad—see crucial roles for both industry and governments worldwide in aggressively pursuing collaborative RD&D over the next 20+ years to create a full portfolio of commercially self-sustaining, competitive advanced coal power generation and CCS technologies.

The key points I will make today include:

- Advanced coal power plant technologies with integrated CO_2 capture and storage (CCS) will be crucial to lowering U.S. electric power sector CO_2 emissions. They will also be crucial to substantially lowering world CO_2 emissions as well.
- The availability of advanced coal power and integrated CCS technologies could dramatically reduce the projected increases in the cost of wholesale electricity under a carbon cap, thereby saving the U.S. economy as much as $1 trillion by 2050.
- EPRI's *CoalFleet for Tomorrow®* program has identified the RD&D pathways to demonstrate, by 2025, a full portfolio of economically attractive, commercial-scale advanced coal power and integrated CCS technologies suitable for use with the broad range of U.S. coal types. Some technologies will be ready for some fuels sooner, but the economic benefits of competition will not be realized until the full portfolio is developed.
- The identified RD&D is estimated to cost $8 billion between now and 2017 and $17 billion cumulatively by 2025, and we need to begin immediately to ensure that these climate change solution technologies will be fully tested at scale by 2025.
- Major non-technical barriers must be addressed before CCS can become a commercial reality, including resolution of regulatory and long-term liability uncertainties.
- Potential sale of CO_2 captured from coal power plants for enhanced oil recovery (EOR) could help the economics of early CCS applications in "oil patch" areas—with the added benefit of increasing U.S. oil production—but the value of such sales in offsetting CCS costs would likely diminish over time as wider CCS deployment (i.e., CO_2 supply) depressed market prices and CO_2-EOR applications reach saturation. At the scale that CCS needs to be deployed to help achieve atmospheric CO_2 stabilization at an acceptable level, EPRI believes that the primary economic driver for CCS will be the value of carbon that results from a future climate policy.

The Role of Advanced Coal Generation with CO_2 Capture and Storage in a Carbon-Constrained Future

EPRI's "Electricity Technology in a Carbon-Constrained Future" study suggests that it is technically feasible to reduce U.S. electric sector CO_2 emissions by 25–30% relative to current emissions by 2030 while meeting the increased demand for electricity. The study showed that the largest single contributor to emissions reduction would come from the integration of CCS technologies with advanced coal-based power plants coming on-line after 2020.

Economic analyses of scenarios to achieve the study's emission reduction goals show that in 2050, a U.S. electricity generation mix based on a full portfolio of technologies, including advanced coal technologies with integrated CCS and advanced light water nuclear reactors, results in wholesale electricity prices at less than half of the wholesale electricity price for a generation mix without advanced coal/CCS and nuclear power. In the case with advanced coal/CCS and nuclear power, the cost to the U.S. economy of a

CO_2 emissions reduction policy is $1 trillion less than in the case without advanced coal/CCS and nuclear power, with a much stronger manufacturing sector. Both of these analyses are documented in the 2007 EPRI Summer Seminar Discussion paper, "The Power to Reduce CO_2 Emissions – the Full Portfolio," available at http://epri-reports.org/DiscussionPaper2007.pdf.

Accelerating RD&D on Advanced Coal Technologies with CO_2 Capture and Storage—Investment and Time Requirements

The portfolio aspect of advanced coal with integrated CCS technologies must be emphasized because no single advanced coal technology (or any generating technology) has clear-cut economic advantages across the range of U.S. applications. The best strategy for meeting future electricity needs while addressing climate change concerns and minimizing economic disruption lies in developing a *full portfolio* of technologies from which power producers (and their regulators) can choose the option best suited to local conditions and preferences and provide power at the lowest cost to the customer. Toward this end, four major technology efforts related to CO_2 emissions reduction from coal-based power systems must be undertaken:

1. Increased efficiency and reliability of integrated gasification combined cycle (IGCC) power plants
2. Increased thermodynamic efficiency of pulverized-coal (PC) power plants
3. Improved technologies for capture of CO_2 from coal combustion- and gasification-based power plants
4. Reliable, acceptable technologies for long-term storage of captured CO_2

Identification of mechanisms to share RD&D financial and technical risks and to address legal and regulatory uncertainties must take place as well.

In short, a comprehensive recognition of all the factors needed to hasten deployment of competitive, commercial advanced coal and integrated CO_2 capture and storage technologies—and implementation of realistic, pragmatic plans to overcome barriers—is the key to meeting the challenge to supply affordable, environmentally responsible energy in a carbon-constrained world.

A typical path to develop a technology to commercial maturity consists of moving from the conceptual stage to laboratory testing, to small pilot-scale tests, to larger-scale tests, to multiple full-scale demonstrations, and finally to deployment in full-scale commercial operations. For capital-intensive technologies such as advanced coal power systems, each stage can take years or even a decade to complete, and each sequential stage entails increasing levels of investment. As depicted in Figure 1, several key advanced coal power and CCS technologies are now in (or approaching) an "adolescent" stage of development. This is a time of particular vulnerability in the technology development cycle, as it is common for the expected costs of full-scale application to be higher than earlier estimates when less was known about scale-up and application challenges. Public agency and private funders can become disillusioned with a technology development effort at this point, but as long as fundamental technology performance results continue to meet expectations, and a path to cost reduction is clear, perseverance by project sponsors in maintaining momentum is crucial.

Unexpectedly high costs at the mid-stage of technology development have historically come down following market introduction, experience gained from "learning-by-doing," realization of economies of scale in design and production as order volumes rise, and removal of contingencies covering uncertainties and first-of-a-kind costs. An International Energy Agency study led by Carnegie Mellon University (CMU) observed this pattern of cost-reduction-over-time for power plant environmental controls, and CMU predicts a similar reduction in the cost of power plant CO_2 capture technologies as the cumulative installed capacity grows.[1] EPRI concurs with their expectations of experience-based cost reductions and believes that RD&D on specifically identified technology refinements can lead to greater cost reductions sooner in the deployment phase.

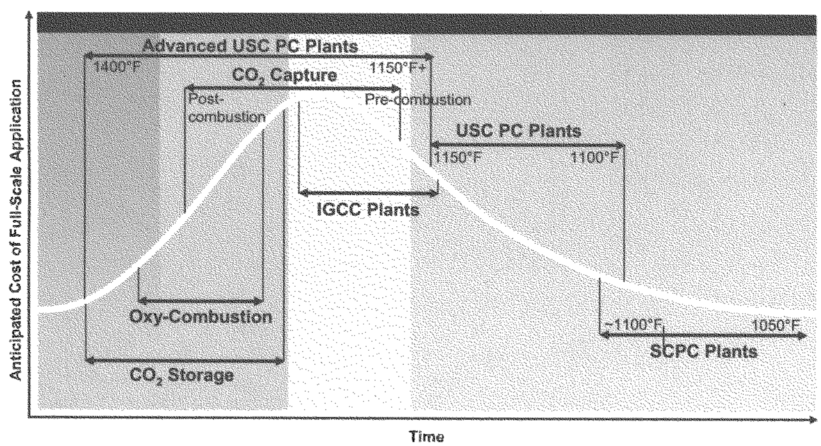
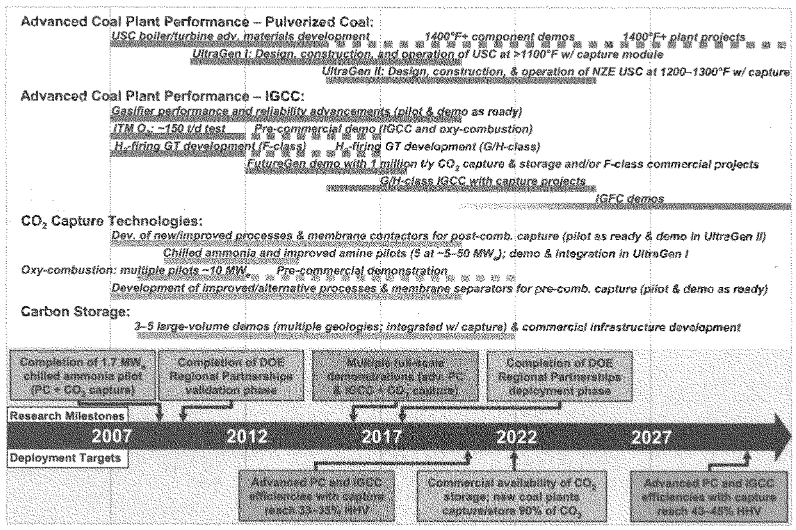


Figure 1 – Model of the development status of major advanced coal and CO_2 capture and storage technologies (temperatures shown for pulverized coal technologies are turbine inlet steam temperatures)

Of the coal-based power generating and carbon sequestration technologies shown in Figure 1, only supercritical pulverized coal (SCPC) technology has reached commercial maturity. It is crucial that other technologies in the portfolio—namely ultra-supercritical (USC) PC, integrated gasification combined cycle (IGCC), CO_2 capture (pre-combustion, post-combustion, and oxy-combustion), and CO_2 storage—be given sufficient support to reach the stage of declining constant dollar costs *before* society's requirements for greenhouse gas reductions compel their application in large numbers.

[1] IEA Greenhouse Gas R&D Programme (IEA GHG), "Estimating Future Trends in the Cost of CO_2 Capture Technologies," 2006/5, January 2006.

Figure 2 depicts the major activities in each of the four technology areas that must take place to achieve a robust set of integral advanced coal/CCS solutions. Important, but not shown in the figure, are the interactions between RD&D activities. For example, the ion transport membrane (ITM) oxygen supply technology shown under IGCC can also be applied to oxy-combustion PC units. Further, while the individual goals related to efficiency, CO_2 capture, and CO_2 storage present major challenges, significant challenges also arise from complex interactions that occur when CO_2 capture processes are integrated with gasification- and combustion-based power plant processes.



Source: The Power to Reduce CO2 Emissions – the Full Portfolio," http://epri-reports.org/DiscussionPaper2007.pdf

Figure 2 – Timing of advanced coal power system and CO_2 capture and storage RD&D activities and milestones

Reducing CO_2 Emissions Through Improved Coal Power Plant Efficiency—A Key Companion to CCS that Lowers Cost and Energy Requirements

Improved thermodynamic efficiency reduces CO_2 emissions by reducing the amount of fuel required to generate a given amount of electricity. A two-percentage point gain in efficiency provides a reduction in fuel consumption of roughly 5% and a similar reduction in flue gas and CO_2 output. Because the size and cost of CO_2 capture equipment is determined by the volume of flue gas to be treated, higher power block efficiency reduces the capital and energy requirements for CCS. Depending on the technology used, improved efficiency can also provide similar reductions in criteria air pollutants, hazardous air pollutants, and water consumption.

A typical baseloaded 500 MW (net) coal plant emits about 3 million metric tons of CO_2 per year. Individual plant emissions vary considerably given differences in plant steam cycle, coal type, capacity factor, and operating regimes. For a given fuel, however, a new supercritical PC unit built today might produce 5–10% less CO_2 per megawatt-hour (MWh) than the existing fleet average for that coal type.

With an aggressive RD&D program on efficiency improvement, new ultra-supercritical (USC PC) plants could reduce CO_2 emissions per MWh by up to 25% relative to the existing fleet average. Significant efficiency gains are also possible for IGCC plants by employing advanced gas turbines and through more energy-efficient oxygen plants and synthesis (fuel) gas cleanup technologies.

EPRI and the Coal Utilization Research Council (CURC), in consultation with DOE, have identified a challenging but achievable set of milestones for improvements in the efficiency, cost, and emissions of PC and coal-based IGCC plants. The EPRI-CURC Roadmap projects an overall improvement in the thermal efficiency of state-of-the art generating technology from 38–41% in 2010 to 44–49% by 2025 (on a higher heating value [HHV] basis; see Table 1). As Table 1 indicates, power-block efficiency gains (i.e., without capture systems) will be offset by the energy required for CO_2 capture, but as noted, they are important in reducing the overall cost of CCS. Coupled with opportunities for major improvements in the energy efficiency of CO_2 capture processes per se, aggressive pursuit of the EPRI-CURC RD&D program offers the prospect of coal power plants *with* CO_2 capture in 2025 that have net efficiencies meeting or exceeding current-day power plants without CO_2 capture.

It is also important to note that the numeric ranges in Table 1 are not simply a reflection of uncertainty, but rather they underscore an important point about differences among U.S. coals. The natural variations in moisture and ash content and combustion characteristics between coals have a significant impact on attainable efficiency. An advanced coal plant firing Wyoming and Montana's Powder River Basin (PRB) coal, for example, would likely have an HHV efficiency two percentage points lower than the efficiency of a comparable plant firing Appalachian bituminous coals. Equally advanced plants firing lignite would likely have efficiencies two percentage points lower than their counterparts firing PRB. Any government incentive program with an efficiency-based qualification criterion should recognize these inherent differences in the attainable efficiencies for plants using different ranks of coal.

Table 1 – Efficiency Milestones in EPRI-CURC Roadmap

	2010	**2015**	**2020**	**2025**
PC & IGCC Systems *(<u>Without</u> CO_2 Capture)*	38–41% HHV	39–43% HHV	42–46% HHV	44–49% HHV
PC & IGCC Systems *(<u>With</u> CO_2 Capture*)*	31–32% HHV	31–35% HHV	33–39% HHV	39–46% HHV

**Efficiency values reflect impact of 90% CO_2 capture, but not compression or transportation.*

New Plant Efficiency Improvements–IGCC

Although IGCC is not yet a mature technology for coal-fired power plants, chemical plants around the world have accumulated a 100-year experience base operating coal-based gasification units and related gas cleanup processes. The most advanced of these units are similar to the front end of a modern IGCC facility. Similarly, several decades of experience firing natural gas and petroleum distillate have established a high level of maturity for the basic combined cycle generating technology. Nonetheless, ongoing RD&D continues to provide significant advances in the base technologies, as well as in the suite of technologies used to integrate them into an IGCC generating facility.

Efficiency gains in currently proposed IGCC plants will come from the use of new "FB-class" gas turbines, which will provide an overall plant efficiency gain of about 0.6 percentage point (relative to IGCC units with FA-class models, such as Tampa Electric's Polk Power Station). This corresponds to a decrease in the rate of CO_2 emissions per MWh of about 1.5%. Alternatively, this means 1.5% less fuel is required per MWh of output, and thus the required size of pre-combustion water-gas shift and CO_2 separation equipment would be slightly smaller.

Figure 3 depicts the anticipated timeframe for further developments identified by EPRI's *CoalFleet for Tomorrow®* program that promise a succession of significant improvements in IGCC unit efficiency. Key technology advances under development include:

- larger capacity gasifiers (often via higher operating pressures that boost throughput without a commensurate increase in vessel size)
- integration of new gasifiers with larger, more efficient G- and H-class gas turbines
- use of ion transport membrane or other more energy-efficient technologies in oxygen plants
- warm synthesis gas cleanup and membrane separation processes for CO_2 capture that reduce energy losses in these areas
- recycle of liquefied CO_2 to replace water in gasifier feed slurry (reducing heat loss to water evaporation)
- hybrid combined cycles using fuel cells to achieve generating efficiencies exceeding those of conventional combined cycle technology

Improvements in gasifier reliability and in control systems also contribute to improved annual average efficiency by minimizing the number and duration of startups and shutdowns.

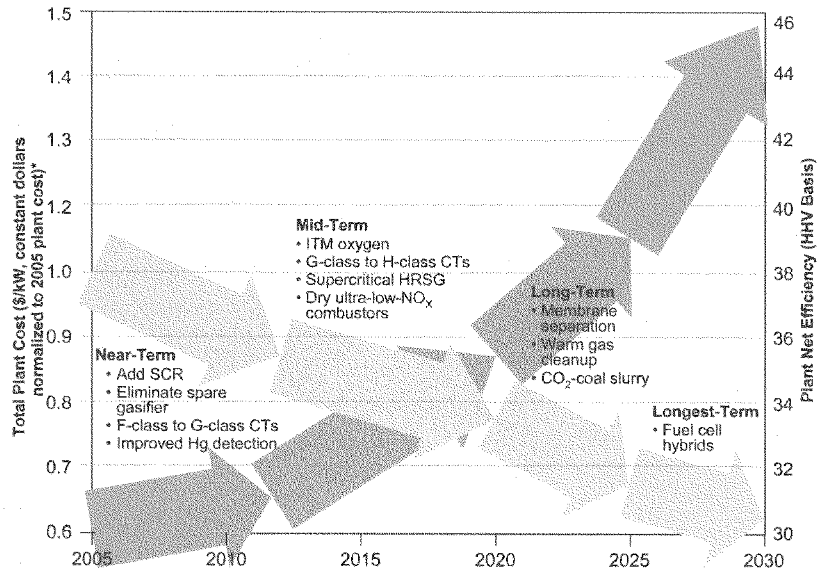


Figure 3 – RD&D path for capital cost reduction (falling arrows) and efficiency improvement (rising arrows) for IGCC power plants with 90% CO_2 capture

* *For a slurry-fed gasifier designed for 90% unit availability and 90% pre-combustion CO_2 capture using Pittsburgh #8 bituminous coal; cost normalization using Chemical Engineering Plant Cost Index or equivalent. A similar trend is observed in analyses of dry-fed gasifiers using Power River Basin subbituminous coal, although the absolute values vary somewhat from those shown.*

Counteracting Gas Turbine Output Loss at High Elevations. IGCC plants designed for application in high-elevation locations must account for the natural reduction in gas turbine power output that occurs where the air is thin. This phenomenon is rooted in the fundamental volumetric flow limitation of a gas turbine, and can reduce power output by up to 15% at an elevation of 5000 feet (relative to a comparable plant at sea level). EPRI is exploring measures to counteract this power loss, including inlet air chilling (a technique used at natural gas power plants to mitigate the power loss that comes from thinning of the air on a hot day) and use of supplemental burners between the gas turbine and steam turbine to boost the plant's steam turbine section generating capacity.

Larger, Higher Firing Temperature Gas Turbines. For plants coming on-line around 2015, the larger size G-class gas turbines, which operate at higher firing temperatures (relative to F-class machines) can improve efficiency by 1 to 2 percentage points while also decreasing capital cost per kW capacity. The H-class gas turbines coming on-line in the same timeframe, which also feature higher firing temperatures as well as steam-based internal cooling of hot turbine components, will provide a further increase in efficiency and capacity.

Ion Transport Membrane–Based Oxygen Plants. Most gasifiers used in IGCC plants require a large quantity of high-pressure, high purity oxygen, which is typically generated on site with an expensive and energy-intensive cryogenic process. The ITM process allows the oxygen in high-temperature air to pass through a membrane while preventing passage of non-oxygen atoms. According to developers, an ITM-based oxygen plant consumes 35–60% less power and costs 35% less than a cryogenic plant. EPRI is performing a due diligence assessment of this technology in advance of potential participation in technology scale-up efforts.

Supercritical Heat Recovery Steam Generators. In IGCC plants, hot exhaust gas exiting the gas turbine is ducted into a heat exchanger known as a heat recovery steam generator (HRSG) to transfer energy into water-filled tubes producing steam to drive a steam turbine. This combination of a gas turbine and steam turbine power cycles produces electricity more efficiently than either a gas turbine or steam turbine alone. As with conventional steam power plants, the efficiency of the steam cycle in a combined cycle plant increases when turbine inlet steam temperature and pressure are increased. The higher exhaust temperatures of G- and H-class gas turbines offer the potential for adoption of more-efficient supercritical steam cycles. Materials for use in a supercritical HRSG are generally established, and thus should not pose a barrier to technology implementation once G- and H-class gas turbines become the standard for IGCC designs.

Synthesis Gas Cleaning at Higher Temperatures. The acid gas recovery (AGR) processes currently used to remove sulfur compounds from synthesis gas require that the gas and solvent be cooled to about 100°F, thereby causing a loss in efficiency. Further costs and efficiency loss are inherent in the process equipment and auxiliary steam required to recover the sulfur compounds from the solvent and convert them to useable products. Several DOE-sponsored RD&D efforts aim to reduce the energy losses and costs imposed by this recovery process. These technologies (described below) could be ready—with adequate RD&D support—by 2020:

- The Selective Catalytic Oxidation of Hydrogen Sulfide process eliminates the Claus and Tail Gas Treating units, along with the traditional solvent-based AGR contactor, regenerator, and heat exchangers, by directly converting hydrogen sulfide (H_2S) to elemental sulfur. The process allows for a higher operating temperature of approximately 300°F, which eliminates part of the low-temperature gas cooling train. The anticipated benefit is a net capital cost reduction of about $60/kW along with an efficiency gain of about 0.8 percentage point.
- The RTI/Eastman High-Temperature Desulfurization System uses a regenerable dry zinc oxide sorbent in a dual loop transport reactor system to convert H_2S and COS to H_2O, CO_2, and SO_2. Tests at Eastman Chemical Company have shown sulfur species removal rates above 99.9%, with 10 ppm output versus 8000+ ppm input sulfur, using operating temperatures of 800–1000°F. This process is also being tested for its ability to provide a high-pressure CO_2 by-product. The anticipated benefit for IGCC, compared with using a standard oil-industry process for sulfur removal, is a net capital cost reduction of $60–90 per kW, a thermal efficiency gain of 2–4% for the gasification process, and a slight reduction in operating cost. Tests are also under way

for a multi-contaminant removal processes that can be integrated with the transport desulfurization system at temperatures above 480°F.

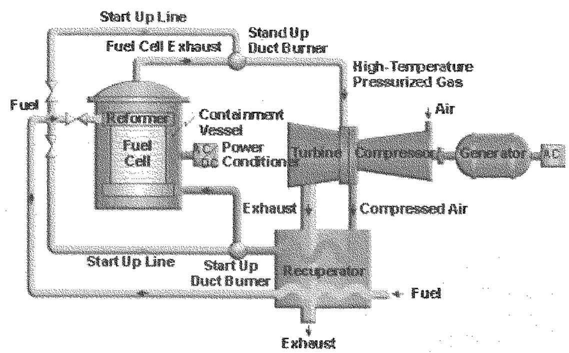
Liquid CO_2-Coal Slurrying for Gasification of Low-Rank Coals. Future IGCC plants with CCS may recycle some of the recovered liquid CO_2 to replace water as the slurrying medium for the coal feed. This is expected to increase gasification efficiency for all coals, but particularly for subbituminous coal and lignite, which have naturally high moisture contents. The liquid CO_2 has a lower heat of vaporization than water and is able to carry more coal per unit mass of fluid. The liquid CO_2-coal slurry will flash almost immediately upon entering the gasifier, providing good dispersion of the coal particles and potentially yielding the higher performance of a dry-fed gasifier with the simplicity of a slurry-fed system.

Traditionally, slurry-fed gasification technologies have a cost advantage over conventional dry-fed fuel handling systems, but they suffer a large performance penalty when used with coals containing a large fraction of water and ash. EPRI identified CO_2 coal slurrying as an innovative fuel preparation concept 20 years ago, when IGCC technology was in its infancy. At that time, however, the cost of producing liquid CO_2 was too high to justify the improved thermodynamic performance. Requirements for CCS change that, as it will substantially reduce the incremental cost of producing a liquid CO_2 stream.

To date, CO_2-coal slurrying has only been demonstrated at pilot scale and has yet to be assessed in feeding coal to a gasifier, so the estimated performance benefits remain to be confirmed. It will first be necessary, however, to update previous studies to quantify the potential benefit of liquid CO_2 slurries with IGCC plants designed for CO_2 capture. If the predicted benefit is economically advantageous, a significant amount of scale-up and demonstration work would be required to qualify this technology for commercial use.

Fuel Cells and IGCC. No matter how far gasification and turbine technologies advance, IGCC power plant efficiency will never progress beyond the inherent thermodynamic limits of the gas turbine and steam turbine power cycles (along with lower limits imposed by available materials technology). Several IGCC–fuel cell hybrid power plant concepts (IGFC) aim to provide a path to coal-based power generation with net efficiencies that exceed those of conventional combined cycle generation.

Along with its high thermal efficiency, the fuel cell hybrid cycle reduces the energy consumption for CO_2 capture. The anode section of the fuel cell produces a stream that is highly concentrated in CO_2. After removal of water, this stream can be compressed for sequestration. The concentrated CO_2 stream is produced without having to include a water-gas shift reactor in the process (see Figure 4). This further improves the thermal efficiency and decreases capital cost. IGFC power systems are a long-term solution, however, and are unlikely to see full-scale demonstration until about 2030.



Source: U.S. Department of Energy; http://www.netl.doe.gov/technologies/coalpower/fuelcells/hybrids.html

Figure 4 – Schematic of fuel cell-turbine hybrid

Role of FutureGen. The FutureGen Industrial Alliance and DOE are building a first-of-its-kind, near-zero emissions coal-fed IGCC power plant integrated with CCS. The commencement of full-scale operations is targeted for 2013. The project aims to sequester CO_2 in a representative geologic formation at a rate of at least one million metric tons per year.

The FutureGen design will address scaling and integration issues for coal-based, zero emissions IGCC plants. In its role as a "living laboratory," FutureGen is designed to validate additional advanced technologies that offer the promise of clean environmental performance at a reduced cost and increased reliability. FutureGen will have the flexibility to conduct full-scale and slipstream tests of such scalable advanced technologies as:

- Membrane processes to replace cryogenic separation for oxygen production
- An advanced transport reactor sidestream with 30% of the capacity of the main gasifier
- Advanced membrane and solvent processes for H_2 and CO_2 separation
- A raw gas shift reactor that reduces the upstream clean-up requirements
- Ultra-low-NO_X combustors that can be used with high-hydrogen synthesis gas
- A fuel cell hybrid combined cycle pilot
- Challenging first-of-a-kind system integration
- Smart dynamic plant controls including a CO_2 management system

Figure 5 provides a schematic of the "backbone" and "research platform" process trains envisioned for the FutureGen plant.

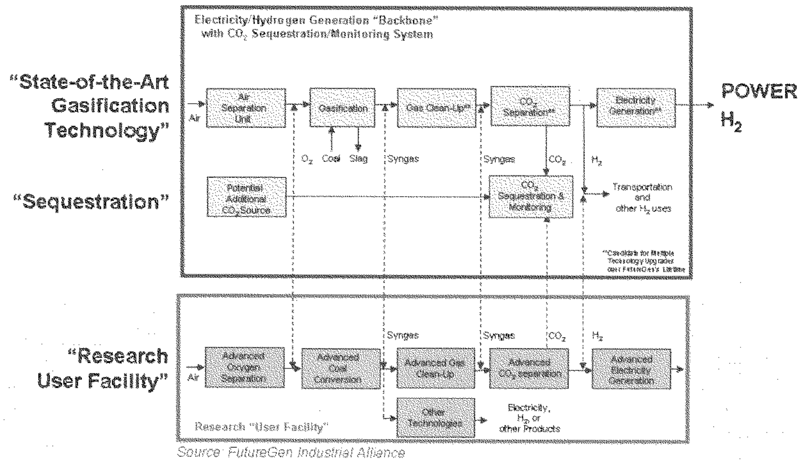


Figure 5 – FutureGen technology platforms

Figure 6 summarizes EPRI's recommended major RD&D activities for improving the efficiency and cost of IGCC technologies with CO_2 capture.

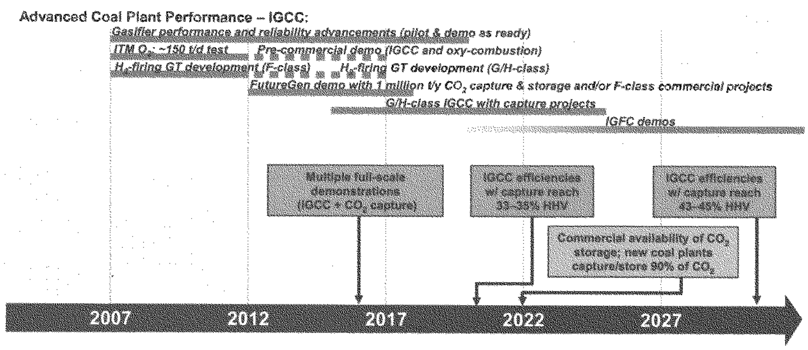


Figure 6 – Timing of advanced IGCC and CO_2 capture integration RD&D activities and milestones

New Plant Efficiency Improvements – Advanced Pulverized Coal

Pulverized-coal power plants have long been a primary source of reliable and affordable power in the United States and around the world. The advanced level of maturity of the technology, along with basic thermodynamic principles, suggests that significant efficiency gains can most readily be realized by increasing the operating temperatures and pressures of the steam cycle. Such increases, in turn, can be achieved only if there is adequate development of suitable materials and new boiler and steam turbine designs that allow use of higher steam temperatures and pressures.

Current state-of-the-art plants use supercritical main steam conditions (i.e., temperature and pressure above the "critical point" where the liquid and vapor phases of water are indistinguishable). SCPC plants typically have main steam conditions up to 1100°F. The term "ultra-supercritical" is used to describe plants with main steam temperatures in excess of 1100°F and potentially as high as 1400°F.

Achieving higher steam temperatures and higher efficiency will require the development of new corrosion-resistant, high-temperature nickel alloys for use in the boiler and steam turbine. In the United States, these challenges are being address by the Ultra-Supercritical Materials Consortium, a DOE R&D program involving Energy Industries of Ohio, EPRI, the Ohio Coal Development Office, and numerous equipment suppliers. EPRI provides technical management for the consortium. Results are applicable to all ranks of coal. As noted, higher power block efficiencies translate to lower costs for post-combustion CO_2 capture equipment.

It is expected that a USC PC plant operating at about 1300°F will be built during the next seven to ten years, following the demonstration and commercial availability of advanced materials from these programs. This plant would achieve an efficiency (before installation of CO_2 capture equipment) of about 45% (HHV) on bituminous coal, compared with 39% for a current state-of-the-art plant, and would reduce CO_2 production per net MWh by about 15%.

Ultimately, nickel-base alloys are expected to enable stream temperatures in the neighborhood of 1400°F and pre-capture generating efficiencies up to 47% HHV with bituminous coal. This approximately 10 percentage point improvement over the efficiency of a new subcritical pulverized-coal plant would equate to a decrease of about 25% in CO_2 and other emissions per MWh. The resulting saving in the cost of subsequently installed CO_2 capture equipment is substantial.

Figure 7 illustrates a timeline developed by EPRI's *CoalFleet for Tomorrow®* program to establish efficiency improvement and cost reduction goals for USC PC plants with CO_2 capture.

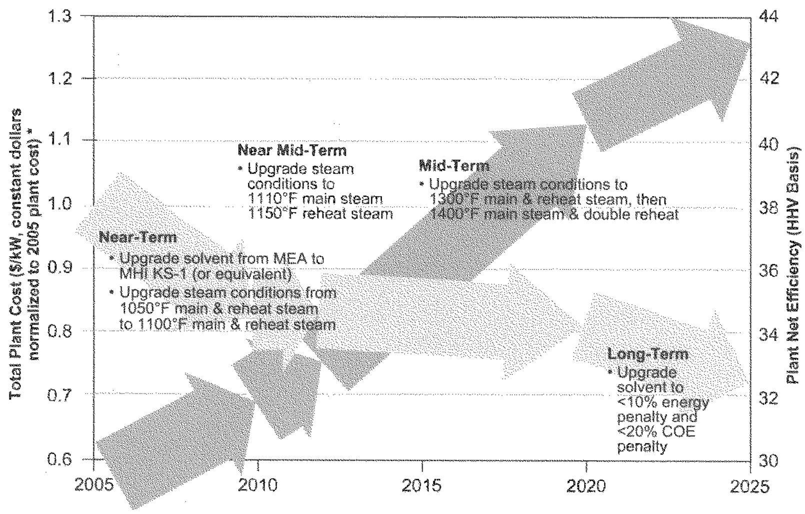


Figure 7 – RD&D path for capital cost reduction (falling arrows) and efficiency improvement (rising arrows) for PC power plants with 90% CO_2 capture

** For a unit designed for 90% unit availability and 90% post-combustion CO_2 capture firing a Pittsburgh #8 bituminous coal; cost normalization using Chemical Engineering Plant Cost Index or equivalent. A similar trend is observed in analyses of PC units with CCS using other U.S. coals, although the efficiency values are up to two percentage points lower for units firing subbituminous coal such as Powder River Basin and up to four percentage points lower for units firing lignite.*

UltraGen USC PC Commercial Projects. EPRI and industry representatives have proposed a program to support commercial projects that demonstrate advanced PC and CCS technologies. The vision entails construction of two (or more) commercially operated USC PC power plants that combine state-of-the-art pollution controls, ultra-supercritical steam power cycles, and innovative CO_2 capture technologies.

The UltraGen I plant will use the best of today's proven ferritic steels in high-temperature boiler and steam turbine components, while UltraGen II will be the first plant in the United States to feature nickel-based alloys that are able to withstand the higher temperatures of advanced ultra-supercritical steam conditions.

UltraGen I will feature an approximately quarter-scale CO_2 capture system demonstration using the best established technology. This system will be about 15 times the size of the largest CO_2 capture system operating on a coal-fired boiler today. UltraGen II will double the size of the UltraGen I CO_2 capture system, and may demonstrate a new class of chemical solvent if one of the emerging low-regeneration-energy processes has reached a sufficient stage of development. Both plants will demonstrate ultra-low emissions. Both UltraGen demonstration plants will dry and compress the captured CO_2 for long-term geologic storage and/or use in enhanced oil or gas recovery operations. Figure 8 depicts the proposed key features of UltraGen I and II.

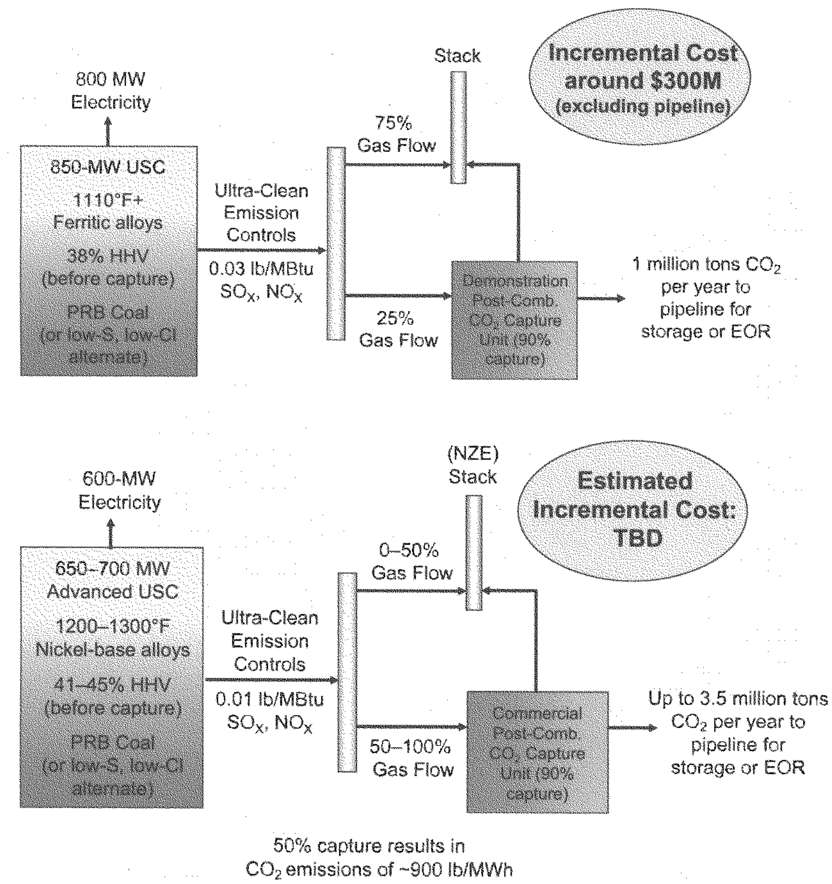


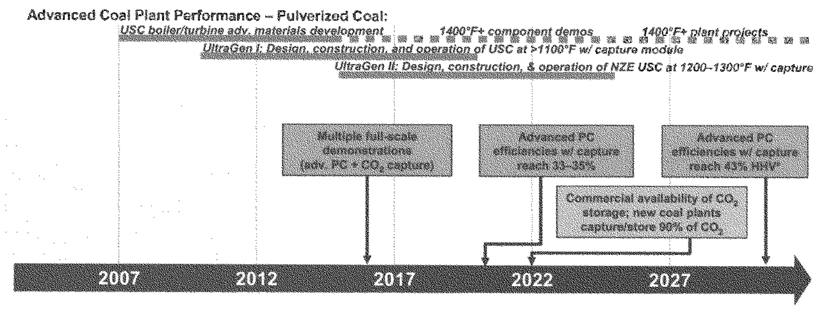
Figure 8 – Key parameters for UltraGen I (upper schematic) and UltraGen II (lower schematic), assuming a subbituminous feed coal such as Powder River Basin

To provide a platform for testing and developing emerging PC and CCS technologies, the UltraGen program will allow for technology trials at existing sites as well as at the sites of new projects. Unlike FutureGen, EPRI expects the UltraGen projects will be commercially dispatched by electricity grid operators. The differential cost to the host company for demonstrating these improved features are envisioned to be offset by any available tax credits (or other incentives) and by funds raised through an industry-led consortium formed by EPRI.

The UltraGen projects represent the type of "giant step" collaborative efforts that need to be taken to advance integrated PC/CCS technology to the next phase of evolution and assure competitiveness in a carbon-constrained world. Because of the time and expense for each "design and build" iteration for coal power plants (3 to 5 years not counting the permitting process and ~$2 billion), there is no room for hesitation in terms of commitment to advanced technology validation and demonstration projects.

The UltraGen projects will resolve technical and economic barriers to the deployment of USC PC and CCS technology by providing a shared-risk vehicle for testing and validating high-temperature materials, components, and designs in plants also providing superior environmental performance.

Figure 9 summarizes EPRI's recommended major RD&D activities for improving the efficiency and cost of USC PC technologies with CO_2 capture.



*for bituminous coal; equally advanced PC plants firing subbituminous coal and lignite will have efficiencies two to four percentage points lower due to higher moisture and ash contents

Figure 9 – Timing of advanced PC and CO_2 capture integration RD&D activities and milestones

Efficiency Improvement and CCS Retrofits for the Existing PC Fleet. It would be economically advantageous to operate the many reliable subcritical PC units in the U.S. fleet well into the future. Premature replacement of these units or mandatory retrofit of these units for CO_2 capture en masse would be economically prohibitive. Their flexibility for load following and provision of support services to ensure grid stability makes them highly valuable. With equipment upgrades, many of these units can realize modest efficiency gains, which, when accumulated across the existing generating fleet could make a sizeable reduction in CO_2 emissions. For some existing plants, retrofit of CCS will make sense, but specific plant design features, space limitations, and economic and regulatory considerations must be carefully analyzed to determine whether retrofit-for-capture is feasible.

These upgrades depend on the equipment configuration and operating parameters of a particular plant and may include:

- turbine blading and steam path upgrades
- turbine control valve upgrades for more efficient regulation of steam
- cooling tower and condenser upgrades to reduce circulating water temperature, steam turbine exhaust backpressure, and auxiliary power consumption
- cooling tower heat transfer media upgrades
- condenser optimization to maximize heat transfer and minimize condenser temperature
- condenser air leakage prevention/detection
- variable speed drive technology for pump and fan motors to reduce power consumption
- air heater upgrades to increase heat recovery and reduce leakage
- advanced control systems incorporating neural nets to optimize temperature, pressure, and flow rates of fuel, air, flue gas, steam, and water
- optimization of water blowdown and blowdown energy recovery
- optimization of attemperator design, control, and operating scenarios
- sootblower optimization via "intelligent" sootblower system use
- coal drying (for plants using lignite and subbituminous coals)

Coal Drying for Increased Generating Efficiency. Boilers designed for high-moisture lignite have traditionally employed higher feed rates (lb/hr) to account for the large latent heat load to evaporate fuel moisture. An innovative concept developed by Great River Energy (GRE) and Lehigh University uses low-grade heat recovered from within the plant to dry incoming fuel to the boiler, thereby boosting plant efficiency and output. [In contrast, traditional thermal drying processes are complex and require high-grade heat to remove moisture from the coal.] Specifically, the GRE approach uses steam condenser and boiler exhaust heat exchangers to heat air and water fed to a fluidized-bed coal dryer upstream of the plant pulverizers. Based on successful tests with a pilot-scale dryer and more than a year of continuous operation with a prototype dryer at its Coal Creek station, GRE (with U.S. Department of Energy support and EPRI technical consultation) is now building a full suite of dryers for Unit 2 (i.e., a commercial-scale demonstration). In addition to the efficiency and CO_2 emission reduction benefits from reducing the lignite feed moisture content by about 25%, the plant's air emissions will be reduced as well.[2] Application of this technology is not limited to PC units firing lignite. EPRI believes it may find application in PC units firing subbituminous coal and in IGCC units with dry-fed gasifiers using low-rank coals.

Improving CO_2 Capture Technologies

[2] C. Bullinger, M. Ness, and N. Sarunac, "One Year of Operating Experience with Prototype Fluidized Bed Coal Dryer at Coal Creek Generating Station," 32nd International Technical Conference on Coal Utilization and Fuel Systems, Clearwater FL, June 10–15, 2007.

CCS entails pre-combustion or post-combustion CO_2 capture technologies, CO_2 drying and compression (and sometimes further removal of impurities), and the transportation of separated CO_2 to locations where it can be stored away from the atmosphere for centuries or longer.

Albeit at considerable cost, CO_2 capture technologies can be integrated into all coal-based power plant technologies. For both new plants and retrofits, there is a tremendous need (and opportunity) to reduce the energy required to remove CO_2 from fuel gas or flue gas. Figure 10 shows a selection of the key technology developments and test programs needed to achieve commercial CO_2 capture technologies for advanced coal combustion- and gasification-based power plants at a progressively shrinking constant-dollar levelized cost-of-electricity premium. Specifically, the target is a premium of about $6/MWh in 2025 (relative to plants at that time without capture) compared with an estimated 2010 cost premium of perhaps $40/MWh (not counting the cost of transportation and storage). Such a goal poses substantial engineering challenges and will require major investments in RD&D to roughly halve the currently large energy requirements (operating costs) associated with CO_2 solvent regeneration. Achieving this goal will allow power producers to meet the public demand for stable electricity prices while reducing CO_2 emissions to address climate change concerns.

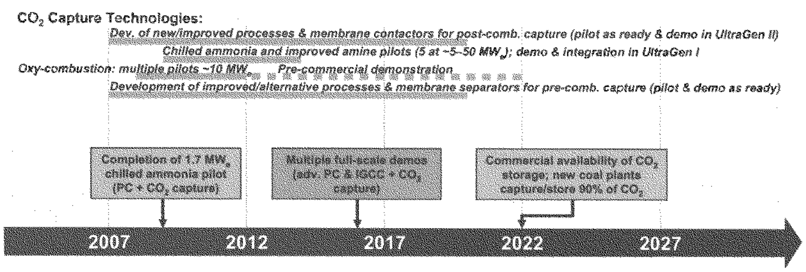


Figure 10 – Timing of CO_2 capture technology development RD&D activities and milestones

Pre-Combustion CO_2 Capture (IGCC)

IGCC technology allows for CO_2 capture to take place via an added fuel gas processing step at elevated pressure, rather than at the atmospheric pressure of post-combustion flue gas, permitting capital savings through smaller equipment sizes as well as lower operating costs.

Currently available technologies for such pre-combustion CO_2 removal use a chemical and/or physical solvent that selectively absorbs CO_2 and other "acid gases," such as hydrogen sulfide. Application of this technology requires that the CO in synthesis gas (the principal component) first be "shifted" to CO_2 and hydrogen via a catalytic reaction with water. The CO_2 in the shifted synthesis gas is then removed via contact with the solvent in an absorber column, leaving a hydrogen-rich synthesis gas for combustion in the gas turbine. The CO_2 is released from the solvent in a regeneration process that typically reduces pressure and/or increases temperature.

Chemical plants currently employ such a process commercially using methyl diethanolamine (MDEA) as a chemical solvent or the Selexol and Rectisol processes, which rely on physical solvents. Physical solvents are generally preferred when extremely high (>99.8%) sulfur species removal is required. Although the required scale-up for IGCC power plant applications is less than that needed for scale-up of post-combustion CO_2 capture processes for PC plants, considerable engineering challenges remain and work on optimal integration with IGCC cycle processes has just begun.

The impact of current pre-combustion CO_2 removal processes on IGCC plant thermal efficiency and capital cost is significant. In particular, the water-gas shift reaction reduces the heating value of synthesis gas fed to the gas turbine. Because the gasifier outlet ratios of CO to methane to H_2 are different for each gasifier technology, the relative impact of the water-gas shift reactor process also varies. In general, however, it can be on the order of a 10% fuel energy reduction. Heat regeneration of solvents further reduces the steam available for power generation. Other solvents, which are depressurized to release captured CO_2, must be re-pressurized for reuse. Cooling water consumption is increased for solvents needing cooling after regeneration and for pre-cooling and interstage cooling during compression of separated CO_2 to a supercritical state for transportation and storage. Heat integration with other IGCC cycle processes to minimize these energy impacts is complex and is currently the subject of considerable RD&D by EPRI and others.

Membrane CO_2 Separation. Technology for separating CO_2 from shifted synthesis gas (or flue gas from PC plants) offers the promise of lower auxiliary power consumption but is currently only at the laboratory stage of development. Several organizations are pursuing different approaches to membrane-based applications. In general, however, CO_2 recovery on the low-pressure side of a selective membrane can take place at a higher pressure than is now possible with solvent processes, reducing the subsequent power demand for compressing CO_2 to a supercritical state. Membrane-based processes can also eliminate steam and power consumption for regenerating and pumping solvent, respectively, but they require power to create the pressure difference between the source gas and CO_2-rich sides. If membrane technology can be developed at scale to meet performance goals, it could enable up to a 50% reduction in capital cost and auxiliary power requirements relative to current CO_2 capture and compression technology.

Post-Combustion CO_2 Capture (PC and CFB Plants)

The post-combustion CO_2 capture processes envisioned for power plant boilers draw upon commercial experience with amine solvent separation at much smaller scale in the food and beverage and chemical industries and upon three U.S. applications of CO_2 capture from a slipstream of exhaust gas from circulating fluidized-bed (CFB) units.

These processes contact flue gas with an amine solvent in an absorber column (much like a wet SO_2 scrubber) where the CO_2 chemically reacts with the solvent. The CO_2-rich liquid mixture then passes to a stripper column where it is heated to change the chemical equilibrium point, releasing the CO_2. The "regenerated" solvent is then recirculated back to the absorber column, while the released CO_2 may be further processed before compression to a supercritical state for efficient transportation to a storage location.

After drying, the CO_2 released from the regenerator is relatively pure. However, successful CO_2 removal requires very low levels of SO_2 and NO_2 entering the CO_2 absorber, as these species also react with the solvent. Thus, high-efficiency SO_2 and NO_X control systems are essential to minimizing solvent consumption costs for post-combustion CO_2 capture. Extensive RD&D is in progress to improve the solvent and system designs for power boiler applications and to develop better solvents with greater absorption capacity, less energy demand for regeneration, and greater ability to accommodate flue gas contaminants.

At present, monoethanolamine (MEA) is the "default" solvent for post-combustion CO_2 capture studies and small-scale field applications. Processes based on improved amines, such as Fluor's Econamine FG Plus and Mitsubishi Heavy Industries' KS-1, are under development. The potential for improving amine-based processes appears significant. For example, a recent study based on KS-1 suggests that its impact on net power output for a supercritical PC unit would be 19% and its impact on the levelized cost-of-electricity would be 44%, whereas earlier studies based on suboptimal MEA applications yielded output penalties approaching 30% and cost-of-electricity penalties of up to 65%.

Accordingly, amine-based engineered solvents are the subject of numerous ongoing efforts to improve performance in power boiler post-combustion capture applications. Along with modifications to the chemical properties of the sorbents, these efforts are addressing the physical structure of the absorber and regenerator equipment, examining membrane contactors and other modifications to improve gas-liquid contact and/or heat transfer, and optimizing thermal integration with steam turbine and balance-of-plant systems. Although the challenge is daunting, the payoff is potentially massive, as these solutions may be applicable not only to new plants, but to retrofits where sufficient plot space is available at the back end of the plant.

Finally, as discussed earlier, deploying USC PC technology to increase efficiency and lower uncontrolled CO_2 per MWh can further reduce the cost impact of post-combustion CO_2 capture.

Ammonia-Based Processes. Post-combustion CO_2 capture using ammonia-based solvents offers the promise of significantly lower solvent regeneration requirements relative to MEA. In the "chilled ammonia" process currently under development and testing by Alstom and EPRI, respectively, CO_2 is absorbed in a solution of ammonium carbonate, at low temperature and atmospheric pressure, and combines with the $NaCO_3$ to form ammonium bicarbonate.

Compared with amines, ammonium carbonate has over twice the CO_2 absorption capacity and requires less than half the heat to regenerate. Further, regeneration can be performed under higher pressure than amines, so the released CO_2 is already partially pressurized. Therefore, less energy is subsequently required for compression to a supercritical state for transportation to an injection location. Developers have estimated that the parasitic power loss from a full-scale supercritical PC plant using chilled ammonia CO_2 capture could be as low as 10%, with an associated cost-of-electricity penalty of just 25%. Low quality heat may also be used in the cycle to regenerate ammonia and reduce the quantity of steam required for regeneration. Following successful experiments at 0.25 MW_e scale, Alstom and a consortium of EPRI members are constructing a 1.7 MW_e pilot unit to test the chilled ammonia process with a flue gas slipstream at We Energies' Pleasant Prairie Power Plant. AEP, also testifying today, plans additional scale-up and testing of the chilled ammonia system.

Other "multi-pollutant" control system developers, such as Powerspan, are also exploring ammonia-based processes for CO_2 removal.

Oxy-Fuel Combustion Boilers

Fuel combustion in a blend of oxygen and recycled flue gas rather than in air (known as oxy-fuel combustion, oxy-coal combustion, or oxy-combustion) is gaining interest as a viable CO_2 capture alternative for PC and CFB plants. The process is applicable to virtually all fossil-fueled boiler types and is a candidate for retrofits as well as new power plants.

Firing coal with high-purity oxygen alone would result in too high of a flame temperature, which would increase slagging, fouling, and corrosion problems, so the oxygen is diluted by mixing it with a slipstream of recycled flue gas. As a result, the flue gas downstream of the recycle slipstream take-off consists primarily of CO_2 and water vapor (although it also contains small amounts of nitrogen, oxygen, and criteria pollutants). After the water is condensed, the CO_2-rich gas is compressed and purified to remove contaminants and prepare the CO_2 for transportation and storage.

Oxy-combustion boilers have been studied in laboratory-scale and small pilot units of up to 3 MW_t. Two larger pilot units, at ~10 MW_e, are now under construction by Babcock & Wilcox (B&W) and Vattenfall. An Australian-Japanese project team is pursuing a 30 MW_e repowering project in Australia. These larger tests will allow verification of mathematical models and provide engineering data useful for designing pre-commercial systems. The first such pre-commercial unit could be built at SaskPower's Shand station near Estevan, Saskatchewan. SaskPower, B&W Canada, and Air Liquide have been jointly developing an oxy-combustion SCPC design, and a decision on whether to proceed to construction is expected by late 2007, with a target in-service date of 2011–12.

CO_2 Transport and Geologic Storage

Application of CO_2 capture technologies implies that there will be secure and economical forms of long-term storage that can assure CO_2 will be kept out of the atmosphere. Natural underground CO_2 reservoirs in Colorado, Utah, and other western states testify to the effectiveness of long-term geologic CO_2 storage. CO_2 is also found in natural gas reservoirs, where it has resided for millions of years. Thus, evidence suggests that similarly sealed geologic formations will be ideal for storing CO_2 for millennia or longer.

The most developed approach for large-scale CO_2 storage is injection into depleted or partially depleted oil and gas reservoirs and similar geologically sealed "saline formations" (porous rocks filled with brine that is impractical for desalination). Partially depleted oil reservoirs provide the potential added benefit of enhanced oil recovery (EOR). [EOR is used in mature fields to recover additional oil after standard extraction methods have been used. When CO_2 is injected for EOR, it causes residual oil to swell and become less viscous, allowing some to flow to production wells, thus extending the field's productive life.] By providing a commercial market for CO_2 captured from industrial sources, EOR may help the economics of CCS projects where it is applicable, and in some cases might reduce regulatory and liability uncertainties. Although less developed than EOR, researchers are exploring the effectiveness of CO_2 injection for enhancing production from depleted natural gas fields (particularly in compartmentalized formations where pressure has dropped) and from deep methane-bearing coal seams. DOE and the International Energy Agency are among the sponsors of such efforts. However, at the scale that CCS needs to be deployed to help achieve atmospheric CO_2 stabilization at an acceptable level, EPRI believes that the primary economic driver for CCS will be the value of carbon that results from a future climate policy.

Geologic sequestration as a CCS strategy is currently being demonstrated in several RD&D projects around the world. The three largest projects (which are non-power)—Statoil's Sleipner Saline Aquifer CO_2 Storage project in the North Sea off of Norway; the Weyburn Project in Saskatchewan, Canada; and the In Salah Project in Algeria—together sequester about 3–4 million metric tons of CO_2 per year, which collectively matches the output of one baseloaded 500–600 MW coal-fired power plant. With 17 collective operating years of experience, these projects have thus far demonstrated that CO_2 storage in deep geologic formations can be carried out safely and reliably. Statoil estimates that Norwegian greenhouse gas emissions would have risen incrementally by 3% if the CO_2 from the Sleipner project had been vented rather than sequestered.[3]

Table 2 lists a selection of current and planned CO_2 storage projects as of early 2007.

[3] http://www.co2captureandstorage.info/project_specific.php?project_id=26

Table 2 – Select Existing and Planned CO_2 Storage Projects as of Early 2007

PROJECT	CO_2 SOURCE	COUNTRY	START	Anticipated amount injected by:		
				2006	2010	2015
Sleipner	Gas. Proc.	Norway	1996	9 MT	13 MT	18 MT
Weyburn	Coal	Canada	2000	5 MT	12 MT	17 MT
In Salah	Gas. Proc.	Algeria	2004	2 MT	7 MT	12 MT
Snohvit	Gas. Proc.	Norway	2007	0	2 MT	5 MT
Gorgon	Gas. Proc.	Australia	2010	0	0	12 MT
DF-1 Miller	Gas	U.K.	2009	0	1 MT	8 MT
DF-2 Carson	Pet Coke	U.S.	2011	0	0	16 MT
Draugen	Gas	Norway	2012	0	0	7 MT
FutureGen	Coal	U.S.	2012	0	0	2 MT
Monash	Coal	Australia	NA	0	0	NA
SaskPower	Coal	Canada	NA	0	0	NA
Ketzin/CO_2 STORE	NA	Germany	2007	0	50 KT	50 KT
Otway	Natural	Australia	2007	0	100 KT	100 KT
TOTALS				**16 MT**	**35 MT**	**99 MT**

Source: Sally M. Benson, "Can CO_2 Capture and Storage in Deep Geological Formations Make Coal-Fired Electricity Generation Climate Friendly?" Presentation at Emerging Energy Technologies Summit, UC Santa Barbara, California, February 9, 2007. [Note: Statoil has subsequently suspended plans for the Draugen project and announced a study of CO_2 capture at a gas-fired power plant at Tjeldbergodden. BP and Rio Tinto have announced the coal-based "DF-3" project in Australia.]

Enhanced Oil Recovery. Experience relevant to CCS comes from the oil industry, where CO_2 injection technology and modeling of its subsurface behavior have a proven record of accomplishment. EOR has been conducted successfully for 35 years in the Permian Basin fields of west Texas and Oklahoma. Regulatory oversight and community acceptance of injection operations for EOR seem well established.

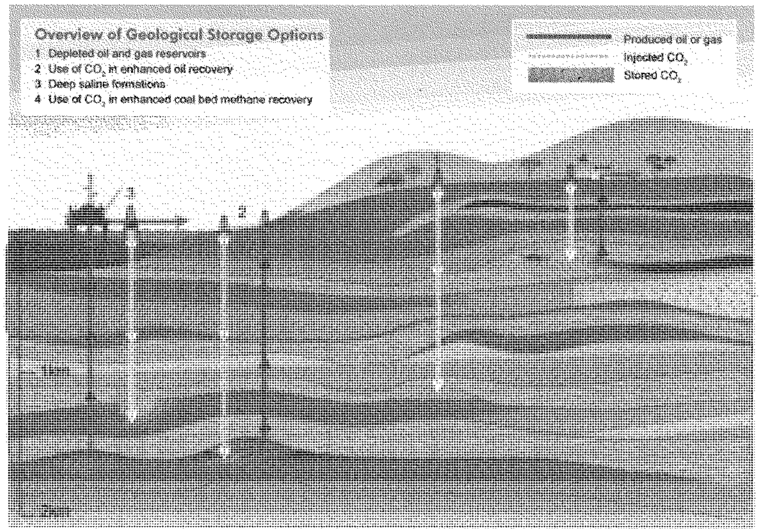
Although the purpose of EOR heretofore has not been to sequester CO_2, the practice can be adapted to include large-volume residual CO_2 storage. This approach is being demonstrated in the Weyburn-Midale CO_2 monitoring projects in Saskatchewan, Canada. The Weyburn project uses captured and dried CO_2 from the Dakota Gasification Company's Great Plains synfuels plant near Beulah, North Dakota. The CO_2 is transported via a 200-mile pipeline constructed of standard carbon steel. Over the life of the project, the net CO_2 storage is estimated at 20 million metric tons, while an additional 130 million barrels of oil will be produced.

Although EOR might help the economics of early CCS projects in oil-patch areas, EOR sites are ultimately too few and too geographically isolated to accommodate much of the CO_2 from widespread industrial CO_2 capture operations. In contrast, saline formations are available in many—but not all—U.S. locations.

CCS in the United States

A DOE-sponsored R&D program, the "Regional Carbon Sequestration Partnerships," is engaged in mapping U.S. geologic formations suitable for CO_2 storage. Evaluations by these Regional Partnerships and others suggest that enough geologic storage capacity exists in the United States to hold several centuries' production of CO_2 from coal-based power plants and other large point sources.

The Regional Partnerships are also conducting pilot-scale CO_2 injection validation tests across the country in differing geologic formations, including saline formations, deep unmineable coal seams, and older oil and gas reservoirs. Figure 11 illustrates some of these options. These tests, as well as most commercial applications for long-term storage, will use CO_2 compressed for volumetric efficiency to a liquid-like "supercritical" state; thus, virtually all CO_2 storage will take place in formations at least a half-mile deep, where the risk of leakage to shallower groundwater aquifers or to the surface is usually very low.



Source: Peter Cook, CO2CRC, in Intergovernmental Panel on Climate Change, Special Report "Carbon Dioxide Capture and Storage," http://www.ipcc.ch/pub/reports.htm

Figure 11 – Illustration of potential geological CO_2 storage site types

After successful completion of pilot-scale CO_2 storage validation tests, the Partnerships will undertake large-volume storage tests, injecting quantities of ~1 million metric tons of CO_2 or more over a several year period, along with post-injection monitoring to track the absorption of the CO_2 in the target formation(s) and to check for potential leakage.

The EPRI-CURC Roadmap identifies the need for several large-scale integrated demonstrations of CO_2 capture and storage. This assessment was echoed by MIT in its recent *Future of Coal* report, which calls for three to five U.S. demonstrations of about 1 million metric tons of CO_2 per year and about 10 worldwide.[4] These demonstrations could be the critical path item in commercialization of CCS technology. In addition, EPRI has identified 10 key topics where further technical and/or policy development is needed before CCS can become fully commercial:

- Caprock integrity
- Injectivity and storage capacity
- CO_2 trapping mechanisms
- CO_2 leakage and permanence
- CO_2 and mineral interactions
- Reliable, low-cost monitoring systems

[4] http://web.mit.edu/coal/The_Future_of_Coal.pdf

- Quick response and mitigation and remediation procedures
- Protection of potable water
- Mineral rights
- Long-term liability

Figure 12 summarizes the relationship between EPRI's recommended large-scale integrated CO_2 capture and storage demonstrations and the Regional Partnerships' "Phase III" large-volume CO_2 storage tests.

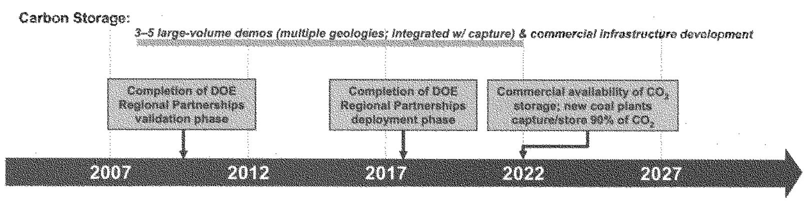


Figure 12 – Timing of CO_2 storage technology RD&D activities and milestones

CO_2 Transportation

Mapping of the distribution of potentially suitable CO_2 storage formations across the country, as part of the research by the Regional Partnerships, shows that some areas have ample storage capacity while others appear to have little or none. Thus, implementing CO_2 capture at some power plants may require pipeline transportation for several hundred miles to suitable injection locations, possibly in other states. Although this adds cost, it does not represent a technical hurdle because long-distance, interstate CO_2 pipelines have been used commercially in oilfield EOR applications. Nonetheless, EPRI expects that early commercial CCS projects will take place at coal-based power plants near sequestration sites or an existing CO_2 pipeline. As the number of projects increases, regional CO_2 pipeline networks connecting multiple industrial sources and storage sites will be needed.

Policy-Related Long-Term CO_2 Storage Issues

Beyond developing the technological aspects of CCS, public policy need to address issues such as CO_2 storage site permitting, long-term monitoring requirements, and post-closure liability. CCS represents an emerging industry, and the jurisdictional roles among federal and state agencies for regulations and their relationship to private carbon credit markets operating under federal oversight has yet to be determined.

Currently, efforts are under way in some states to establish regulatory frameworks for long-term geologic CO_2 storage. Additionally, stakeholder organizations such as the Interstate Oil and Gas Compact Commission (IOGCC) are developing their own suggested regulatory recommendations for states drafting legislation and regulatory procedures for CO_2 injection and storage operations.[5] Other stakeholders, such as environmental groups, are also offering policy recommendations. EPRI expects this field to become very active soon.

Because some promising sequestration formations underlie multiple states, a state-by-state approach may not be adequate. At the federal level, the U.S. EPA published a first-of-its-kind guidance (UICPG # 83) on March 1, 2007, for permitting underground injection of CO_2.[6] This guidance offers flexibility for pilot projects evaluating the practice of CCS, while leaving unresolved the requirements that could apply to future large-scale CCS projects.

Long-Term CO_2 Storage Liability Issues

Long-term liability for injected CO_2 will need to be assigned before CCS can become fully commercial. Because CCS activities will be undertaken to serve the public good, as determined by government policy, and will be implemented in response to anticipated or actual government-imposed limits on CO_2 emissions, a number of policy analysts have suggested that the entities performing these activities should be granted a measure of long-term risk reduction assuming adherence to proper procedures during the storage site injection operations and closure phases.

RD&D Investment for Advanced Coal and CCS Technologies

Developing the suite of technologies needed to achieve competitive advanced coal and CCS technologies will require a sustained major investment in RD&D. As shown in Table 3, EPRI estimates that an expenditure of approximately $8 billion will be required in the 10-year period from 2008–17. The MIT *Future of Coal* report estimates the funding need at up to $800–850 million per year, which approaches the EPRI value. Further, EPRI expects that an RD&D investment of roughly $17 billion will be required over the next 25 years.

Investment in earlier years may be weighted toward IGCC, as this technology is less developed and will require more RD&D investment to reach the desired level of commercial viability. As interim progress and future needs cannot be adequately forecast at this time, the years after 2023 do not distinguish between IGCC and PC.

[5] http://www.iogcc.state.ok.us/PDFS/CarbonCaptureandStorageReportandSummary.pdf
[6] http://www.epa.gov/safewater/uic/pdfs/guide_uic_carbonsequestration_final-03-07.pdf

Table 3 – RD&D Funding Needs for Advanced Coal Power Generation Technologies with CO_2 Capture

<table>
<tr><th></th><th>2008–12</th><th>2013–17</th><th>2018–22</th><th>2023–27</th><th>2028–32</th></tr>
<tr><td>Total Estimated RD&D Funding Needs
(Public + Private Sectors)</td><td>$830M/yr</td><td>$800M/yr</td><td>$800M/yr</td><td>$620M/yr</td><td>$400M/yr</td></tr>
<tr><td>Advanced Combustion, CO₂ Capture</td><td>25%</td><td>25%</td><td>40%</td><td rowspan="2">80%</td><td rowspan="2">80%</td></tr>
<tr><td>Integrated Gasification Combined Cycle (IGCC), CO₂ Capture</td><td>50%</td><td>50%</td><td>40%</td></tr>
<tr><td>CO₂ Storage</td><td>25%</td><td>25%</td><td>20%</td><td>20%</td><td>20%</td></tr>
</table>

By any measure, these estimated RD&D investments are substantial. EPRI and the members of the *CoalFleet for Tomorrow®* program, by promoting collaborative ventures among industry stakeholders and governments, believe that the costs of developing critical-path technologies for advanced coal and CCS can be shouldered by multiple participants. EPRI believes that government policy and incentives will also play a key role in fostering CCS technologies through early RD&D stages to achieve widespread, economically feasible deployment capable of achieving major reductions in U.S. CO_2 emissions.

The CHAIRMAN. Thank your, Mr. Dalton, very much.

There are two roll calls on the House floor right now, with about six minutes for the members to go over there to make those votes. So we will take a very brief recess, and I think that we can reconvene around 11:15, if all of you can take note of that, and we will take a brief recess.

[Recess.]

The CHAIRMAN. The Committee will reconvene, and the Chair will recognize himself for a round of questions.

Let me begin with you, Governor. In your testimony you state that many major investments in the electricity generation sector will not come to fruition until we provide regulatory certainty by enacting federal limits on carbon dioxide emissions. Is it fair to say that further delays in federal action will impose significant costs, and that it is in everyone's best interest that we take action as soon as possible?

Governor FREUDENTHAL. Mr. Chairman, being a lawyer, I hesitate to agree in the affirmative, because the devil is in the details. I do believe, and we have the same people come talk to us who come talk to this Committee, they want to make the investment, but they don't know in the absence of a federal regulatory scheme whether they are going to be able to capture the return. That is, will it be recognized by the public utility commissions around the country as being legitimately in their rate base?

But having said that, the action that we take becomes important, because it has to have some form of glide path that recognizes the relative availability of the technologies at a given state in time. So, for instance, I think if one of the suggestions that I have heard is that we would just say nobody can build any powerplants today because—if they don't have carbon capture and sequestration.

The problem with that is is that in spite of all of the rhetoric nobody has actually done carbon capture, and so what you need to do is something that I think most of the companies are looking at is, give us a clue what we need to do. We will try to make this thing carbon capture-ready, but we may need to proceed to meet our demand with some level of construction. So I think the failure to act freezes in place a lot of investment money.

If we act wrong, we will permanently freeze it out, so we need to act in a way that says we are going to be realistic about the standard, here is what it is, here is your guidance. If you do this, you can get your recovery.

The CHAIRMAN. Now, you cite a projection that GDP will decline by $400 to $800 billion if CCS is not deployed. Can you expand on that, and the likely costs?

Governor FREUDENTHAL. It is one of those numbers that my staff picked up. It is either out of the MIT study—I think it is out of the MIT study, because frankly, as I admitted before, I am a lawyer, so I don't pretend to have the answer. But what we are saying is is that if we don't act, and somehow we act inappropriately, I think those are the costs.

And so this is something that has to be done with a scalpel and not with a machete. We need to very carefully think about how we are going to sculpt the regulatory environment, so that the states can essentially, in the Clean Air Act model, have some parallel system that helps on the enforcement under a state-approved implementation plan, and the private sector then knows what standards they have to meet, which of those costs can be recaptured through the various public utility commissions, and the means by which they are going to be captured.

If we lay that out, I think people will react, because they are the same ones who talk to you. They come and say, "Look, we are ready to do this, but we can't do it out of speculation, particularly in a regulated environment."

The CHAIRMAN. Can I ask you—can I ask Mr. Morris this. What does "carbon capture-ready" mean to AEP, in terms of the technology you are going to install?

Mr. MORRIS. Congressman, for us, we see carbon capture in two different worlds. The most important and the most critical for all of us, this country and my company, is the retrofit technology on the existing fleet, because we, as a nation, based on the comments that you and others made in your introductory timeline point to the notion that over half of today's generation fleet is coal-based. Actually, more than half of the megawatt hours produced, and, therefore, used to fuel the U.S. economy is coal-based.

So we have to find a way to capture on the existing stations, and that is why we are going forward with the validation projects that I mentioned in West Virginia and in Oklahoma, so that we can across our entire fleet put that technology to work, presuming that the validation undertakings work.

Now, I, like the Governor, am a lawyer-environmentalist, so I am not bothered by the engineering challenges that my team constantly tells me about. I am blessed at American Electric Power having among the best engineers for over a century. We have made many, many breakthrough technological changes in this industry, and we think we are doing that again now.

Secondly, to the comments that David made, to the comments that the Governor just made, we see this as a challenge for a new station as well. I would not argue that you cannot go forward at the state level and get authority to build a carbon-ready, and, as soon as technology is validated, deployed, powerplant built without federal intervention, without a federal program. I think that there will be bold states that will take that step.

As I think the Committee knows, clearly in our testimony we have such applications in front of the Commission in the State of Ohio. They have given us the preliminary go-ahead that is now being challenged at the Supreme Court level in the State of Ohio, which is the jurisdiction of appeal by right. And in West Virginia, we are going forward with an integrated plant. We have filed that to the West Virginia Commission and Virginia. Our Appalachian Power Company serves both of those particular states.

So we have every reason to believe that the potential to get those plants approved without a federal process will work, but it is a societal cost, and it is a states' rights issue. And when you think of Virginia and West Virginia, very important coal-based states in this country, it may well be in their best interest. Clearly, Governor Manchin is a supporter of it, Governor Kaine appears to be a supporter of the issue, but it is the charge of their state regulatory commission to make those decisions.

Out west, where you are working with lower-ranked coals—no offense, Governor—we are hoping to deploy what is called ultra-supercritical technology, which has not been done in this country. It has been done in Germany, it has been done in Japan. Higher temperatures, higher pressures, less fuel in for megawatt hours out, more expensive than supercritical, no question.

That issue and, in fact, this very day in Louisiana—excuse me, in Little Rock, Arkansas, we have a team testifying in front of the Arkansas Commission seeking authority to do that. We have closed the record on a similar plant to be built in Oklahoma, as I mentioned. So I am a believer that with logic and timelines that are realistic states will go forward and allow us to do these things, because they will, in fact, validate the carbon capture both for the existing fleet as well as technologies for the new fleet.

And as the technology goes forward for the capture, we will simply deploy that as we go. I think that is a much better approach than a command-control approach. That probably was necessary in Clean Air Act days, because so many in our industry thought not now, not ever. This is a willing industry. We just need the support of the states to get that done.

The CHAIRMAN. You have 30 seconds, Governor.

Governor FREUDENTHAL. Mr. Chairman, if I might, under our law we will, and have, and will continue to permit coal-fired plants. The more interesting question to me is: if those plants choose to take actions to be carbon-ready, will those expenses be capturable in the rate base? And I think under the current law in most states it would not be, because it is not least cost, most reliable, whereas the—and so I am—I do believe we are going to continue to build plants.

If we are going to want to send a signal to people that says, “As you build them, you should contemplate this,” we also have to send a commensurate market signal in some sense that they are going to be able to recapture those costs. Otherwise, those are shareholder costs and not ratepayer costs.

And I think that the importance of this discussion is that whatever we do in this area it is going to cost, and it is going to be expensive. And one of the things that—and it is entirely an appropriate investment of societal resources. The only thing I would ask is that, as the Committee moves forward, you think about the consequences of that up and down the income scale.

In our state, the bottom quartile we estimate spends about 16 percent of their disposable income on energy. The top quartile spends somewhere between 1½ and 3. And so you begin these increments—and I was having this discussion with Mr. Hawkins that all of these things cost funding, and it is an appropriate expenditure, but we need to be mindful of the people who are going to bear those costs, not just the—we may have the capacity to impose those costs. The correctness of how we impose those costs I think has to be a consideration.

The CHAIRMAN. You invoked Mr. Hawkins’ name. Can you make some observations here on what you just heard?

Mr. HAWKINS. Certainly, with your permission. I think that, first, the MIT study on the future of coal has some very informative findings on the concept of capture-ready, and I think it is worth the Committee taking a look at.

It is an elusive concept, and may prove to be illusory. The Energy Policy Act of 2005 has a definition of capture-ready that essentially is leaving space for installation of some undefined piece of equipment, which has led me to say that, well, I have a driveway that is Ferrari-ready. [Laughter.]

If that is the definition. It is not going to be a simple matter to take a plant, which is optimized to run without capturing its CO_2, and turn it into a plant that is optimized to run and capture its CO_2. The energy flows are significantly different. The balance of plant equipment is significantly different. What hardware you put on in the first place is a complicated calculus.

All of that leads us to believe that we need to jump to the outcome that we need to pursue in order to reconcile the use of coal and protecting the climate, which is just to have a policy that says starting in X date new coal plants will have to capture their carbon. Period. And I have outlined in the testimony proposals on how you can spread the additional costs associated with that policy, so that no single company's customers see a rate shock.

This is not—we are not talking about doing this for all 300 gigawatts of coal-fired powerplants that are out there operating today. We are talking about phasing it in one plant at a time, and the trick is to get those costs to be spread across the electric consumer's rate base. That is a reasonable thing to do, because by keeping coal in the mix we are avoiding spikes in gas prices that will wind up costing customers of gas-based utilities money, even if they never consume a kilowatt hour of power made from coal.

So this is a reasonable approach. We need to get started, and we have the technology, and we should not flirt further with the concept of capture-ready, in my view.

The CHAIRMAN. My time has expired.

The Chair recognizes the gentleman from Washington, Mr. Inslee.

Mr. INSLEE. Yes. I want to pursue this issue of capture-ready, because it seems more amorphous than a Ferrari even to me. Can any of you tell us what that would actually look like? If we were going to say, "We want the industry, after a certain date, to build only capture-ready plants," what would that look like, if we know? Anyone?

Mr. SUSSMAN. Let me try an answer to that question. I think that talking about a plant being capture-ready is only the first part of the equation. The real question is: when is the plant going to implement CCS? And we have a proposal, which is very similar to David's, which is a proposal for an emission performance standard under which new plants would be required to implement CCS.

Now, and this is a very important point, we would have a phase-in period. Basically, we are saying any plant built after 2008, which would be the presumed date when legislation would be enacted, any plant built after 2008 would need to capture, either by 2016 or four years after the first date of operation, whichever is later.

And the significance of that is that there is a phase-in period. So if a plant is built on date X, the owners of that plant know that they have to capture and sequester on date Y. And so, therefore, when they build and design the plant, they can take into account the requirement that capture will ultimately be necessary. During that phase-in period, the plant will be "capture-ready," but the important thing is to have a hard deadline for implementation.

And we are saying that ought to be 2016 or four years after the plant begins operating, whatever is later.

Mr. MORRIS. Mr. Inslee, I might offer an additional thought there, because I think, although I have no reason to argue with either of the colleagues, my colleagues to the left, I am a firm supporter of both of these well-meaning individuals.

If "capture-ready" simply means, you know, buy a big lot, I couldn't agree more with David that that's Ferrari desirous or something. When we look at the design of our integrated plants with General Electric Company and the Bechtel Corporation, we are actually looking at the technologies, we are looking at the metallurgy, we are looking at the steam flows, we are looking at the things that will need to be done to make certain that once the technology of capturing the carbon out of the fuel stream before it is introduced to the plant—very different from a post-combustion where you are capturing the carbon out of the flue gas—very, very different concepts, is a technology that will be there, and we are looking at the requirements of the turbine itself, which will mostly run on oxygen, then, rather than run on the synthetic gas. The synthetic gas itself will be mostly oxygen rather than a methane-based gas, which we are all much more familiar with.

So to David's point, if capture-ready simply means buy a big lot, you are not doing anything. To Bob's point, if we take this pre-requirement period, then all we are doing is build the same capture-ready plant that I am speaking to. So why have a command-control approach to it when it isn't necessary? Because we will develop this technology as a country for the very point that our friend from Wisconsin mentioned in his opening comments: because it is economically in our best interest. It is environmentally in the world's best interest that we develop that technology.

To us, when we say "capture-ready" that is what we mean. There isn't a technology at the 639 megawatt level, which is what these plants will be, that is deployable today. It needs to be validated, tested, and then put in place, and that is a difference, I think, not a great difference but a difference between what we are talking about.

Governor FREUDENTHAL. Mr. Inslee, it was—in my earlier comments I made reference to the fact that there was no incentive package for these technologies, the sort of capture part, in trying to make these so-called clean coal technologies function. It seems to me that one of the ways to accelerate and to better define how quickly these can get into the plants is for the Federal Government to be as aggressive with regard to supporting these technologies as we have been with regard to wind power.

We are all very proud of the progress that is made on wind power, great benefits for my State, and great potential benefits. But this is really dependent on a tax credit that the Federal Government put in place for wind power. If we are equally serious—the other reason I like the tax credit is it allows the delivered rate at the busbar to be much more consistent with what the consumer can adopt out of wind power.

I think we need to do the same level of commitment to these questions about the clean coal technologies, including the carbon capture portion, so that you don't end up with a physical impossibility or a technological impossibility of knowing what to—how to prepare the plant for them or how and when to get input in place.

People have been sort of, "Oh, I don't want to do anything that helps—that appears to be helping coal." I would reverse that and say if we don't do something to assist in the capture of carbon from coal, you are essentially putting in place a continuation of the status quo going forward, because you have neither market forces nor tax forces that align the incentives for people to make those investments on a broad enough base.

Mr. INSLEE. My time is up. I just want to comment. I hope we have cleaner coal before David Hawkins has a Ferrari in his driveway. [Laughter.]

That is my timeframe. Thank you.

Mr. MORRIS. I would happily have him have the car. [Laughter.]

The CHAIRMAN. The gentleman's time has expired.

The gentleman from Oklahoma, Mr. Sullivan.

Mr. SULLIVAN. Thank you, Mr. Chairman.

And this is a question I guess for everybody. The Intergovernmental Panel on Climate Change has concluded that global greenhouse gas emissions must be cut by 50 to 85 percent by the year 2050. In order to keep atmospheric concentrations in the range of 450 to 490 parts per million CO_2 equivalent, in your opinion, is there any way to meet that goal without including China and India?

Mr. MORRIS. Absolutely none.

Mr. HAWKINS. China and India have to be a participant. The U.S. climate science program has recently conducted a modeling analysis. The MIT study also conducted an analysis that basically points out that China and India do not have to proceed necessarily on the same precise timetable as industrialized countries.

But if they don't come to the table and participate aggressively in the next 10 or 15 years, we can't meet those targets, and that is why we are such strong advocates of U.S. leadership, because we think that the developing world is going to come to the table much faster if the U.S. is playing a leadership role.

Mr. SULLIVAN. Anyone else?

Mr. BAUER. I will agree with what my colleagues have said, and point out one other thing, that we—when we think about my statement earlier about 30 gigawatts and a quarter of growth from Chinese coal production and power generation, and you think about TVs and computers, it used to be that what America wants was what drove the world's marketplace. But since we don't build too many plants, whoever builds the most is going to be most rapidly be able to move the technology.

So if they don't engage in this conversation, the technology is not going anywhere. That is the marketplace. That is why the—in fact, one of the thing—tax credits or tax penalties on carbon—when we build powerplants on here, in this country, most of the heavy portions come from China. So if we penalize them with taxing their carbon—lack of doing by way of what we do on imports—I know there is a discussion on that somewhere else—we will probably pay for that tax on our import of power generation facilities.

Governor FREUDENTHAL. Mr. Sullivan, I would say that I agree they have to be part of it. The part where I get nervous is when people pose that question and the answer is clearly yes, is then that we say that the United States is not going to move until China and India do. And I don't make that second step, because I think if we move properly we will be okay. If we move improperly, we are going to create an immense number of problems for this society, let alone worldwide.

So I—you know, I never do understand how things happen in this—in the nation's capital. Mine is the simple life in a rural state. But it just seems to me that the logic is you have got to incent the technologies you want, you have to figure out a way to get part of the cost built into the rate base in a way that protects the low-end consumer and user, you have to end up with some willingness to say it is going to take a reasonable glide path time to get there.

You have got to come up with something that is uniform across the country, so the states aren't pitted against each other, and you end up with some rational basis. And you need to invest significant funds in how we capture carbon—that is in those clean coal technologies—and significant funds in how you are ultimately going to store it.

And the issue that nobody has talked about today that I want to make sure gets on the table is is the Federal Government has got to own at some point the liability. I have seen proposals where you are going to shift the long-term liability for CO_2 to the states.

And if you thought you had a mutiny with the Real ID Act, the states are really going to come off the wall if you say, "Once this is injected, states, you own that," because ultimately the—if we are talking about trying to sequester something for a couple hundred years, the liability for that—really, the only place that that can rest is with the Federal Government, not with the individual states.

Mr. MORRIS. And I would just like to make sure I add to my comment, because it was quick to the point that absolutely not, I believe that wholeheartedly, but I do share the Governor's view. That does not mean that my company or this industry or this country ought to sit back and do nothing if those others don't join us. That would be the wrong approach.

But what we as a society need to then understand is that we often by ourselves can't fix this. So if you want to add—you know, you pick the number, $4, $5, $7, $10, $20 trillion to the U.S. economy, and you haven't moved the global warming needle a nano-inch, then that is a society debate that, for better or worse, you are all elected to make those decisions. And with all trust and confidence, we believe you will make solid and reasonable decisions in that light.

Mr. SULLIVAN. Anybody else?

[No response.]

All right.

The CHAIRMAN. The gentleman's——

Mr. SULLIVAN [continuing]. I am out of time?

The CHAIRMAN. You can ask another question.

Mr. SULLIVAN. Okay. I have got a question for you, Mr. Morris. I am concerned about the potential impact of requiring new technologies on the rates that our constituents pay for electricity. Can you tell me what the best way to prevent prices from skyrocketing would be under a scenario where the government requires new technology for carbon capture or cap and trade?

Mr. MORRIS. Congressman, what I would offer is that a carbon-controlled, coal-based powerplant in the long run is going to be much more cost effective for my customers at Public Service of Oklahoma, as well as the customers that we serve across this country, because the other option is to go forward with a much larger renewable standard, which is considerably more expensive than a carbon-controlled coal plant, or we lean on either new nuclear, which we are now beginning to see equally high prices—it won't be so cheap to meter. It will be quite expensive.

Or we lean to natural gas, which you know even in Oklahoma, a very major gas-producing State, as is the Governor's, we are an 18-, 19 trillion foot supply. If we start running gas plants or build nothing but gas plants, we will be at a 24-, 27 trillion demand. We import less than 1 trillion feet of LNG, and I don't see that growing any time. And we import 3- or 4 trillion feet from Canada, which will continue to be reduced as they meet the successor to the Kyoto Protocol, because they won't meet that now.

So the real cost, if we don't do this, will be skyrocketing natural gas powerplants.

The CHAIRMAN. The gentleman's time has expired. I apologize. The gentleman's time has expired.

Mr. SULLIVAN. No problem.

The CHAIRMAN. The gentleman from Oregon, Mr. Blumenauer.

Mr. BLUMENAUER. Thank you. I am curious as to your reflections on underground coal gasification technology. I have been intrigued with what I have heard about the conversion of deep, unminable coal into syn gas, and then that could be used to produce almost now I guess any hydrocarbon fuel or petrochemical. Lots of applications for that.

But it appears to be very clean and easy to capture and sequester the carbon in the spent seam after you remove the syn gas, technically. Theoretically, it would appear to have tremendous potential. Do any of you gentlemen have experience with that and have some observations that you might share with the Committee?

Governor FREUDENTHAL. Mr. Chairman, Congressman, both in my life as a private lawyer before I got into this less respectable line of work, and my experience as Governor——

Mr. BLUMENAUER. Being a witness or——

Governor FREUDENTHAL. No. [Laughter.]

I had clients who did underground coal gasification, and the technology has come a long way, because the question is: how do you control the reaction underground and your capacity to characterize the formation with reliability, so that you know the CO_2 stays and you get the gas?

The potential for this to be a remarkably viable long-term source of energy for this country is amazing. There are immense reserves.

In our State, we characterize anything under more than 3,000 feet deep as qualifying, and it is—the reserve is extensive. Again, the problem with the formation is that coal has all of these fractures and fissures, and so you have a lot of money. It is not unlike trying to make sure the CO_2 stays down in a cavity.

You have a lot of money invested in characterizing the formation, so that you can, with reliability, predict your capacity to control the gasification process, as well as where the off-gases are going to go. But it is one of those things that I would encourage the Committee to think about.

Again, if you want to advance the rate at which the private sector pursues the development of those technologies, the way you do that is to set up some form of a tax credit that is essentially technology neutral and allows them to say okay. I mean, Shell has an approach that they like on gasification. I know a number of other companies have different technologies that they would like to try, but right now the assured price for natural gas is not sufficient for them to justify that long-term investment.

But it is—I think it is one of those things—and I think you have hit upon one of the real nuggets for this country. Notwithstanding that I may have some bias, since we have a lot of that resource, but it really is there, and it allows you to have that reaction take place in a contained environment.

Mr. BLUMENAUER. Thank you, Governor.

Other comments?

Mr. HAWKINS. Well, I only have a familiarity with it based on reports and talking with some researchers in the field. And I think the Governor has identified one of the first issues, which is controlling the conversion process.

Another issue that is a challenge is dealing with the combustion products. A lot of these coal seams have groundwater that is flowing through them, and that groundwater, once you have taken an area and subjected it to the gasification process, you are going to have a lot of byproducts. Those byproducts may have a lot of complicated and rather unfriendly chemical compounds associated with them, and you have to have a plan for managing the potential intersection between that groundwater and all of these combustion byproducts.

These things are not necessarily impossible to solve, but they will require energy, they will require dollars. This is a concept that is worth looking at, worth researching. It is probably a couple of decades behind the surface gasification technologies that are commercially proven today, though.

Mr. BAUER. If I may just add, I think the Governor did a great characterization. I think David also reflected on some of the challenges. We are involved in some of this preliminary work. The country of Brazil was looking at doing this, as well as some other countries in Eastern Europe. It has a great deal of promise. There are substantial needs, which I think are similar to the sequestration storage issue of how do you characterize, how do you monitor, how do you avoid unintended consequences to groundwater or other things in the area that have to be dealt with.

So, again, the things that are being done around carbon sequestration or storage actually will have benefits, just as the things in oil reservoir mapping have had benefits for storage characterization.

Mr. BLUMENAUER. Thank you.

Mr. Chairman, I would hope that there may be an opportunity for us at a subsequent hearing to explore this in greater detail. I think there are actually other applications that are taking place in North America, in Canada. There has been, as Mr. Bauer mentioned, some experience in Central Europe. I think it holds great promise. It is something that isn't commonly talked about and looks like it could marry a number of the problems and opportunities together. And if it would be possible, I would appreciate your consideration.

The CHAIRMAN. We can do that. To the gentleman from Oregon, obviously coal is the biggest problem, so we have to explore all of these potential solutions. So——

Mr. BLUMENAUER. Thank you.

The CHAIRMAN [continuing]. It will be done. Thank you.

I just want to—I am going to recognize the gentleman from Missouri, Mr. Cleaver, but you should know that we promised Governor Freudenthal that he could leave at 12:00, and it is three minutes of 12:00. He made this request long ago, so if you have any questions for the Governor, you have got three minutes on the clock for him.

And we thank you, Governor, for being here. Your testimony has been excellent. Thank you.

Governor FREUDENTHAL. Thank you, Mr. Chairman.

The CHAIRMAN. The gentleman from Missouri.

Mr. CLEAVER. Thank you. Governor, thank you very much for being here, and your responses have been very helpful. You know, to some degree you do understand what it is like to be on this side of the table, so I appreciate your concerns. I don't have any questions for the Governor necessarily.

I am interested in how we, you know, successfully sequester, but it seems to me that if you turn loose the American ingenuity we can solve a lot of those problems. The one problem I am not sure is going to be resolved as easily is the issue with China and India and, to a lesser degree, Southeast Asia, including Indonesia.

If we are going to end up paying higher prices in Wal-mart by imposing some kind of tariff or, you know, if we—if our incentive is to force the Chinese and the Indians to use more money, pay more money to satisfy us, and if we don't want to pay more at Walmart and Target, what in the world are we—I mean, are we going to do? I mean, we—as I think we are learning, nations don't obey us well.

And so, I mean, just saying "you had better" is not going to work. So what are we going to do?

Mr. MORRIS. Congressman, if I might, the International Brotherhood of Electrical Workers' President, Ed Hill, and our company, American Electric Power, have put forth, now with the support of the AFL–CIO, UAW, the Mine Workers, the Boilermakers, the concept of creating a World Trade Organization compliant tariff requirement for those products which we would import for those nations that have not addressed the issue of global warming, because, again, what we are trying to address ourselves here is the issue of global warming, not U.S. warming, if, in fact, you are concerned about the climate process that may or may not unfold as time goes forward if we do nothing about this as a world.

So the notion that there may be an additional cost for a good at the Wal-mart store or the Target store is a societal reality for the globe. Believing and dictating to those countries what they ought to do will not work, to your point. We now know that in any one of a number of demonstrations.

But this concept—again, the way it works under the World Trade Organization is once you have required a carbon program on U.S. manufacturers, and it has been in place for half a decade, you can then require the same kind of program on international manufacturers who would export goods to this country. And that is the plan, and, quite honestly, it is gaining very reasonable support.

Both the Bingaman-Specter bill have that in it, the Lieberman-Warner bill has a sketch of that in it. We have heard at least from the principal committee under Chairman Dingell and Committee Chair Boucher that they are very much in support of that concept as we go forward. That is one way to go about doing that.

The thing that would worry me even more about that as we go forward, however, would be, how would we verify that those programs are in fact being followed? And so with this particular piece, we don't need to be as concerned about what they are or are not doing there. We just know that that is an economic driver that will eventually cause them to move in the right direction, as will their own populations.

I think The New York Times this weekend had an excellent piece on the general feeling about the population in China in particular. But you are right to point out Indonesia, Brazil, there are many other countries involved.

Thank you.

Mr. HAWKINS. If I could just comment, there is an opportunity for a virtuous circle here. NRDC has an office in Beijing. We now have nine people on staff there. And we spend most of our time analyzing the Chinese energy economy and pointing out the bottlenecks to growth that are represented by the inefficient processes in industrial production and in power production and trying to make the case to Chinese officials that by adopting better standards for end use efficiency, better standards for production efficiency, they can actually have more dollars go to value added products and fewer dollars go to BTUs that are moving around in the economy.

And the adoption of the kind of program that Mike Morris just described by the United States could be just the added extra kicker to kind of help the Chinese officials to make this happen, because right now you have tension between the national government. A lot of the officials get this problem; they understand it. But the provincial governments are making money hand over fist building powerplants to feed the power hungry east coast of China.

And so you have—you don't have a system that is necessarily in the best interests of China as a nation, but it is certainly in the short-term interests of a lot of provincial officials who are making lots of money for their provinces through this very rapid explosion of coal-fired powerplants that actually don't have to be built if the Chinese economy had efficiency programs. And we are trying to get those done. The politics are challenging. And, obviously, as a U.S.-based environmental organization, we have limited capacity to make those changes.

But with supporting policies in the United States that essentially give another reason for the Chinese to pay more attention to these opportunities, we think we could make it happen.

Mr. CLEAVER. Thank you, Mr. Chairman.

The CHAIRMAN. The gentleman's time has expired.

Do any of the other members have any—does anyone have a final question they would like to ask? Mr. Inslee or Mr. Blumenauer? Mr. Cleaver, do you have any——

Mr. CLEAVER. No, thank you.

The CHAIRMAN. Great. Well, let us do this. Let us, in reverse order, ask each of you to give us your one-minute summation of what it is that you want the Committee to remember from your testimony. As we deal with this energy bill over the next month or so, we will—this is going to be a city that will turn its attention to this climate change issue and cap and trade legislation.

So tell us what it is that you want us to remember as we are moving forward. We will begin with you, Mr. Dalton.

Mr. DALTON. Thank you, Mr. Chairman. First off, I would like to point out that the increased efficiency and integrated testing at full-scale is important for these technologies relatively quickly, even before full-scale commercial installation. The R&D needs to move forward, and the demonstration and deployment needs to move forward rapidly.

Increased thermodynamic efficiency of pulverized coal, increased efficiency and reliability of intergasification that matches the combustion—the CO_2 capture is very important, as well as improved technologies for CO_2 capture. Reliable technologies for CO_2 storage and mechanisms to deal with the financial and technical risks in that storage are important, but a full portfolio is really required.

The CHAIRMAN. Is required. Thank you.

Mr. Sussman.

Mr. SUSSMAN. Thank you. On the path that we are on right now, I think it is a high likelihood that we are just not going to see widespread deployment of CCS before 2030 at the earliest. And I would submit that that is too late. What we need is we need a national implementation date. We would say that that implementation date is 2016. Others might say that it is 2020.

And we need to send a very clear message to developers and builders of coal plants that any new coal plant would be expected to have CCS in place by that national implementation date. Then, we need to address the cost differential and the potential impacts on electricity price increases. And as we outline in our report, there is simply no alternative but to subsidize CCS until the price of carbon gets to a level that would incentivize CCS in the market.

And that I think means a national expenditure, in our view, of somewhere between $35- and $40 billion to make CCS cost competitive until around 2030 when it should be cost competitive under a cap and trade system.

The CHAIRMAN. Okay. Thank you.

Mr. Hawkins.

Mr. HAWKINS. Mr. Chairman, every month of delay hurts us in attacking the climate problem and raises the costs of doing so. Every month 10 new coal plants are started up somewhere around the world. Each one of those coal plants is going to operate for 60 years or more, and we have no reliable prospect that any of the CO_2 from those coal plants will be captured, because they are not being designed to allow that. Maybe it will happen, but we can't count on it.

So it is critical that the United States act, and this Congress has the ability to act. We think the policy package that I outlined is the one that can make a huge change; that is a cap and trade program. And then, focused performance standards for making sure that the next coal plants that get built in the United States capture their carbon.

There has been a lot of talk about proving things out, but the way we will prove this out is by operating these things at scale. We would get the learning by doing. These technologies are all commercially proven in pieces. We need to put them together, and we need a policy package to make it happen.

The CHAIRMAN. Thank you, Mr. Hawkins.

Mr. Bauer.

Mr. BAUER. Thank you, Mr. Chairman. I would have a few points. The carbon capture and storage is achievable, it is realistic, and the R&D and large-scale demonstration that will take place over the next 15 years will fully make that a very feasible technology.

There needs to be investment in the R&D. There needs to be regulatory certainty for the investment to come from the private sector as well, as well as the actual implementation, as Mr. Morris spoke to.

I think it is also important to recognize that the energy industry is the private sector. The U.S. Government does not make electricity, although we do have the hydropower and some TVA, and like that, yet the majority is private sector. So things that make it for the private sector, the signals—both regulatory and otherwise—that make it work are very essential in this.

One thing we did not talk about today is 60 percent of electricity demand is residential and commercial buildings. The ability to reduce demand or slow the growth in demand, not by slowing building but by higher standards of building codes, is a very important tool that is often undervalued, but yet substantially possible. I think that is worth looking at.

And then, lastly, I think that the Committee has already indicated a recognition that our domestic resource coal and fossil fuels have to be an essential component, so we are talking about how do we do that realistically and economically.

Thank you very much for your time.

The CHAIRMAN. Thank you, Mr. Bauer.

Mr. Morris.

Mr. MORRIS. Thank you very much, Mr. Chairman. It seems to me that it is inevitable that we are going to work to a cap and trade program, and we would argue that it needs to be an economy-wide cap and trade program, that it needs to have timelines and reduction schedules that are realistic, and, in fact, achievable.

We would believe that credits ought to be allocated to those who will invest the capital to make a difference in the environment, rather than auctioned, so that those who buy them can make money by the positions that they have taken. We obviously believe that the global nature of it needs to be addressed and cannot be denied or ignored. We obviously believe that we also ought to have a price cap on those credits, so that if you need to create more or you need to buy more, at least in the early go we know what that cost is, so that the U.S. economy can digest and adjust to that cost, whatever it might be.

And, lastly, we think that those who have implemented early action and taken voluntary steps ought to get credits and bonus recognition for the steps that they have taken, because we, in fact, in a voluntary nature have made a huge difference in the CO_2 footprint of our company alone, and many of my colleagues have done that as well.

Thanks very much for the time to be here and share some ideas.

The CHAIRMAN. Thank you, Mr. Morris, very much.

Congresswoman Herseth Sandlin has arrived, and so this hearing is now officially in overtime as we recognize her for a round of questions. [Laughter.]

Ms. HERSETH SANDLIN. I thank you, Mr. Chairman, and I thank the witnesses for their patience.

I did want to explore just a couple of issues quickly, and if I could start with you, Mr. Bauer. You had talked about coal and biomass. Are you working with and familiar with the Department of Energy's workshops that they have done?

They have set up by region, and in South Dakota, for example, within our region, one of our land grant universities is sort of leading these workshops to help calculate the availability and sustainability of feedstocks like switchgrass of—the sustainability of biomass by region that would then, of course, assist as it relates to those regional calculations and where the coal-fired facilities are located. And maybe you could just elaborate a little bit on the IGCC technology as it relates to integrating biomass with the coal plant.

Mr. BAUER. Yes, ma'am, Congresswoman. I am familiar with that. In fact, there are two entities that implement that for DOE—the Golden office out of Denver and NETL where I am, Pittsburgh, Morgantown. We are operating mostly in the eastern half of the United States—Denver, Texas, you expect the western half. But I am familiar with the process of working with the land grant colleges and the State Energy Boards about funding to look at renewables and the source.

Going specifically—the issue about biomass with coal is an issue, just like biomass anywhere. Is there a sufficient amount of biomass in a reasonable radius of transport to make it happen? That is when I mentioned switchgrass and those kind of crops that have a potential to add to it.

Gasifiers can and do—and moving them over to The Netherlands it does about 30 percent—that is a wood waste biomass that they use over there with coal to produce electricity. They are looking at building another plant and actually capturing the CO_2 and storing it, store sequestration.

So it is doable. There are challenges, because of the characterization of the biomass and the different kinds of coals, and those are all technologically able to be addressed, but they aren't being done regularly so there will be R&D issues that have to be done with in the process of implementation.

Ms. HERSETH SANDLIN. Do you think one of the other challenges—and I guess maybe not a challenge, but the importance of facilitating getting these measurements and calculations, because of the issue of biomass for electricity generation, and biomass for transportation biofuel production—I mean, do you anticipate some sort of tension developing there if we don't get these calculations and measurements so we can adequately define what are reachable goals on both the electricity sector and the transportation sector side of the equation here?

Mr. BAUER. Yes, I believe there is a realistic marketplace, just like there is today. Natural gas is one of the fuels that cuts across all marketplaces of use. We have lost the fertilizer industry offshore. We are importing natural gas from other countries in the form of fertilizer today. We lost chemical production because we can use natural gas for power generation and other things, so the price in the marketplace drives that.

And the same thing will be true on competition for biomass for both biofuels—direct conversion and thermal conversion of biomass and coal together to perform coal biomass liquids for transportation. I think the economics of the market will work and sort that out, and also will drive towards certain crops besides food crops as sources for rapid growth of biomass.

Ms. HERSETH SANDLIN. Thank you. And then, one final question, which anyone can additionally respond to either the issue of the biomass in the coal-fired facilities and what your company or what the sector is doing to respond to that.

But, Mr. Hawkins, specifically, when you set forth the three-part policy package for a comprehensive cap and trade system, where do you see American agriculture playing a role in that system? Because when we traveled to Europe earlier this year, they don't include agriculture in their cap and trade system, and I think that they made a mistake in setting up their system not to do.

And I think there is great potential for agriculture in certain farming practices and grazing practices to play a role in helping store carbon, especially as we transition to these new technologies. So your thoughts on that, please.

Mr. HAWKINS. Thank you, Congresswoman. We think that agriculture has an important role to play, and we think it would be important to design a cap and trade program to create incentives for practices that will reduce greenhouse gas emissions and enhance the storage of carbon in soils, for example.

Our view is the best way to do that is to have a portion of the allowances that will be administered under any cap and trade program be available on basically a best bid basis for projects and programs in the agricultural sector that will reduce these greenhouse gas emissions. And that way American agriculture could be incented by being able to receive either allowances directly or the proceeds from allowance sales in order to support these programs.

Mr. MORRIS. Two of the programs that we have used in our voluntary nature of reducing our carbon footprint drive themselves specifically to agriculture. One is the whole notion of methane capture, which, as you know, has a much more beneficial environmental global warming impact.

Farmers create, through contracting with firms that do that work, particularly in the manure side of the business, that capture the methane, create credits, which we in turn would purchase and put in our bank to make certain that we have credits to take against our own global warming footprint, as well as no-till farming, which is another breakthrough undertaking.

So including the entirety of the U.S. economy and the entirety of the U.S. creativity is what is going to be needed if we are going to be successful in this endeavor.

The CHAIRMAN. Great. The gentlelady's time has expired, and all time for this hearing has expired as well.

This is going to be the first of many, many hearings that we are going to have on this and related subjects that will result in legislation passing that will begin to change the relationship between the United States and greenhouse gases. We thank you very much for your participation today.

[Whereupon, at 12:16 p.m., the Committee was adjourned.]

THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

Dear Governor Freudenthal,
Following your appearance in front of the Select Committee on Energy Independence and Global Warming, members of the committee submitted additional questions for your attention. I have attached the document with those questions to this email. Please respond at your earliest convenience, or within 2 weeks. Responses may be submitted in electronic form, back to me at aliya.brodsky@mail.house.gov. Please call with any questions or concerns.

Thank you,
Ali Brodsky
Chief Clerk
Select Committee on Energy Independence and Global Warming

1) Do you think the adoption of a cap and trade program would have a direct impact on the development of new technology in the area of carbon capture and storage?

It is imperative that we monetize the cost of carbon. The uncertainty surrounding this issue is paralyzing market investment. The impact of monetization, be it cap and trade, carbon tax or some hybrid is entirely dependent on the details of the structure. An effective program must include significant incentives to accelerate technology development.

Monetizing carbon is one of the key variables likely to influence investment in carbon capture and storage technology. We would expect that the structure of any system will influence investment to the extent they effectively monetize carbon. Like most laws, the devil is in the details. The timeline, increasing price, allowance schedule, tax treatment of technology investments, and allowable off-ramps are all likely to directly affect the rate of development and deployment of carbon capture and storage in fossil fuel based electric generation. We would expect IOUs and REAs to take all these variables into consideration when completing their cost-benefit analyses and financial assessments for new infrastructure investments.

2) Do you think it is realistic to restrict coal in our energy portfolio at this point in time?

I believe we will need all our resources in an energy portfolio if we are to move the economy forward. As coal is our most abundant, indigenous energy resource it makes no sense to restrict it at this point. However, it is important to reconcile the use of coal with the apparent political imperative of managing greenhouse gas emissions. Therefore, I believe rather than restrict the use of coal we need to accelerate those programs and policies that lead to the use of coal in a much cleaner manner.

I think it's appropriate for Congress to set a value on carbon that reflects our nation's environmental, security and economic values. Once an economic value is placed on carbon, the market can best determine the optimal composition of an energy portfolio necessary to meet demand on a regional basis. We've seen private sector companies make portfolio investment adjustments in the last year in response to a change in values. But with a 40% increase in energy demand expected by 2030, and 50% of our current electric generation from coal-fired power, it would be imprudent to restrict coal in our energy portfolio. If anything, our historical, current and projected continued reliance on coal only reinforces the need for greater investment in technology which reduces the carbon footprint of coal-fired power generation.

3) Given that coal is a bigger challenge in the scheme of climate change because of CO2 emissions, would you support the development of more nuclear power as we look toward the future in a carbon constrained environment?

Our nation is going to need all its available resources as we address our future energy needs. Coal, natural gas, nuclear, renewables and what some refer to as the "fifth fuel", energy efficiency and conservation, will all play a role. Low cost, reliable and less carbon intensive power BTUs are a clear preference. It is also important not to disregard the externalities associated with our energy choices, whether it be water consumption, view shed or wildlife impacts or public safety. Safe storage of spent fuel rods remain a critical, and to my knowledge unresolved, issue in the wide scale deployment of nuclear energy plants.

4) Given that most everyone agrees that dependence on foreign energy resources is not the best policy for America, are you concerned about restrictions in using our vast resources of coal?

We need to develop policies that enable the use of coal while simultaneously addressing the emission profile of this fuel. It makes common sense that we would use our indigenous resources.

5) The Energy Information Administration projects that U.S. electricity demand will grow by over 40% by 2030. What do you think is the most efficient, affordable and cleanest way to meet that demand in the future?

I believe that increased demand will be so robust that we will need to bring to bear all our energy resources. There is no magic bullet to the question of how we can best meet our energy demands. Conservation and energy efficiency are some of the most readily available resources at our disposal today. Energy efficiency investments will play an important role in slowing demand while public and private investments in technology development and commercial scale deployment of fossil and renewable energy solutions come to market in the next two decades.

6) On the issue of technology, would you agree that it is better to let market forces decide the direction that technology takes? What, if any, government action is necessary to help technology to develop more quickly?

I believe strongly in the power of the marketplace and the innovation and creativity that it produces. The proper role of the government then is to set performance standards and to remain technologically agnostic about how these standards are achieved. Choosing technologies however attractive they may be is a distraction to the functioning of a healthy marketplace. The government incentives (tax policy and/or financing) must be available to all developing energy technologies – not just ethanol and wind.

7) What are the principal barriers to the commercial deployment of carbon capture technologies?

Capital investment, driven by a low or inadequate value for carbon, is perhaps the most significant barrier to commercial deployment of carbon capture technologies. Additionally, we need several large scale (1MM tons of CO2 or greater) demonstration projects and operating history of measuring, monitoring and verifying the movement and activity of CO2 in non-porous structures such as saline aquifers. Without this information, we cannot make defensible conclusions about the impacts of CCS on other natural resources or the chemical changes which may occur. Furthermore, we cannot launch a public education campaign which will be required to gain political support and community acceptance for CCS projects. A robust regulatory and legal framework and risk management program that appropriately parses risk and responsibility between the private and public sectors for an indefinite period of time is also required.

8) How do you define "affordable" as you look at technology that you might want to employ in carbon capture?

This is ultimately a question of rational economic decisions. Carbon capture is "affordable" if the cost of the initial capital investment for CCS equipment, the ongoing operational costs associated with sequestering, compressing, moving and storing CO2, and the cost of monitoring and insuring against long-term risk is lower than the cost of emitting CO2. States and the federal government will also need to determine that the cost assessed to the private sector, ultimately passed back to ratepayers and taxpayers, addresses the public sector investment required to ensure public safety and manage any potential environmental risk.

9) The Energy Policy Act of 2005 provided a 20% investment tax credit for the constructions of IGCC plants, federal loan guarantees for IGCC plants and subsidies for research on technologies including IGCC. Do you support those provisions?

Yes, but keep in mind that these provisions may not be enough. I support a variety of measures to promote widespread adoption of IGCC or equivalent technology. These include tax-exempt bond financing for plants that meet a CO2 cap on a BTU basis, tax-exempt bond financing for carbon capture and sequestration equipment and components, an accelerated depreciation schedule for CCS components, and transferable investment tax credits. Transferable investment tax credits would function as a financial vehicle much the way a production tax credit does for a wind or biofuels project. This asset can be used to obtain equity financing so that financing terms for an IGCC plant and a mature SCPC plant are comparable. It is also critical that the mechanics and terms loan guarantee program are modified to reflect standard market terms and address the entire financing amount typical to a private sector loan.

10) Enhanced Oil Recovery is one way to use captured CO2 to our advantage. Do you support EOR? Do you see other applications for the use of CO2 in this way?

Given our nation's energy security needs and scarcity of resources, the use of CO2 for EOR is a smart economic and environmentally preferable solution. To my knowledge, Wyoming follows only Texas in terms of CO2 usage for EOR. That said, I do not view the use of CO2 for EOR as in the same vein as long-term storage of CO2 in geologic formations such as a saline aquifer when it comes to measuring reduced CO2 emissions. By definition, some portion of CO2 for EOR will release into the atmosphere again. This differential will become increasingly important in the event that a cap and trade system is established and long-term storage of CO2 must be warranted and ascribed an economic value.

11) When we look at current government programs and research in the area of carbon sequestration, are we on the right track? Other than throwing more money in the mix, where would you make improvements or change focus to help bring carbon capture and storage closer to reality?

We need to invest in a manner that allows large scale sequestration projects to be demonstrated in various geological structures across the country. If we are serious about sequestration, we will need to develop a number of sites and the attendant infrastructure in a variety of locations. As we compare the generally successful sulfur dioxide cap and trade scheme with the management of carbon dioxide, we must keep in mind the relative scale of each emission. The amount of carbon dioxide emitted in power generation is roughly 240 times the amount of sulfur dioxide. Therefore the necessary infrastructure to handle this amount of material is not trivial. We will need to use all kinds of sequestration sites across the country to optimize the infrastructure investment.

The most important element to bringing carbon capture and storage closer to reality is a clear market indication of the value of carbon and rules and regulations to monitor it. Establishing a cap and trade, carbon tax or other hybrid system coupled with a federal government investment level commensurate with the scope of our problem and need for cleaner energy solutions will move the needle. Federal investment comparable to the levels provided for the wind or biofuels markets would jumpstart the private sector investment also required. We've certainly seen this to be true in the wind and solar markets and see no reason why CCS should not experience a similar trajectory.

12) How could performance standards be incorporated into the development of new coal-fired power plants?

It makes sense to develop a 'glide path' with respect to performance standards. By this method you can create 'stretch but achievable' standards for the first couple of plants and then begin to work toward more stringent standards through time. If the initial standards are not reasonably achievable then the financial markets are likely not willing to engage. A glide path provides a level of certainty that will be required to get the kind of dollar investment necessary for these large projects.

Natural gas plants seem to be the solution du jour for meeting our energy needs. If we assume that the natural gas standard CO_2 output on a BTU basis is the benchmark, we should be able to set a goal of coal-fired powered generation at a similar level. But we must take a critical look at the construction, financing, technology and political hurdles that must be overcome to be able to deliver coal-fired power at a natural gas standard. We must also consider the timeline and investment level required to reach it. Performance standards should include a multi-tiered set of goals, a timeline and glide path that sets stretch but attainable goals.

13) As we look at long term storage of CO_2, have any of you looked at the pipeline needs related to this issue?

The Enhance Oil Recovery Institute at the University of Wyoming has done some preliminary work on this question as has the Wyoming Pipeline Authority. We are in the process of doing a detailed, specific inventory of EOR sites as well as similar detailed inventory of sequestration sites. Once those are completed and we have an idea where future plants may locate we can be more specific in laying out a pipeline scheme to link these sources and sinks.

14) What concerns, if any, do you have about the long-term storage of CO_2 in geologic formations? Are you concerned about the legal and regulatory complexities of long-term storage?

According to my geological advisors, CO_2 currently exists in many geologic formations and has been in place in many cases for millions of years. In some cases, CO_2 is currently re-injected as part of oil and gas exploration and production operations. Having said that, it makes a great deal of sense to make the necessary investment in sequestration at scale (1,000,000 tons per year over several years) which would include thorough measurement, monitoring and verification.

There are two types of liability associated with CO_2 management—operational liability and post-injection liability. Operational liability includes the environmental, health and safety risks associated with carbon dioxide storage, transport and injection. Historically, the private sector has fairly successfully managed these risks with EOR and other activities. Post-injection liability, namely the in situ liability of harm to human health, the environment and property related to leakage of CO_2 is an area of greater concern and direct government responsibility. These risks include potential groundwater contamination, seismic activity, subsurface trespass and the unlikely event of a catastrophic release. Robust monitoring, measurement and verification of data and activity over the long-term are required to determine the scope and specifics of this in situ risk. Given the scope of the CO2 management problem our world faces, I believe we need to accelerate the number, size and geographic distribution of these projects post-haste to begin to adequately answer these questions. It is imperative that the legal and regulatory framework be developed. The Wyoming Legislature has also been asked to address these exact questions as they are imperative to resolve to move forward. Fundamentally, the multi-generational liability for CO2 sequestration must be borne by the federal government.

15) Since Wyoming is a large producer of uranium, are you supportive of nuclear energy?

Yes. I believe we are going to need all kinds of energy resources going forward to meet demand. This includes nuclear, wind, solar, coal, gas and others we will discover from a robust marketplace.

16) Your emphasis on who pays the price of long term carbon management is a point well taken. Given that concern, do you agree that mandated cap and trade as well as carbon capture requirements are likely to increase costs to consumers? What would be your suggestion to mitigate that concern?

Any carbon management system which puts a value on carbon is likely to increase the costs to consumers. The question is how much of that cost gets passed on in the rate base, and ultimately to the consumers, versus getting passed on through government funding, and therefore to the taxpayers. My concern is for the lowest income earning quartile of our society who spends nearly 8x as much of their income on energy consumption as the highest income earning quartile of our society. There needs to be one or more mechanisms to offset some of these impacts to those who can least afford to shoulder the cost of carbon management. I have read proposals for payroll tax deductions, or an income tax deduction which make sense. I also support a tiered utility price system which rewards for lower consumption levels coupled with well executed energy efficiency programs and improvements.

17) You mention that the Wyoming is doing a geological survey to identify the optimal CO2 sequestration sites, but I am glad you also mentioned the potential risk assumption that is inherent in a carbon storage program. As a Governor, how do you balance the concern about environmental liability and the opportunity improving our climate and potentially profiting from doing so?

The process of developing a safe, effective and efficient carbon dioxide sequestration scheme will take technical understanding as well as reasoned judgments about risk and liability. As it stands now there are things we just don't know which are why we need the research to understand the technical aspects of sequestration. Simultaneously we need organized, rational thought about risk and liability to move toward reasonable state and federal policy. With these sideboards in place, the economics will begin to sort themselves out. Conversely, without these boundaries the financial community will likely not engage in a substantial enough manner to make the necessary investment to end up with a viable national solution. Given the current state of the available science and the energy demand worldwide, I see no other choice than to develop a serious CO2 sequestration effort worldwide.

18) You note on page 4 of your statement that "we need to accelerate those programs that lead quickly to economically viable, commercial scale electric generation plants." Would you support streamlining the permit process for new coal plants if they were IGCC plants as a reward for companies who chose to build IGCC plants?

I believe one hallmark of a well functioning government is a responsive, timely and efficient permitting process. This does not mean we cut corners on environmental rules or safeguards, but rather we set a clear and consistent process based on our environmental and economic values and follow it. I do believe streamlining the permitting process for new electric generation plants which meet identified performance thresholds, such as a maximum CO_2 level per BTU output, is one tool governments have and should use to promote cleaner energy development. I do not believe it is government's role to pick specific technologies such as IGCC. The market is better able to determine the right technology to achieve the desired performance standard. In no event would I support compromising applicable environmental standards. The operator of an IGCC should still conform to the standards for safety, land reclamation, currently regulated pollutants, etc. Positive procedural treatment is a logical step, waiver of substantive standards is not.

THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

Dear Mr. Morris,
Following your appearance in front of the Select Committee on Energy Independence and Global Warming, members of the committee submitted additional questions for your attention. I have attached the document with those questions to this email. Please respond at your earliest convenience, or within 2 weeks. Responses may be submitted in electronic form, back to me at aliya.brodsky@mail.house.gov. Please call with any questions or concerns.

Thank you,
Ali Brodsky
Chief Clerk
Select Committee on Energy Independence and Global Warming

Mike Morris, AEP Responses to Select Committee Questions

1) Do you think the adoption of a cap and trade program would have a direct impact on the development of new technology in the area of carbon capture and storage?

   Yes._A cap and trade program will provide a price signal for carbon emissions that does not exist on a national basis in the US today. This will provide market incentives to employ technologies that reduce carbon and other greenhouse gas emissions including carbon capture and storage.

2) Do you think it is realistic to restrict coal in our energy portfolio at this point in time?

   No. Coal accounts for approximately 50% of our electricity production in the US today. It is one of the few options we have today that produces low cost, reliable and affordable electricity. Further, the development of new clean coal power plant technology such as integrated gasification combined cycle (IGCC) and ultra supercritical (USC) and ultimately commercially proven carbon capture and storage technology hinges on allowing new coal to be built.

3) Given that coal is a bigger challenge in the scheme of climate change because of CO2 emissions, would you support the development of more nuclear power as we look toward the future in a carbon constrained environment?

   Yes. We believe that both coal with carbon capture and storage technology and nuclear technology need to play an important role in a future carbon constrained environment. Realistically, we cannot meet the future demand for power and reduce our carbon emissions without using both approaches.

4) Given that most everyone agrees that dependence on foreign energy resources is not the best policy for America, are you concerned about restrictions in using our vast resources of coal?

   Yes, coal is our single largest energy resource and undue restrictions will limit our ability to continue to power our economy cost-effectively, reliably and cleanly. New clean coal plants should be encouraged, not discouraged.

5) The Energy Information Administration projects that U.S. electricity demand will grow by over 40% by 2030. What do you think is the most efficient, affordable and cleanest way to meet that demand in the future?

   There is no single answer to this question. It is simply not possible for one energy technology or fuel to meet our growth in demand over the next twenty to thirty years. Instead, we believe that there must be a portfolio of cost-effective, clean energy solutions.

This would include the combination of (1) improved energy efficiency on the part of our customers, (2) continuing improvements in the efficiency of existing fossil, hydro and nuclear power plants, (3) clean coal technology such as IGCC and USC, (4) new nuclear, (5) renewable power sources such as wind and biomass with the accompanying transmission build out, and (6) high efficiency combined cycle gas power plants. I would note that AEP is already investing or considering investing in all of these options to meet the future energy demands of our customers.

6) On the issue of technology, would you agree that it is better to let market forces decide the direction that technology takes? What, if any, government action is necessary to help technology to develop more quickly?

Market forces and competition among vendors, suppliers and energy companies must play a central role in the development of long-term technology solutions. However, with a large multi-billion dollar investment required to build a single new clean coal power plant, some government support is essential to help cushion the costs and large risks to companies (and their customers) that are deploying these new technologies, particularly as they are being developed. As such, three broad types of government financial support are needed to help technology develop more quickly. This includes (1) research, development and deployment funding and grants, (2) investment tax credits to help reduce up-front costs and (3) bonus allowances in cap and trade legislation to specifically encourage more rapid deployment of technologies. In addition, federal regulatory support is essential to reducing risk and encouraging investment.

7) What are the principal barriers to the commercial deployment of carbon capture technologies?

There are three major barriers to the deployment of carbon capture. First, the energy costs of carbon capture at power plants are very high today and need to be reduced before we will see widespread commercial deployment. Second, the capital investment needed for carbon capture is also large, particularly when including the large loss of generating capacity (e.g. energy needed to capture the carbon) that must be made up through additional new generating capacity additions. Third, there are a host of institutional, regulatory and legal uncertainties primarily pertaining to the ultimate storage of carbon that must be resolved so that investment and project risks are shared and minimized.

8) How do you define "affordable" as you look at technology that you might want to employ in carbon capture?

There is no one definition of "affordahle" or "reasonable cost" when one considers new technology such as carbon capture. We would note that based on recent studies by the

Electric Power Research Institute (EPRI) the costs of carbon capture would increase the costs of a new IGCC plant by 40-50% and a new pulverized coal plant by 60-70% which for many is outside the range of being "affordable" or a "reasonable cost". This is the very reason we are trying to commercially validate chilled ammonia carbon capture and storage (CCS) technology at our plants in order to bring down costs of CCS to a more reasonable or affordable range.

9) The Energy Policy Act of 2005 provided a 20% investment tax credit for the constructions of IGCC plants, federal loan guarantees for IGCC plants and subsidies for research on technologies including IGCC. Do you support those provisions?

Yes, we do support such provisions though federal loan guarantees for IGCC do not provide much in the way of financial incentives for AEP. However, we understand that such loan guarantees can play an important role for some investors in IGCC plants.

10) Enhanced Oil Recovery is one way to use captured CO2 to our advantage. Do you support EOR? Do you see other applications for the use of CO2 in this way?

Yes, we support EOR. EOR is a very logical way to use captured CO2 to help expand our energy supply and improve the net economics of carbon capture. In fact, we just signed a contract to sell the CO2 emissions from our retrofit CO2 capture project at our Northeastern plant in Oklahoma to a company that plans to use it for EOR. In addition to EOR, captured CO2 could also provide significant value in being used to enhance gas recovery in depleted gas fields and in deep unmineable coal seams for enhanced coal bed methane recovery.

11) When we look at current government programs and research in the area of carbon sequestration, are we on the right track? Other than throwing more money in the mix, where would you make improvements or change focus to help bring carbon capture and storage closer to reality?

The most important non-monetary contribution that the federal government could make would be to establish clear rules, procedures and timelines so that investment uncertainties are reduced. This would include development of appropriate federal measurement, monitoring and verification (MMV) protocols and national standards for permitting of storage reservoirs, among other issues.

12) How could performance standards be incorporated into the development of new coal-fired power plants?

We do not support performance standards as we believe a cap and trade approach has been proven to be a more cost-effective way to reduce emissions. If performance standards are

required, we would urge that they be implemented flexibly, allow for trading and be developed in light of the expected time needed for commercialization of CCS technology.

13) As we look at long-term storage of CO2, have any of you looked at the pipeline needs related to this issue?

Based on the studies conducted by or on behalf of AEP to date, AEP power plants are largely located at or near good or acceptable sites for carbon storage, making very long pipelines unnecessary for most AEP plants. We do recognize that other power companies particularly those in parts of the Southeastern US may have significant pipeline requirements given that they are not located close to adequate storage capacity.

14) What concerns, if any, do you have about the long-term storage of CO2 in geologic formations? Are you concerned about the legal and regulatory complexities of long-term storage?

Many of the geologic studies conducted to date suggest that there are probably no major technical problems associated with the efficacy and effectiveness of long-term storage in deep saline formations, oil and gas formations and other geologic formations. Further, the studies suggest that the amount of storage capacity in the US is very large in relation to the amount of CO2 emissions we may ultimately need to sequester. However, this is not meant to minimize the technical challenges ahead with CCS. For one, the use of deep saline geologic storage formations as primary long-term storage locations has not yet been sufficiently demonstrated. Further, there are numerous other questions including how many injector wells are needed, the lifespan of the wells, proximity to other wells, and time span for post-injection monitoring, to name just a few. We are also concerned about the legal and regulatory matters that must be resolved to encourage and facilitate long-term storage of CO2.

15) Do you agree that there is an urgent need in the U.S. for more energy generating capacity? And do you think that carbon capture and storage should be required at this point in time?

We agree that there is an urgent need for more generating capacity. All of the data and reports that have been developed including the recent North American Electric Reliability Council (NERC) reliability report suggest that we may face a serious shortage in electricity generating capacity in just a few years in a number of regions across the US. In our own case, we have active plans to construct coal and natural gas power plants to meet growing demands, though we still need regulatory approvals to proceed in a number of cases.

We do not feel that carbon capture and storage should be required at this point in time. CCS should not be mandated until and unless it has been demonstrated to be effective and

it becomes commercially engineered and available on a widespread basis. Until that threshold is met, it would be technologically unrealistic and economically unacceptable to require the widespread installation of carbon capture equipment.

16) I am impressed by your commitment to developing new technology and considering the environment in your decision making. Have you made a commitment at this point to only build IGCC plants when you build a new coal-fired plant? If not, what is keeping you from that commitment?

We have not made a commitment to build only IGCC plants because there are other viable clean coal options (e.g. USC) which may ultimately prove to be as cost-effective as IGCC, including the costs of carbon capture and depending on the location and fuel type used. Our present plans include building two IGCC plants in the Eastern part of the AEP system in West Virginia and Ohio. Both of these plants still require state rate regulatory approvals for us to commence construction. In the Western part of the AEP system, we recently received approval to build an USC coal plant in Arkansas. We also examined the possibility of building an IGCC plant in Arkansas. However, we were unable to receive adequate contractual guarantees on the reliability and performance of the type of IGCC technology that would have been used with the lower BTU coals we would use at the plant.

17) I am concerned about the potential impact of requiring new technologies on the rates that our constituents pay for electricity. Can you tell me what the best way to prevent prices from skyrocketing would be under a scenario where the government requires new technology for carbon capture or cap and trade?

In the case of cap and trade legislation, there are a number of provisions that will help moderate large increases in electricity prices. These would include reasonable targets and timetables (with major required reductions postponed until after 2020 when the technology begins to be commercially available), full allowance allocations with limited auctions, unrestricted use of real and verifiable domestic and international greenhouse gas offsets and a safety valve price.

We do not support technology mandates or standards because they are a more costly way to reduce emissions than an economy wide cap and trade system. If there are to be technology requirements, they should be flexible and phased in very gradually to allow for time for CCS technology to develop and be commercialized.

18) Are you doing any work at your current plants to increase efficiency or reduce emissions? What, if anything, do you recommend that the federal government do to assist with improvements at current plants that have not outlived their lifecycle?

Yes. AEP has made a number of investments in our existing plants to improve their efficiency and reduce their rate of CO2 emissions. Since the AEP new source review (NSR) litigation settlement with EPA, DOJ and other plaintiffs announced several weeks ago, we are now able to make a number of additional efficiency investments without fear of further lawsuits. Nonetheless, we would strongly recommend that the government reform the current NSR rules so that companies are able to invest in improving the efficiency and lowering the CO2 emissions rate of existing facilities without NSR uncertainty.

19) You support an economy wide cap and trade program that is "well thought-out, achievable, and reasonable." What do you mean by that?

By "achievable", we mean that the targets and timetables provide adequate time for CCS technology to develop on a commercial scale before large reductions are required. We have noted that this generally means 2020 and after before significant reductions can be achieved. By "reasonable" we mean that the cap and trade program focuses on achieving its emission reduction objectives in the least cost manner possible to the economy at large and to our sector and customers specifically. There are many elements that will help ensure a cost-effective program including (1) allocation of reduction fairly across sectors and within the power sector such that each source/company is making a similar percent reduction of its emissions (2) limiting auctions so that companies and their rate payers do not have to pay for buying auctioned allowances in addition to the costs of emission reductions (3) unrestricted use of domestic and international greenhouse gas offsets as long as they are real and verifiable and (4) a safety valve price to minimize price volatility.

20) What kind of tax credits do you support for new technologies for carbon capture and sequestration?

There are two types of tax credits, which we would support for carbon capture and storage. First, investment tax credits can help reduce the up-front capital costs of the technology and encourage investment. Second, production tax credits or tax credits based on CO2 captured annually can play an important role in improving the long run economics of investing in a CCS project. As an example, the production tax credit for wind power and other renewables has been integral in the development and larger deployment of these technologies across the US.

21) I want to congratulate you on the voluntary emission reductions that your company has achieved. Given that you did so without federal mandates – do you think they are necessary? If so, what do you think the most reasonable timeframe is for federal requirements on carbon capture and storage?

We believe that voluntary programs such as the Chicago Climate Exchange have helped make important progress in reducing CO2 emissions at a number of US companies including AEP. However, in order to achieve economy wide reductions and ultimately large reductions in US greenhouse gas emissions, we believe a mandatory federal cap and trade program with reasonable reduction targets and timetables is necessary.

22) How do you calculate "reasonable cost" when considering a technology?

See answer to #8 above.

23) Does AEP provide nuclear power to its customers? Do you support the inclusion of nuclear power as we look at our future energy portfolio?

Yes. AEP operates a large nuclear power plant in the state of Michigan, which serves customers in the Eastern part of our system. As I have noted before, AEP definitely supports inclusion of nuclear plants as part of our future energy portfolio.

Department of Energy
Washington, DC 20585

March 20, 2008

The Honorable Edward J. Markey
Chairman
Select Committee on Energy Independence
and Global Warming
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

On September 6, 2007, Carl O. Bauer, Director of the National Energy Technology Laboratory, testified regarding: The Future of Coal under Carbon Capture and Trade.

Enclosed are the answers to 17 questions that were submitted by Members of the Committee for the hearing record. The four remaining responses are being prepared and will be forwarded to you as soon as possible.

If we can be of further assistance, please have your staff contact our Congressional Hearing Coordinator, Lillian Owen, at (202) 586-2031.

Sincerely,

Eric Nuson

for Lisa E. Epifani
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q1. Do you think the adoption of a cap and trade program would have a direct impact on the development of new technology in the area of carbon capture and storage?

A1. The success or failure of any regulatory program designed to stimulate commercial deployment of CCS technologies would, of course, depend on many factors, of which cap and trade or other carbon price-raising mechanisms is but one. Weak cap and trade programs with an initial low carbon price would not provide the economic incentive necessary for the deployment of CCS technologies. Strict programs with an initial high carbon price may generate an economic incentive, but before ancillary, but necessary, infrastructure and regulatory issues are resolved, and in the absence of a significantly expanded federal R&D&D program, before the technology is available at costs much lower than those of today. The result would be high economic costs to the country.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q2. Do you think it is realistic to restrict coal in our energy portfolio at this point in time?

A2. It would create a serious problem for electricity supply reliability to restrict coal-fired generation within the Nation's energy portfolio at this point in time. Because the Nation's economic growth and electricity supply growth have long been closely correlated, the inability to increase electricity supply, particularly with competitive coal-fired baseload power generation, would likely have a significant negative impact on U.S. regional economies that would be most impacted by restricting coal-fired generation, and it could affect the Nation's energy security, as well. Natural gas would be the most probable substitute fuel for electricity generation in the near-to-mid term. However, it is also an essential fuel for heating as well as an essential feedstock for chemical and fertilizer production. Further, the Nation's forecast for natural gas supply to the U.S., based on the early release of the Annual Energy Outlook 2008 (AEO08), shows no growth in supply of natural gas from North American sources through 2030. This limitation would lead to greater imports of Liquefied Natural Gas (LNG) to meet the demand for mid-term electricity growth. Since 2005, the AEO energy forecast for LNG supply to the U.S. in year 2025 has fallen by more than half, from 6.37 Tcf per year to 2.98 Tcf. EIA notes in AEO08: *"The lower projection is attributable to two factors: higher costs throughout the LNG industry, especially in the area of liquefaction, and decreased U.S. natural gas consumption due to higher natural gas prices, slower economic growth, and expected greater competition for supplies within the global LNG market."* As recently projected in the NERC 2007 Long-Term Reliability Analysis (October 2007), summer peak capacity margins may be at risk in the near-term (as early as 2009) for several major U.S. regions, and a related concern exists for over-reliance on natural gas resources. Specifically, North American Electric Reliability Corporation (NERC) noted the following regions to be most susceptible: *"Continued high levels of dependence on natural gas for electricity generation in Florida, Texas, the Northeast, and Southern California have increased the bulk power system's exposure to interruptions in fuel supply and delivery. Efforts to address this dependence must be continued and actively expanded to avoid risks to future resource adequacy."* Other options include nuclear power, which over the longer term may be able to fill some of the baseload power needs if coal-fired capacity is constrained.

The development of cost-effective carbon capture and storage technologies, therefore, remains a high priority for the Department.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q3. Given that coal is a bigger challenge in the scheme of climate change because of CO_2 emissions, would you support the development of more nuclear power as we look toward the future in a carbon constrained environment?

A3. Tackling the climate change challenge will require a broad portfolio of technology options to provide power and fuels needed for a growing economy. Reducing greenhouse gas emissions while simultaneously meeting our Nation's electricty demand in an affordable and reliable manner, will require taking advantage of *all* clean energy sources, including clean coal, nuclear power, and renewable energy. Nuclear power may play an important role, but no single technology will be able to reduce greenhouse gas emissions while supplying the energy needed for our growing economy.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q4. Given that most everyone agrees that dependence on foreign energy resources is not the best policy for America, are you concerned about restrictions in using our vast resources of coal?

A4. The Administration's policy for national energy security is based on diversifying not only the types of energy we use, but also the sources of energy we use. Recent experience with near-record levels of global oil prices, in real terms, reinforces the need to maintain a significant potential for effectively using an array of domestic energy resources that will help keep the U.S. secure and economically competitive. Coal is an important element of this potential domestic energy mix. At current reserves and production rates, the U.S. has approximately 250 years of coal available, a tremendous domestic resource. It is important that we develop the technologies to use this resource in an environmentally responsible manner. DOE has long been active in researching and developing clean coal technologies, such as coal gasification and CO_2 sequestration, which today are being seen throughout the world as important technology alternatives to maintain coal in the energy mix, on an environmentally acceptable basis. DOE is also conducting analyses of means to combine these key clean coal technologies with the benefits of co-feeding coal and biomass in electricity and liquid fuel production. Combining these technologies could theoretically achieve at these plants "net negative" carbon emissions, that is, emission reductions greater than 100 percent. The potential benefits of these emerging coal technologies make clear that coal should remain a strong part of the Nation's clean energy strategy.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q7. What are the principal barriers to the commercial deployment of carbon capture technologies?

A7. The two major challenges confronting the development and deployment of carbon capture technologies for both new and existing coal-based power systems are cost and associated energy penalty/parasitic load. Other challenges include: technology scale-up, market considerations/readiness, power plant diversity, reliance on other enabling technologies, process integration, and an uncertain regulatory framework/sequestration issues. These challenges are discussed below.

Cost: There are numerous analyses in literature that estimate the cost of carbon capture and storage. Generally, they all indicate that it is very expensive and, if installed, substantially de-rates the power plant electricity generation capacity. A recent NETL Fossil Energy Baseline Study estimated that adding carbon capture increases the cost of electricity for new natural gas combined cycle (NGCC) plants by 42%, for new pulverized coal (PC) plants about 78% to 86% (depending on the PC plant technology used), and for new integrated gasification combined cycle (IGCC) plants about 36%.

Energy Penalty/Parasitic Load: The energy penalty (or "parasitic load") is the decrease in net power plant efficiency caused by the addition of CO_2 capture and compression technologies. Depending on the CO_2 capture technology employed, the energy penalty is made up of different forms of energy losses to support the CO_2 capture process, such as auxiliary power usage or steam. These losses can be significant and will need to be reduced. The DOE/NETL research goal is to improve carbon capture technologies to the point where they add less than 10% to the coat of providing power (measured by cost-of-energy services). Current carbon capture technologies are energy-intensive and degrade the overall efficiency of power plants, derating a power plant by up to 40% of total generating capacity. This extra "parasitic" load creates the need for substantially more electric power capacity to be built, at a large capital cost, and also more fuel to be used. Through development of more energy efficient capture technologies and related systems (e.g., compressors), the energy penalty would be reduced and lead to improved performance and lower costs.

Technology Scale-up: There are more than 30 small amine scrubbing plants, worldwide, currently capturing CO_2 from flue gas sources (NG and PC fuel) used as feed sources for enhanced oil recovery, the chemical industry, and the food/beverage industries. Some of these plants have been operating for over 20 years. AES's Warrior Run coal-fired power plant in Maryland also captures a small amount of CO_2 from a flue gas slipstream for beneficial use in beverages. The size of the current installations range from less than 50 up to about 1,000 tons of CO_2 captured per day. The Dakota Gasification plant is an outlier, capturing and separating 6,183 tons CO_2/day from gasified coal. These levels are significantly smaller than that required for a full-size PC power plant removing 90% of CO_2 emissions, approximately 13,000 tons CO_2/day. Scale-up of these and other emerging capture technologies have not been demonstrated for typical power generation systems, where much larger gas flows are handled on, an order of magnitude larger than current commercial experience.

Market Considerations/Readiness/Power Plant Diversity: According to the Annual Energy Outlook, the level of base case capacity additions projected for the next 10-15 years reflects a level of construction activity not seen for more than 40 years, and the rate of capacity growth has not been seen for 50 years. There are concerns regarding the engineering, manufacturing, and construction industries' ability to deliver the new capacity in a timely and cost-effective manner. This projected growth in power plant construction would be further challenged by the need for additional capacity to make up for the high parasitic power demand associated with current carbon capture technology, as previously discussed. A second market consideration relates to the ability to ramp-up manufacture of the actual carbon capture technologies. For example, oxy-combustion requires approximately 10,800 tons per day (TPD) of oxygen for a 500-MW power plant. The largest current commercial scale of an air separation unit (ASU) is about 3,500 TPD, implying that three ASUs would be needed per 500-MW power plant. If only 5% of U.S. existing coal-fired power plant capacity converted to oxy-combustion, global ASU manufacture would need to double to meet the demand. Clearly, there is a concern whether the chemicals industry would have the ability to meet this increased demand, especially if a significantly larger proportion of power plants convert to oxy-combustion.

Reliance on Other Enabling Technologies: Some carbon capture technologies will rely on other technologies to enable them to effectively operate. Oxy-combustion relies on the production of oxygen from air to provide a concentrated oxygen stream that, when combusted with coal or as a feed in the production of synthesis gas, results in a highly concentrated stream of CO_2. However, current air separation technology relies on cryogenic operations to produce oxygen, which is capital and energy intensive. Novel oxygen separation concepts would need to be developed, tested, and demonstrated at scales required to meet the demand for oxygen for large power system applications. Other enabling technology devices, such as particulate matter, sulfur dioxide, chlorine, and mercury removal technologies, must also be enhanced for efficient and effective carbon capture.

Process Integration: Advanced carbon capture technologies integrated with other processes and technologies will need to be demonstrated. This integration and demonstration is critical to understand how carbon capture technologies fit into the overall system, test system reliability, improve process control strategies, reduce energy requirements for carbon capture, and optimize materials development efforts. Carbon capture retrofits at existing plants would require that additional land be available to accommodate capture equipment, and separate utility systems, such as cooling water, may be required for the capture equipment operation. Other existing equipment may also have to be modified so that the capture equipment can be incorporated into the plant. Systems analysis studies are required to comprehend the complex interactions of the numerous sub-processes.

Uncertain Regulatory Framework/Sequestration Issues: It is uncertain as to the timing of any future laws and regulations governing CO_2 capture, transportation, and storage. The Department of Energy is working closely with the Environmental Protection Agency to establish a regulatory regime for CO_2 sequestration. The Department of Energy has ongoing programs to evaluate storage media, geographical diversity; storage permanence; monitoring, mitigation, and verification processes.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q8. How do you define "affordable" as you look at technology that you might want to employ in carbon capture?

A8. "Affordable" implies that fossil fuels with CO_2 capture and storage would be competitive with other clean energy technologies. With this in mind, DOE has developed cost goals for the performance of carbon capture systems. These goals are less than a 10% increase in the cost of electricity for pre-combustion carbon capture systems, and less than a 20% increase in the cost of electricity for post-combustion and oxy-combustion carbon capture systems, while capturing at least 90% of plant CO_2 emissions.

Limiting the increase in the cost of producing electricity to 10% for pre-combustion and 20% for post- and oxy-combustion systems would enable fossil fuel systems with CO_2 capture and sequestration to remain viable power generation options meet energy needs while reducing the greenhouse gas intensity of energy supply.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q9. The Energy Policy Act of 2005 provided a 20% investment tax credit for the constructions of IGCC plants, federal loan guarantees for IGCC plants and subsidies for research on technologies including IGCC. Do you support those provisions?

A9. The provisions for IGCC in the Energy Policy Act (EPAct) of 2005 have been beneficial to the power generation industry. IGCC is a promising power generation technology that is highly efficient, has extremely low sulfur dioxide, nitrogen dioxide, and particulate emissions, and provides the lowest cost option for capturing carbon dioxide. The demonstration plants built and successfully operated thus far have been relatively few in number both here in the U.S. and worldwide. IGCC technology and the costs associated with it will benefit from replication at future commercial-sized plants currently underway or in planning.

EPAct 2005 provisions for 20% investment tax credits have resulted in the advancement of a number of projects that will produce 500-1000 MW of electric power and will reduce costs and risks for future users of this technology. The investment tax credits, along with other provisions like research subsidies, can incentivize deployment of IGCC projects that use Western coal after the technology has been demonstrated. The loan guarantee program is currently underway and pre-application responses have been reviewed. Three IGCC project sponsors were selected in the pre-application review to submit full applications for loan guarantees. No full loan guarantee applications have been received at this time. Loan guarantees would shift the risk elements of these proposed projects from the private sector to the government and allow lower-cost financing for new technology projects that the traditional banking community has avoided in recent years.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q11. When we look at current government programs and research in the area of carbon sequestration, are we on the right track? Other than throwing more money in the mix, where would you make improvements or change focus to help bring carbon capture and storage closer to reality?

A11. DOE is taking a leadership role in the development of carbon capture and storage (CCS) technologies. Through its Carbon Sequestration Program (Program) – managed within the Office of Fossil Energy (FE) and implemented by its National Energy Technology Laboratory (NETL) – DOE is developing both core and supporting technologies through which CCS will become an effective and economically viable option for reducing CO_2 emissions. The Program works in concert with other programs within FE that are developing technologies integral to coal-fueled power generation with carbon capture: advanced integrated gasification combined cycle, advanced turbines, fuel cells, and advanced research. Successful R&D would enable carbon control technologies to overcome the various technical, economic, and social challenges, including cost-effective CO_2 capture, long-term stability (permanence) of CO_2 in underground formations, monitoring and verification, integration with power generation systems, and public acceptance.

The year 2007 marks the 10-year anniversary of DOE's Carbon Sequestration Program. Launched in 1997 as a small-scale research effort to ascertain the technical viability of CCS, the Program has grown into a multi-faceted research, development, and demonstration program that aims to provide the means by which fossil fuels can continue to be used for power generation in a carbon-constrained world. The first 10 years have significantly advanced the knowledge base pertaining to CO_2 separation, geologic storage, regulations and permitting, and process economics. Much work remains, however, to enable the large-scale deployment of CCS technologies. In particular, extended field tests, as is being conducted in the Regional Partnerships, are required to fully characterize potential storage sites and demonstrate the long-term storage of sequestered carbon to achieve cost-effective integration with power plant systems.

Looking forward, it is also important to recognize CCS as more than just an end-of-process emissions control technology. CCS technologies represent important elements in the entire energy supply picture, providing CO_2 capture and storage solutions that could help enable sustained fossil fuel conversion, and offer a resource recovery pathway that will facilitate greater recovery of domestic oil, natural gas, and coalbed methane.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q12. How could performance standards be incorporated into the development of new coal-fired power plants?

A12. Performance standards based on state-of the art technologies, proven at commercial scale, could be used to set immediate standards for new coal plant development activity; performance standards for proven technologies that have not reached commercial scale could be used for future standards, assuming success is achieved at commercial scale; aspirational performance goals for developing technologies can be used for R&D goals.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q13. As we look at long term storage of CO_2, have any of you looked at the pipeline needs related to this issue?

A13. CO_2 pipelines are a critical link between carbon capture sources and sequestration (storage) sites and the Department of Energy/National Energy Technology Laboratory (DOE/NETL) is evaluating this important aspect of a carbon capture and storage (CCS) integrated approach. DOE/NETL realizes that if decreasing greenhouse gas (GHG) emissions becomes mandatory and power plants incorporate CO_2 capture technologies, a network of CO_2 pipelines will be necessary to efficiently deliver the captured CO_2 to geologic formations for sequestration, enhanced oil recovery (EOR), enhanced gas recovery, or other commercial uses. DOE/NETL is conducting a study that will review the costs and benefits of expanding the existing CO_2 pipeline network, the challenges (technology, market, regulations, and social) that would be faced in doing so, and how such a system would enhance the development of new carbon markets and technologies for the CCS process steps.

Some infrastructure exists within the mature fields where CO_2-EOR would be implemented, but more would be needed. In addition, pipelines connecting CO_2 sources with the oil fields would be required, even if these were in the same general location. Demonstrations of the carbon capture technology and the advanced geologic storage technologies within the context of EOR could help industry make the case that investments in the needed infrastructure would make business sense and help spur wider commercial application of CO_2-EOR.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q14. What concerns, if any, do you have about the long-term storage of CO_2 in geologic formations? Are you concerned about the legal and regulatory complexities of long-term storage?

A14. In order to undertake sequestration on a wide-scale, industry would need a regulatory framework for carbon capture and storage (CCS) operations. This regulatory framework would need to be adopted by State and Federal Governments. Modifications to existing regulations, or possibly the introduction of new ones, would be needed for Geologic Sequestration to be possible. This would include making changes to the existing Environmental Protection Agency (EPA) Underground Injection Control (UIC) program to modify the existing permitting requirements, or the addition of a new well class for the injection of CO_2 into deep saline formations.

Along with a regulatory framework, a legal framework for understanding and managing long-term liability would be needed to allow industry the ability to move forward with some certainty. The Government, industry, and insurance agencies would need to develop models for long-term liability for post-injection occurrences.

A risk management framework must be established that balances the needs of operators for certainty, while ensuring the protection of the environment and the public health. The legal framework for managing risks associated with long-term CO_2 storage will be required to ensure proper incentives are created for CCS best practices and management.

The Safe Drinking Water Act (SDWA) provides the sole authority for EPA and States to regulate and permit underground injection of fluids to protect underground sources of drinking water. EPA and the States are currently permitting and regulating CO_2 injection operations throughout the U.S. for enhanced oil recovery (EOR) and coalbed methane operations. Modifications to how these projects are permitted would be necessary to account for the long-term storage of CO_2 in these formations. Possible changes to permits issued where CCS and enhanced recovery are coupled would include changes in well construction, site closure, and long-term monitoring requirements. For saline injection projects, it would be necessary for the responsible permitting agencies that administer the existing UIC programs to determine where CO_2 storage operation in saline formations could be permitted through the existing regulations, or that a new class of wells for CO_2 storage operations would need to be developed. In March 2007, the U.S. EPA issued interim guidance for permitting carbon sequestration injection wells under the Regional Carbon Sequestration Partnership pilot projects. DOE is currently working with EPA through an interagency working group on the development of a new well class for carbon sequestration under the SDWA UIC program that would include site selection, well construction, operations, health and safety, site construction and closure, and simulation and monitoring standards.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q15. What do you think is the best way to promote technology development for carbon capture and storage?

A15. There are three primary technology challenges that could impact the widespread deployment of safe carbon capture and storage (CCS) in the United States. They are the need to: 1) greatly reduce the cost of currently available options; 2) prove the practicality, safety, and permanence of storing large volumes of CO_2 in deep geologic formations; and 3) demonstrate the integrated operation of CCS technology at full commercial scale.

The Department's Fossil Energy RD&D Program is addressing each of these areas by: 1) supporting the development of revolutionary technologies in advanced gasification, turbines, membrane separations, and materials, all expected to result in dramatic reductions in CCS costs; 2) supporting a comprehensive program of large-volume CCS field demonstrations covering a broad range of geologies and power plant technology options; and 3) soliciting Clean Coal Power Initiative (CCPI) Round 3 and FutureGen competitive proposals with the anticipation of selecting multiple projects for the full-scale commercial integration of coal-fueled power plant operations with CCS technology.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q16. You have done a lot of research through the Coal Technology Program, what have you learned about the potential cost of commercially available technology to the cost of electricity?

A16. The Department of Energy/National Energy Technology Laboratory (DOE/NETL) recently published a study to establish baseline performance and cost estimates for today's fossil energy plants both with and without carbon capture. (refer to http://www.netl.doe.gov/energy-analyses/baseline_studies.html). The following information is derived from the results of that study. Although the carbon capture technologies assumed in the study have been commercially available for smaller industrial applications, they have not been commercially demonstrated at the large scale necessary for power plants. Both scale-up and integration with the power cycle remain to be demonstrated. According to the analysis, a pulverized coal (PC) plant with carbon capture and storage (CCS) technology would increase the levelized cost of electricity by approximately 75%, when compared to a similar plant without CCS. Depending upon the type of gasifier selected, the levelized cost of electricity for an integrated gasification combined cycle (IGCC) power plant with CCS would be 35-45% higher when compared to a similar plant without CCS. Estimates for the CCS are based on plants designed for approximately 90% carbon capture; after compression, the CO_2 is transported for storage and monitoring. The cost estimate for a PC plant equipped with carbon capture assumes use of a Fluor Econamine Flue Gas (FG) Plus™ process. The cost estimate for IGCC carbon capture assumes a water-gas-shift reactor that converts carbon monoxide to carbon dioxide, and a two-stage Selexol acid gas removal process that separates the hydrogen sulfide and CO_2.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q17. What do you think the appropriate, reasonable time frame is for any proposed mandate for carbon capture and storage for coal plants?

A17. A mandate today that would force the use of commercially available technology is fraught with uncertainty in technical, economic, and environmental risks and would, as a minimum, place an unfair economic burden on our industries and their ability to compete in global markets. By 2012, we expect to have developed advances in technologies such as gasification and oxy-combustion that could significantly reduce the cost burden and risk. These advanced technologies would then be ready for demonstration at commercial scale. By 2016, we expect to have results available from commercial-scale projects such as the Clean Coal Power Initiative (CCPI), and by our Carbon Sequestration Regional Partnerships. These projects will demonstrate technical feasibility, produce reliable economic data, and provide important environmental information, which will help commercial investors to understand and evaluate the risks associated with commercial financing of coal projects with carbon capture and storage. During the decade beginning in 2020, our ability to implement any mandates could be enhanced by improved technologies and real world commercial experience.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q19. I agree that patent and intellectual property agreements are very important as we look at sharing technology world wide. Do you have recommendations on how to protect ourselves as we promote our new technology?

A19. DOE's various funding agreements permit companies to maintain their proprietary technology positions. From an international protection standpoint, the United States Trade Representative may offer suggestions concerning protection in foreign markets.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q20. What kind of regulatory framework do you recommend in advance of investment in order promote technology but not hamstring the industry?

A20. This is a difficult question that requires inputs from all affected stakeholders. However, it is clear that a degree of regulatory certainty at both the State and Federal levels is needed before investments can be realized. The Department of Energy is working closely with the Environmental Protection Agency to establish a Safe Drinking Water Act regulatory regime for CO_2 sequestration that will ensure protection of underground sources of drinking water while not discouraging deployment of this technology. To kick off this process, a Public Workshop on Geologic Sequestration of CO_2 was held December 3-4 in Washington and a second Workshop will be held February 26-27 in Arlington, VA. We expect to be able to provide considerably more information on this process by the summer of 2008.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q21. What about current coal plants? Have you done any research on technologies that will help improve efficiency or reduce emissions at current plants?

A21. DOE's Sequestration Program is addressed by the Offices of Fossil Energy and Science that are looking at the short- and long-term technology needs. The Sequestration Program within Fossil Energy is developing post-combustion carbon capture and sequestration technologies that would be applicable to the existing fleet. Research in this area has historically been funded through Fossil Energy's Carbon Sequestration Program. Approximately $12 million was provided in FY 2007 for the development of CO_2 capture technology, which has potential application to both new and existing pulverized coal-fired boilers. Continued laboratory- through pilot-scale R&D of post-combustion CO_2 capture technology that could be applied to the existing coal-fired power plants is funded in the FY 2008 appropriation for the Carbon Sequestration Program. The FY 2008 Omnibus Consolidated Appropriations Bill provided $36 million in support of post-combustion and oxy-combustion carbon capture as part of the Innovations for Existing Plants Program. DOE's research program is developing technologies in the areas of post-combustion carbon capture and oxy-combustion that are applicable for existing coal-fired power plants.

The following are current R&D projects:

Participation	Project Title	Research Pathway	Scale
	Post Combustion		
Research Triangle Inst.	Dry Regenerable CO_2 Sorbent	Chemical Sorbent	Bench
Carbozyme, Inc.	Biomimetic Membrane	Membrane	Laboratory
Univ. of Notre Dame	Ionic Liquids (IL)	Physical Solvent	Laboratory
UOP LLC	Metal Organic Frameworks (MOF)	Chemical & Physical Sorbent	Laboratory
University of Akron	Amine-grafted Zeolites	Chemical Sorbent	Laboratory
Membrane Technology and Research, Inc.	Novel Polymer Membranes	Membrane	Laboratory
NETL	Solid CO_2 Sorbents	Chemical Sorbent	Bench
NETL	Solid CO_2 Sorbent Reactor Design	Chemical Sorbent	Laboratory
NETL	Ammonia-based Process	Chemical Solvent	Laboratory
NETL	Novel Amine Sorbents	Chemical Sorbent	Laboratory
NETL	MOF CO_2 Membranes	Membrane	Laboratory
NETL	IL and poly(ionic liquids) (PIL)	Physical Solvent	Laboratory
	Oxy-Combustion		
The BOC Group, Inc.	Pilot Test CAR Oxy-combustion Unit	Oxy-combustion	Pilot
B&W	PC Oxy-combustion Pilot Testing	Oxy-combustion	Pilot
SRI	Oxy-fired CO_2 Recycle Retrofit	Oxy-combustion	Bench
Praxair, Inc.	Oxygen Enriched Combustion	Oxy-combustion	Laboratory
NETL/Jupiter Oxygen	PC Oxy-combustion with Integrated Pollutant Removal	Oxy-combustion	Bench
NETL	Oxy-combustion Modeling & Optimization	Oxy-combustion	Laboratory
NETL	Chemical Looping	Oxy-combustion	Laboratory

Internationally, DOE also leads the Carbon Sequestration Leadership Forum, with 22 member governments. The CSLF's main focus is assisting the development of technologies to separate, capture, transport, and store CO_2 safely over the long term, making carbon sequestration technologies broadly available internationally; and addressing broader issues relating to carbon capture and storage, such as regulation and policy.

Department of Energy
Washington, DC 20585

May 15, 2008

The Honorable Edward J. Markey
Chairman
Select Committee on Energy Independence
and Global Warming
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

On September 6, 2007, Carl O. Bauer, Director of the National Energy Technology Laboratory, testified regarding: The Future of Coal under Carbon Capture and Trade.

Enclosed are the remaining answers to four questions that were submitted by the Committee to complete the hearing record.

If we can be of further assistance, please have your staff contact our Congressional Hearing Coordinator, Lillian Owen, at (202) 586-2031.

Sincerely,

Eric Nixon

for

Lisa E. Epifani
Assistant Secretary
Congressional and Intergovernmental
Affairs

Enclosures

QUESTION FROM THE HOUSE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q5. The Energy Information Administration projects that U.S. electricity demand will grow by over 40% by 2030. What do you think is the most efficient, affordable and cleanest way to meet that demand in the future?

A5. Currently there are over 1.6 billion people in the World without access to electricity. Over the next 25 years, world electricity demand is estimated to increase by over 100 percent from today's levels. This challenge will need to be met by coordinated action on a global scale, including the expansion and diversification of our electricity generation and distribution, an increase in efficiency and the modernization of our current infrastructure. The Department of Energy (DOE) has invested in developing advanced technologies to assist this effort to meet future demand. The development of technologies such as solar, wind, nuclear and environmentally responsible electricity generation like coal-fired plants that utilize carbon-capture and sequestration technology are critical to our energy security. The market, not the government, will decide how much each contributes to meeting demand.

EFFICIENCY

President Bush is committed to increasing energy efficiency in a way that both encourages economic growth and helps us protect our environment. The cheapest, most available and environmentally friendly energy source is the energy we waste every day. Due to recent technological advances, there are exciting emerging opportunities to reduce electricity use in homes, commercial buildings, and in industrial facilities. In homes and businesses, which are responsible for 70 percent of electricity demand, efficiency is being increased by making appliance standards more stringent, and by promoting market penetration of advanced technologies. The recently-enacted Energy Independence and Security Act of 2007 includes many provisions which are expected to increase energy savings through improved standards for appliances and lighting and the Department is working hard to implement these new standards by the specified deadlines.

FOSSIL FUELS

The majority of electricity generation in the United States is fueled by fossil energy, specifically domestic coal and natural gas. Continued reliance on coal as our major electricity source will require efforts to reduce the amount of greenhouse gases emitted into the atmosphere. For this reason, the Administration is increasing research and development of carbon capture and storage (CCS) technologies. The President has made the research, development, and implementation of advanced coal technology a priority as evidenced by significant investment in these technologies. Many of these advanced technology programs include pre-combustion (or gasification), post combustion, and oxy-combustion -- multiple pathways to produce power and capture CO_2 -- as well as a robust program for carbon sequestration to prove the viability of long-term geologic and terrestrial storage. DOE is enthusiastic about developing these advanced technologies, and we are currently funding advanced technology activities at regional carbon sequestration partnerships across the U.S.

NUCLEAR ENERGY

Nuclear energy is a key element of the Administration's energy strategy and the President has repeatedly called for a broad expansion of nuclear power. As the only existing emissions-free source of energy capable of providing base load capacity generation, nuclear power will be essential in providing America with a reliable source of energy and reducing greenhouse gas emissions. Through the Nuclear Power 2010 program the Department is working to reduce the technical, regulatory and institutional barriers to deploying new nuclear power plants in the United States. The Federal Government is also working to implement financial incentives in the form of electricity production tax credits and a loan guarantee program to accelerate the construction of new advanced nuclear power plants in this country. Currently, 20 utilities are considering 34 new nuclear reactors. Nine Combined Construction and Operating License applications have been submitted to the Nuclear Regulatory Commission with three Early Site Permits already issued and one under review. During the past 30 years, operators of the 104 U.S. nuclear power plants have steadily improved economic performance through reduced maintenance and operation costs and improved power plant capacity factors, while maintaining operational safety and reliably. Advanced nuclear energy systems, such as Generation IV reactors, can help ensure nuclear power serves a continuing role in the Nation's energy supply as fundamental research and development related to safety, sustainability, cost-effectiveness and proliferation resistance is addressed. While the existing generation of nuclear power plant designs provide a secure and low-cost electricity supply in many markets, further advances in nuclear energy system design can broaden opportunities for the use of nuclear energy.

RENEWABLE ENERGY

Renewable energy technologies are in various states of market readiness. In the future, renewable technologies will change the way we use electricity in our homes and businesses. The Administration has supported R&D on important technologies, such as solar and wind generation.. The Solar America Initiative – as part of the President's Advanced Energy Initiative – sets a goal of making solar power cost-competitive with other forms of renewable electricity by 2015. Certain geothermal technologies are used in some areas and applications however the Department has established a new Geothermal Technology Program that will focus solely on new Enhanced Geothermal System (EGS) technology, which expected to have broad applicability and could provide baseload, indigenous power and contribute to the security and diversity of U. S. energy supplies. A recent DOE-sponsored MIT study concluded that the U.S. has the potential for 100,000 MW of EGS capacity. The use of wind energy has rapidly expanded over the past fourteen years. From 1994 to 2004, global wind energy capacity increased tenfold. Since that time, EIA has reported that new nameplate electricity capacity additions in the U.S. have gone from just 2% to over 30%, some of which was wind energy.

INFRASTRUCTURE

America's aging energy infrastructure - especially the electricity sector's transmission power grid - needs attention. The Bush Administration recognized the importance of this issue in its May 2001 *National Energy Policy* (NEP), and it has devoted significant resources to maintaining and strengthening our electricity transmission grid. Within a year of the Administration's adoption of the NEP, DOE published its comprehensive *National Transmission Grid Study*. Following up on that ground-breaking study, the Energy Policy Act of 2005 authorized DOE to designate National Interest Electric Transmission Corridors in geographic areas in which the Department found that transmission congestion or constraints were adversely affecting consumers. In October 2007, DOE designated the Mid-Atlantic Area and the Southwest Area National Corridors. The modernization of the Nation's electricity transmission system is also being studied under the Smart Grid program. Smart Grid has been further highlighted by the Energy Independence and Security Act of 2007 and is being implemented by the Department. Our strategy for implementation involves the deployment of innovative, smart technologies, supporting both electric transmission and electric distribution. We look to achieve functions such as real-time and digital information; dynamic pricing and optimization of grid operations; integration of smart meters, appliances, and demand side resources; cyber security; and interoperability.

By adding focus to renewable sources of energy, efficiency and infrastructure, the Department of Energy is aggressively addressing the electricity needs of the Nation and the world. This Administration has taken considerable action towards meeting this growing demand, and will remain committed to these solutions as well as our economic growth.

QUESTION FROM THE HOUSE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q6. On the issue of technology, would you agree that it is better to let market forces decide the direction that technology takes? What, if any, government action is necessary to help technology to develop more quickly?

A6. Yes, we agree. Market forces are best at shaping technology choices, particularly at the later stages of technology development. Generally, the government should not choose *a priori* which technologies should be used to meet a goal.

In the early stages of technology development, however, government leadership in technology research and development (R&D) may play an important role. This may be the case where public needs or purposes are compelling, the R&D risks are high, and market failures may hinder private investment, such as when a firm cannot appropriate to itself sufficient value of the public knowledge it creates, or when the benefits to society of the new technologies are not adequately reflected in market prices, such as may be the case of public safety, national security, or environmental protection in the absence of regulatory drivers.

Once new technologies have been developed, commercialization generally falls to private firms. Even so, new technologies can face additional barriers that can restrict their market uptake. Depending upon circumstances, which are often unique to each technology, the use of additional policies and measures may be warranted to facilitate markets or encourage private investment. These include activities such as product labeling, information dissemination, codes and standards, tax policy, financial incentives, risk mitigation, government procurement programs, and the formation of public-private partnerships or international collaborations.

In the cases of energy security and climate change, markets for associated benefits may not be fully developed. The technologies believed to afford the most benefits by reducing or avoiding greenhouse gas emissions, for example, are often too costly without such a market. Additional Federal R&D could be expected to reduce costs and improve technology performance, facilitating broader private engagement in both more R&D, if needed, and accelerating commercialization and product development.

Successful technology development and deployment is a complex process best left to the marketplace. When public needs or purposes are compelling and market failures known, however, there may be a role for the government. In such cases, Federal programs must satisfy additional criteria related to the appropriate presence, scope, and duration of federal involvement. The Administration's Research and Development Investment Criteria provide guidance to agencies on determining the proper role of government in investing in technology development.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q10. Enhanced Oil Recovery is one way to use captured CO_2 to our advantage. Do you support EOR? Do you see other applications for the use of CO_2 in this way?

A10. Yes, the Department through the National Energy Technology Laboratory supports enhanced oil recovery (EOR). DOE has funded RD&D related to CO_2 flooding for over 30 years and now focuses on permanent geologic storage as a co-benefit of EOR, since EOR is a mature but evolving technology.

Although much of the Nation's onshore petroleum resource has been produced, large volumes of crude oil remain after primary production methods are exhausted, held in place by physical forces or geologic complexities that can be countered by EOR technologies. Some DOE research focuses on technologies to lower the cost of CO_2 from coal power plants. The total volume of stranded oil is estimated to exceed 390 billion barrels, of which roughly 200 billion barrels are relatively accessible (<5,000 feet deep) but are not located near a natural source of CO_2. In 2007, the U.S. produced its one-billionth barrel of oil using CO_2 EOR. Like methane, carbon dioxide is a natural constituent of natural gas. A few gas reservoirs contain essentially pure CO_2. Most of the CO_2 utilized by EOR projects comes from these naturally-occurring CO_2 reservoirs, transported to the oil field via a CO_2 pipeline network. Developing the advanced technologies needed to capture CO_2 and utilize it in EOR projects while assuring permanent storage is a way to significantly increase U.S. oil production and simultaneously sequester significant volumes of CO_2.

CO_2 can also be used to increase natural gas production from coalbed methane wells by enhancing recovery efficiency as the CO_2 molecules displace methane molecules within the coal seam. This will also result in the CO_2 becoming absorbed on coal surfaces and stored in the seam. An additional use of CO_2 for energy development could be in the extraction of hydrocarbons from oil shale.

QUESTION FROM THE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

Q18. Do you think that Enhanced Oil Recovery can help create a market that will drive energy companies to capture their carbon emissions? What can Congress do to help that happen?

A18. Yes, enhanced oil recovery (EOR), an established technology, as well as improvement of enhanced gas recovery (EGR) and enhanced coalbed methane recovery (ECBM) technologies, could help create a market for a limited amount of captured CO_2. Use of CO_2 from power plants for EOR is limited by the cost of capture and requires plants in close proximity to EOR oil fields. As a result only a small fraction of U.S. CO_2 emissions are expected to be used for EOR, even with technology advances. However, EOR is the low-hanging fruit in the market for captured CO_2, and it could be used to jump start the carbon capture market. Achieving this will require the value of the incremental oil or natural gas produced to more than cover the cost of capturing and transporting the CO_2 to the targeted oil or gas fields or coalbed methane projects, as well as the capital investments for pipelines, wells and facilities required as well as an acceptable return on investment. Companies and financial markets currently unfamiliar with carbon sequestration will also need to become fully aware of and manage the risks inherent in this type of investment. Congress can help to make this happen in several ways: 1) continue support of DOE-funded R&D for new technologies that reduce the cost of capturing CO_2 and ensure the permanence of CO_2 storage in the EOR, EGR, or ECBM projects; 2) support development and demonstration of Monitoring, Mitigation, and Verification (MMV) technologies for use during enhanced recovery, subsequent storage, and post-storage closure operations; 3) work with the Executive Branch to develop regulatory and permitting processes and establish greater regulatory certainty for both storage and post-storage closure operations.

RESPONSES OF ROBERT M. SUSSMAN, SENIOR FELLOW, CENTER FOR AMERICAN PROGRESS, TO FOLLOW-UP QUESTIONS ON CARBON CAPTURE AND STORAGE FROM THE HOUSE SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING

1) Do you think the adoption of a cap and trade program would have a direct impact on the development of new technology in the area of carbon capture and storage?

   Answer: By requiring the purchase of allowances by uncontrolled coal plants, a cap-and-trade program would create incentives for coal plants to reduce their emissions. Carbon capture and storage (CCS) is the only known technology by which emissions from coal plants could be reduced and a cap-and-trade program would encourage its adoption. However, the cost per ton of deploying CCS as compared to conventional coal plants is likely to exceed the price of CO2 allowances during the early years of a cap-and-trade program and perhaps much longer if allowance prices remain low. That's why our paper *Global Warming and the Future of Coal* recommends coupling an emission performance standard for new coal plants based on the best performing CCS technology with subsidies to offset the cost differential between CCS and traditional coal plants.

2) Do you think it is realistic to restrict coal in our energy portfolio at this point in time?

   Answer: Coal has traditionally been an important fuel in the US (it currently provides 50% of our electricity) and should play a role in our future energy mix. However, coal power plants are major CO2 emitters and are more carbon-intensive than other sources of electricity. As we discuss in *Global Warming and the Future of Coal,* if a substantial number of new coal power plants are built which do not control their emissions, we will add millions of tons of CO2 emissions to existing levels, compromising our ability to achieve the necessary long-term reductions in our carbon footprint. This is true in the US but even more significant in developing countries like China, where new coal plants are being built at an alarming rate. That's why, domestically and globally, CCS is an essential technology that must be a requirement for any expansion of coal generating capacity.

3) Given that coal is a bigger challenge in the scheme of climate change because of CO2 emissions, would you support the development of more nuclear power as we look toward the future in a carbon constrained environment?

   Answer: Because nuclear power has lower lifecycle greenhouse gas emissions than coal, it offers benefits. However, nuclear also poses challenges, including concerns over safety, long-term waste storage, and proliferation, all of which must be met before wider

deployment of nuclear power can achieve broad pubic acceptance. Renewable sources of energy also have low lifecycle emissions, but do not raise the same issues of public acceptance.

4) Given that most everyone agrees that dependence on foreign energy resources is not the best policy for America, are you concerned about restrictions in using our vast resources of coal?

Answer: Because it is a widely available domestic fuel, coal has national security advantages that natural gas (which we are importing in growing quantities) lacks. However, coal can only remain an important source of energy if we are able to achieve substantial emission reductions through CCS. Additionally, as we consider the nation's future energy mix, we also need to emphasize the role of renewables and reduce energy demand through greater energy efficiency.

5) The Energy Information Administration projects that U.S. electricity demand will grow by over 40% by 2030. What do you think is the most efficient, affordable and cleanest way to meet that demand in the future?

Answer: There is no single energy source that can meet future electricity demand. We need multiple technologies and strategies, including significant increases in the efficiency of electricity production, transmission, storage, and consumption. A cap-and-trade program, backstopped by emission performance standards and incentives for clean power and efficiency, will guide us toward the optimum mix of energy sources, considering cost, reliability and environmental sustainability.

6) On the issue of technology, would you agree that it is better to let market forces decide the direction that technology takes? What, if any, government action is necessary to help technology to develop more quickly?

Answer: Government should be supporting the energy sources with the greatest potential to meet energy demand with a small carbon footprint. This type of public investment is necessary to maximize the benefits of these technologies by making them competitive early in their commercial life cycles and achieving the scale necessary for widespread deployment at a low cost. Government support can take a variety of forms. Traditional incentives like RD&D funding, tax credits, loan guarantees and grants, should continue to play a role. In addition, a cap-and-trade program can incentivize new technologies by placing a price on carbon, thereby encouraging low carbon energy sources, and using the revenues from allowance auctions to provide financial support to CCS and other promising low-carbon technologies.

7) What are the principal barriers to the commercial deployment of carbon capture technologies?

Answer: One barrier is the lack of large-scale experience capturing carbon at commercial generating facilities. A number of demonstration projects underway in the US and in other countries will help fill this gap. Current capture technology is also very energy-intensive, leading to a loss of power plant efficiency and increased costs to produce electricity. These costs should come down with further R&D and greater commercial experience. In *Global Warming and the Future of Coal,* we propose to offset the increased cost of CCS facilities as compared to conventional coal plants during the initial years of a cap-and-trade program until CCS becomes cost-competitive due to rising allowance prices and improvements in the technology.

8) How do you define "affordable" as you look at technology that you might want to employ in carbon capture?

Answer: Affordability ultimately turns on the cost of producing power and the price of electricity to consumers. In the case of CCS, our goal should be for coal plants with CCS to be cost-competitive with conventional coal plants under a cap-and-trade program. This does not mean that there will be no cost increases. Rather, plants with CCS should produce electricity at the same cost as conventional plants, taking into account the costs these plants will incur to purchase allowances under a cap-and-trade program. The CCS subsidies we have proposed would be designed to achieve cost parity in this sense. Insofar as there are increases in electricity costs that consumers will pay because of the underlying price of carbon, we should explore programs to provide financial relief from these costs to low- and middle-income consumers.

9) The Energy Policy Act of 2005 provided a 20% investment tax credit for the constructions of IGCC plants, federal loan guarantees for IGCC plants and subsidies for research on technologies including IGCC. Do you support those provisions?

Answer: Yes.

10) Enhanced Oil Recovery is one way to use captured CO2 to our advantage. Do you support EOR? Do you see other applications for the use of CO2 in this way?

Answer: EOR use of CO2 has a long history and is both safe and economical. There is no doubt that some portion of captured CO2 will be used for EOR and that the resulting revenues from higher oil or gas production will offset and perhaps exceed the costs of capture. There are other potential applications for captured CO2 that could be feasible although they are not as mature as EOR.

11) When we look at current government programs and research in the area of carbon sequestration, are we on the right track? Other than throwing more money in the mix, where would you make improvements or change focus to help bring carbon capture and storage closer to reality?

Answer: The cancellation of the FutureGen project was a step in the wrong direction. We need as many large-scale CCS demonstration projects as possible. While some utilities in the US and other countries are undertaking these projects, we need more. The jury is out on whether the Administration's plans to redirect FutureGen funding to support CCS projects at commercial facilities will pay any dividends before the end of the Administration. The recent energy legislation also calls on DOE to undertake large-scale sequestration testing at 5-7 sites but the Administration's FY 09 budget request did not call for sufficient funding for this testing. Congress needs to appropriate more for this program.

12) How could performance standards be incorporated into the development of new coal-fired power plants?

Answer: As discussed in my testimony and in *Global Warming and the Future of Coal,* I strongly support emission performance standards for new coal-fired power plants which require these plants to meet an emission rate corresponding to the best performing commercially available CCS technology, currently estimated to be 85% capture. Allowing new uncontrolled coal plants to be built will result in a long-term increase in CO2 emissions that would make it more difficult and costly to meet the emission reduction targets of cap-and-trade legislation. Since CCS plants will probably not be cost-competitive in the early years of cap-and-trade legislation, an emission performance standard will accelerate deployment if coupled with subsidies to offset the additional costs of CCS plants as compared to conventional facilities, after the costs of purchasing allowances are taken into account. Our proposal is that an emission performance standard apply to all new plants entering construction after the legislation takes effect. The standard would then need to be met by 2016 or four years after a plant becomes operational, whichever is later.

13) As we look at long term storage of CO2, have any of you looked at the pipeline needs related to this issue?

Answer: I have not studied this issue.

14) What concerns, if any, do you have about the long-term storage of CO2 in geologic formations? Are you concerned about the legal and regulatory complexities of long-term storage?

Answer: Most experts believe that CO2 can be stored without significant leakage and harm to environmental resources over long periods of time in geological formations that have been properly characterized and permitted and will be effectively monitored. Putting in

place a comprehensive legal and regulatory framework for CCS is essential. EPA is now developing regulations for CCS under the Safe Drinking Water Act UIC program but Congress may need to step in to address liability and other issues that are outside EPA's jurisdiction.

15) Do you acknowledge that setting high prices for carbon will inherently cause the price of energy to go up for consumers?

Answer: No. We can control electricity costs by encouraging greater energy efficiency, using allowance auction revenues to offset the increased costs of CCS and other new technologies, and providing financial assistance to low- and middle-income consumers. As the costs of new low-emitting technologies come down, any increased burden on electricity consumers should moderate.

16) What do you think the appropriate, reasonable time frame is for any proposed mandate for carbon capture and storage for coal plants?

Answer: For new coal plants, a reasonable time frame for applying an emission performance standard that effectively requires CCS is 2015-2020. This is the general timetable proposed in my testimony and in *Global Warming and the Future of Coal.* It is supported by industry leaders and independent experts. In the next 7-8 years, assuming adequate government support and industry commitment, we should have sufficient experience with CCS through demonstration projects and site testing to justify deployment at all new coal plants. With subsidies to offset the increased costs of CCS as compared to conventional coal plants, the economic burden of requiring CCS should be manageable. Importantly, an emission performance standard will prevent construction of high-emitting conventional plants and accelerate improvement in CCS technology, bringing down costs sooner and creating a foundation for technology transfer to large emitters like China and India.

17) I share your optimism about the potential for carbon capture and storage, but do you have concerns about the environmental liability of carbon sequestration?

Answer: Most experts believe that the potential for long-term leakage and harm to environmental resources at properly characterized and monitored sequestration sites is negligible. However, the industry's concern about liability is understandable and should be addressed by Congress.

18) Do you agree that we need to remain technology neutral as we make policy decisions related to carbon capture and sequestration? What is the best way to do that?

Answer: I agree that we should not be favoring one type of coal combustion technology (IGCC, pulverized coal or oxy-fuel) over another and, at least in the early years, should recognize that different coal types have different characteristics that may affect the feasibility and cost of capture. The emission performance standard we have recommended would be technology neutral: it would not dictate what type of combustion or capture technology must be employed but would simply require the specified emission capture rate to be met.

19) You note on page 5 of your testimony that "the slowdown in new coal plant construction is not necessarily a positive development. One consequence may be a delay in adding new generation capacity nationwide which could hurt grid reliability and increase the cost of peak generation as demand for power grows." Given that concern, would you support streamlining the permit process for new coal plants if they were IGCC plants as a reward for companies who chose to build IGCC plants?

Answer: I would not streamline the permitting process for IGCC or PC plants that do not in fact capture and sequester their emissions. For plants that do employ CCS and will comply with an emission performance standard, some streamlining may be appropriate if it does not compromise emission control requirements for conventional pollutants (mercury, SO2 and NOx, among others).

20) Do you support tax incentives or loan guarantees to assist companies in pursuing new technologies?

Answer: Yes, providing these incentives will contribute to early, cost-effective deployment of CCS and other low carbon electricity technologies.

THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

Dear Mr. Hawkins,
Following your appearance in front of the Select Committee on Energy Independence and Global Warming, members of the committee submitted additional questions for your attention. I have attached the document with those questions to this email. Please respond at your earliest convenience, or within 2 weeks. Responses may be submitted in electronic form, back to me at aliya.brodsky@mail.house.gov. Please call with any questions or concerns.

Thank you,
Ali Brodsky
Chief Clerk
Select Committee on Energy Independence and Global Warming

1) Do you think the adoption of a cap and trade program would have a direct impact on the development of new technology in the area of carbon capture and storage?

A: Adoption of an adequate cap and trade program will directly stimulate increased investment in carbon capture and disposal. Absent a requirement to limit CO2 emissions there is no economic reason to deploy carbon capture except to meet the relatively modest demands for enhanced oil recovery.

2) Do you think it is realistic to restrict coal in our energy portfolio at this point in time?

A: There is no current proposal of which we are aware to directly limit the use of coal as a means of addressing global warming pollution. We believe that energy and climate policy should not pick a particular resource but rather should create a structure where resources that neither increase global warming pollution nor cause other damage to health or the environment are rewarded in the marketplace. Major cuts in CO2 emissions can be achieved without requiring major cuts in coal consumption. If CO2 from coal use is captured and permanently disposed of in geologic formations there is no inherent conflict between continued use of coal and protection of the earth's climate system. Today's coal use patterns also involve a number of abuses that should be corrected regardless of the amount of coal that we use.

3) Given that coal is a bigger challenge in the scheme of climate change because of CO2 emissions, would you support the development of more nuclear power as we look toward the future in a carbon constrained environment?

A: NRDC's position on nuclear power is that it is a mature technology that should not receive additional subsidies. For nuclear power to play a significant role as a CO2 mitigation technique, a number of challenges, including costs, waste management and proliferation risks, will need to be overcome. NRDC is not optimistic that these challenges can be overcome in the timeframe needed for large-scale deployment of low carbon energy resources. We believe that energy efficiency, renewable energy and carbon capture and disposal can be deployed more rapidly and at lower costs to society.

4) Given that most everyone agrees that dependence on foreign energy resources is not the best policy for America, are you concerned about restrictions in using our vast resources of coal?

A: Please see the answer to question number 2 above. The most rapid way to reduce our dependence on foreign energy resources is to invest in energy efficiency and renewable energy. These are homegrown resources that do not depend on the whim of any foreign power. Current impacts associated with coal production and uses are unnecessarily and unacceptably large. Reducing these impacts is feasible and will not deprive us of needed domestic resources, including coal, as appropriate, considering all relevant impacts and costs. The choice between protecting the climate and reducing our dependence on foreign energy resources is a false one. We have numerous options that are both domestic and cleaner than today's energy mix.

5) The Energy Information Administration projects that U.S. electricity demand will grow by over 40% by 2030. What do you think is the most efficient, affordable and cleanest way to meet that demand in the future?

A: First, we need to recognize that the EIA forecast for electricity demand starts with assumptions about economic growth and then estimates the resulting added demand for electricity, *assuming a continuation of past investment patterns.* Greater attention to efficient design of buildings, appliances and industrial machinery is the lowest cost, fastest and cleanest step we can take to meet the demand for electricity services in a growing economy while avoiding large increases in global warming emissions. More broadly, the President's budget asserts that energy efficiency has the technical potential to effectively flatten total U.S. energy demand through 2030 without impeding economic growth. See, DOE, FY 2009 Congressional Budget, Energy Efficiency and Renewable Energy Overview at 23.

6) On the issue of technology, would you agree that it is better to let market forces decide the direction that technology takes? What, if any, government action is necessary to help technology to develop more quickly?

A: In general we believe that government should set protective performance criteria for energy technologies to meet and rely on the private sector to find efficient ways to provide technologies that meet those criteria. In the context of climate change, the critical criterion is a continuing improvement in reducing greenhouse gas emissions per unit of activity. These performance criteria can be set through multi-sector caps, industry-specific performance standards or a combination of these measures. Because we have delayed too long in beginning the process of the transition to low and zero carbon energy technologies, we believe there is a need for performance standards and targeted financial incentives as a complement to a cap and trade program in order to accelerate deployment of cleaner energy investments.

7) What are the principal barriers to the commercial deployment of carbon capture technologies?

A: Far and away the largest barrier is the absence of a requirement or financial reason to deploy this technology. Where there is a financial reason to separate CO2 from industrial gas streams it is done, as in a number of natural gas processing plants. Where there is a financial rationale to inject large volumes of CO2 into geologic formations it is done, as in the decades old practice of enhanced oil recovery. By enacting emissions cap legislation with appropriate complementary measures, Congress and the President could eliminate the policy barrier to carbon capture and disposal deployment with the stroke of a pen. EPA too has a role to play through prompt development of regulations governing the permitting and operational requirements for geologic repositories. Also important are stepped up efforts to educate policymakers, investors and the public about the substantial knowledge base that exists to assure that geologic disposal can be done safely and effectively.

8) How do you define "affordable" as you look at technology that you might want to employ in carbon capture?

A: It is highly likely that the first generation of carbon capture systems will be more expensive than projects that are deployed later, after learning has occurred. We believe that the most effective way to assure that the first generation of projects is "affordable" is to spread the incremental costs of such projects broadly across the electric power sector. By doing this, we can secure the national benefits of avoiding emissions and acquiring the experience required to reduce costs without imposing the incremental costs of such first generation projects exclusively on the customers of the firms that build and operate the first projects. Congress has at its disposal a number of policy tools to achieve such cost-sharing, including targeted allocations of greenhouse gas allowances and low carbon portfolio standards, which I describe in my testimony.

9) The Energy Policy Act of 2005 provided a 20% investment tax credit for the constructions of IGCC plants, federal loan guarantees for IGCC plants and subsidies for research on technologies including IGCC. Do you support those provisions?

A: Rather than subsidize IGCC or other technologies, we believe a superior approach is to provide subsidies based on environmental performance, expressed as minimum capture percentage requirements or emission performance standards or a combination of these approaches. The Energy Independence and Security Act of 2007 moves in this direction. The Lieberman-Warner Climate Security Act, S.2191, more fully embraces this approach by providing allowance allocations and auction proceeds for projects that meet low carbon performance criteria.

10) Enhanced Oil Recovery is one way to use captured CO2 to our advantage. Do you support EOR? Do you see other applications for the use of CO2 in this way?

A: We do believe that EOR is a good opportunity to produce additional domestic supplies without expanding into areas the public wishes to protect from industrial development. If the CO2 used in EOR is captured from industrial sources and care is taken to operate the EOR project to provide permanent CO2 disposal, EOR can also provide significant reductions in CO2 emissions. However, today about 80% of EOR CO2 comes from natural underground reservoirs so the use of that CO2 in EOR does not result in any emission reduction. In addition, current EOR practices are not designed to assure permanent retention of maximum amounts of CO2, nor are current regulatory systems designed to assure these results. However, with CO2 captured from industrial sources and with a revised regulatory regime to assure permanent retention, EOR can play a modest but important role in achieving emission reductions. Regarding additional opportunities to "sequester" CO2 through commercial or industrial uses, we agree with the IPCC assessment that there are not now significant opportunities.

11) When we look at current government programs and research in the area of carbon sequestration, are we on the right track? Other than throwing more money in the mix, where would you make improvements or change focus to help bring carbon capture and storage closer to reality?

A: My testimony summarizes the most important actions. Congress should enact comprehensive cap and trade legislation including complementary policies to spur rapid deployment of carbon capture and disposal systems. Rather than relying on the appropriations process, which provides inadequate and uncertain financial incentives for these technologies, we believe funding to assure early deployment of these systems should be provided through dedication of auction proceeds and/or allocation of allowances under a comprehensive emissions cap program.

12) How could performance standards be incorporated into the development of new coal-fired power plants?

A: NRDC and others have argued that no new coal plants should be constructed without applying highly-effective CO2 capture systems and geologic disposal of the captured CO2. Performance standards expressed as a maximum of X pounds of CO2 per megawatt hour can achieve this result. EPA has the authority to adopt such standards under the current Clean Air Act. We believe Congress should complement this authority by adopting minimum performance standards as part of a comprehensive cap and trade bill, as discussed in my testimony.

13) As we look at long term storage of CO2, have any of you looked at the pipeline needs related to this issue?

A: In a recently published technical report based on a previous peer reviewed journal article of his looking at large scale commercial adoption of CCS in the U.S., Jim Dooley of the Joint Global Change Research Institute estimates that if nearly all U.S. fossil power plants were equipped with carbon capture by 2050, about 120,000 miles of CO2 pipelines would be required by 2050, with about 30,000 miles deployed by 2030. This compares to over 400,000 miles of major natural gas and oil pipelines that were built in the U.S. in the last 50 years. The authors conclude that the need to build this amount of pipelines "should not pose a significant barrier for the commercial deployment of CCS in the U.S." Dooley, et al., "Comparing Existing Pipeline Networks with the Potential Scale of Future U.S. CO2 Pipeline Networks," Pacific Northwest National Laboratory, PNNL-17381, February 2008.

14) What concerns, if any, do you have about the long-term storage of CO2 in geologic formations? Are you concerned about the legal and regulatory complexities of long-term storage?

A: I personally started to study the question of permanent disposal of CO2 in geologic formations about 11 years ago. At the outside of my inquiries I was quite skeptical that we possessed enough knowledge to assure permanent disposal of injected CO2. The literature and industry experience demonstrates a very broad knowledge base that provides a high level of assurance that if existing knowledge is applied to carefully select and operate large-scale geologic injection projects, such projects can safely and effectively keep CO2 from fossil fuel use at large stationary sources out of the atmosphere for adequately long periods of time. I do not believe the legal and regulatory issues involved in permanent disposal are significantly more complex than with other large industrial operations. Most assessments of the risks of geologic CO2 disposal that I am familiar with indicate that the risks from geological disposal are comparable to other industrial operations in the near-term (first 50 years) and rapidly tail off after that period.

15) On page 5 of your written testimony you state that the NRDC "opposes new coal plants that do not capture their CO2 and supports rapid deployment of capture and disposal systems for any new coal sources." Is this position related to plants in China and India as well?

A: We believe that we should avoid building new coal plants that do not capture CO2 regardless of the country where they are built. As is well known, China and India are building large amounts of new coal plants today and are forecast to build huge amounts of new coal capacity in the near future. It is critical that China and India embrace CO2 capture for any new coal plants as soon as possible. The issue is what is the most effective strategy to make that happen. We believe the U.S. can help speed this embrace of CO2 capture and disposal by leading the way on deployment of this technology here at home and promoting international programs to create incentives for early deployment in countries like China, India, and other fast growing economies that rely on coal.

16) What do you consider a "very modest impact on retail electricity?"

A: According to analyses we have participated in, with cost-sharing, a substantial amount of coal capacity with carbon capture and geologic disposal can be deployed by 2020 with an impact on average retail electricity rates of less than 5%.

17) When looking at environmental policy, does the NRDC consider the impact of the policies that they promote on jobs in the US?

A: Yes. NRDC was founded 38 years ago in 1970. We fully understand and support job creation and robust economic growth as core continuing objectives for the U.S. During the four decades since NRDC's founding we have followed closely the claims about job impacts associated with a broad range of environmental policy reforms and we have made our own assessments. We believe that the experience of the past four decades convincingly demonstrates that there is no conflict between our economic objectives and the imperative of protecting the environment that sustains us.

18) Would you support streamlining the permit process for new coal plants if they were IGCC plants as a reward for companies who chose to build IGCC plants?

A: First, it is important to distinguish between IGCC, which is a particular technology, and the objective of achieving low-carbon emissions from power generation, which is a performance target. We strongly support policies and incentives to deploy low-carbon energy technologies, including IGCC when it is accompanied by carbon capture and disposal. We do not believe that permit processes for such projects are a significant barrier to deployment. Rather, as discussed above, we believe the primary barrier to deployment is the absence of requirements and economic incentives for deployment of these technologies.

19) In North Wales, a system had been developed which captures car exhaust emissions which is released into a bioreactor, fed to algae, which are then crushed to make biodiesel. Does your organization support this type of sustainable system for carbon capture in automobiles?

A: We do not have details regarding this system. Capturing and storing CO2 onboard a vehicle would be extremely challenging due to the volume and weight of CO2 produced from combusting a tank of gasoline.

20) In the United States, there are several developing technologies for the use of carbon capture in power plants that is used for growth of algae which is crushed to make biodiesel. Does your organization support this type of sustainable system for carbon capture in power plants?

A: We are familiar with projects that feed power plant CO2 streams to algae colonies. If these systems are shown to be reliable and cost-effective they would be capable of achieving modest reductions in emissions from existing power plants. They cannot achieve sufficient reductions to be effective as a method of mitigating emissions from new fossil power plants.

Center for American Progress

Global Warming and the Future of Coal

The Path to Carbon Capture and Storage

Ken Berlin and Robert M. Sussman

May 2007

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GLOBAL WARMING AND THE FUTURE OF COAL

The Path to Carbon Capture and Storage

By Ken Berlin and Robert M. Sussman

Bracken Hendricks, Project Manager

Center for American Progress

May 2007

The point of greatest peril in the development of a high-tech market lies in making the transition from an early market dominated by a few visionary customers to a mainstream market dominated by a large block of customers who are predominately pragmatists in orientation. The gap between these two markets, heretofore ignored, is in fact so significant as to warrant being called a chasm.[1]

– Geoffrey Moore

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Executive Summary

Ever-rising industrial and consumer demand for more power in tandem with cheap and abundant coal reserves across the globe are expected to result in the construction of new coal-fired power plants producing 1,400 gigawatts of electricity by 2030, according to the International Energy Agency. In the absence of emission controls, these new plants will increase worldwide annual emissions of carbon dioxide by approximately 7.6 billion metric tons by 2030.[2] These emissions would equal roughly 50 percent of all fossil fuel emissions *over the past 250 years*.

In the United States alone, about 145 gigawatts of new power from coal-fired plants are projected to be built by 2030, resulting in CO_2 emissions of 790 million metric tons per year in the absence of emission controls. By comparison, annual U.S. emissions of CO_2 from *all* sources in 2005 were about 6 billion metric tons.[3]

Policymakers and scientists now recognize that the current growth of greenhouse gas emissions must be reversed and that emissions must be reduced substantially in order to combat the risk of climate change. Yet a dramatic increase in coal-fired power generation threatens to overwhelm all other efforts to lower emissions and virtually guarantees that these emissions will continue to climb. This would preclude any possibility of stabilizing greenhouse gas concentrations in the atmosphere at levels that would acceptably moderate the predicted rise in global temperatures.

In China and other developing countries experiencing strong economic growth, demand for power is surging dramatically, with low-cost coal the fuel of choice for new power plants. Emissions in these countries are now rising faster than in developed economies in North America and Europe: China will soon overtake the United States as the world's number one greenhouse gas emitter. With the power sector expanding rapidly, China and India will fall further behind in controlling greenhouse gas emissions unless new coal plants adopt emission controls. Lack of progress in these countries would doom to failure global efforts to combat global warming.

The Promise of Carbon Capture and Storage

Fortunately, there is a potential pathway that would allow continued use of coal as an energy source without magnifying the risk of global warming. Technology currently exists to capture CO_2 emissions from coal-fired plants before they are released into the environment and to sequester that CO_2 in underground geologic formations. Energy companies boast extensive experience sequestering CO_2 by injecting it into oil fields to enhance oil recovery. Although additional testing is needed, experts are optimistic this practice can be replicated in saline aquifers and other geologic formations that are likely to constitute the main storage reservoirs for CO_2 emitted from power plants.

However, these so-called carbon capture and storage, or CCS systems, require modifications to existing power plant technologies. Today the prevailing coal-based generation technology in the United States is pulverized coal, with high-temperature (supercritical and ultra-supercritical) designs available to improve efficiency. It is possible to capture CO_2 emissions at these pulverized coal units, but the CO_2 capture technology currently has performance and cost drawbacks.

But there's a new coal-based power generation technology, Integrated Gasification Combined Cycle, or IGCC, which allows CCS systems in new plants to more efficiently capture and store CO_2 because the CO_2 can be removed before combustion. Motivated by this advantage, some power plant developers have announced plans to use IGCC technology but very few have committed to installing and operating CCS systems.

The great challenge is ensuring that widespread deployment of CCS systems at new IGCC and pulverized coal plants occurs on a timely basis. Despite growing recognition of the promise of carbon capture and storage, we are so far failing in that effort. The consequences of delay will be far-reaching—a new generation of coal plants could well be built without CO_2 emission controls.

Barriers to the Adoption of Carbon Capture and Storage Systems

Industry experts today are projecting that only a small percentage of new coal-fired plants built during the next 25 years will use IGCC technology. IGCC plants currently cost about 20 percent to 25 percent more to build than conventional state-of-the-art coal plants using supercritical pulverized coal, or SCPC, technology. What's more, because experience with IGCC technology is limited, IGCC plants are still perceived to have reliability and efficiency drawbacks.

More importantly, IGCC plants are not likely to capture and sequester their CO_2 emissions in the current regulatory environment since add-on capture technology will reduce efficiency and lower electricity output. This will increase the cost of producing electricity by 25 percent to 40 percent over plants without CCS capability.[4]

These barriers can be partially overcome by tax credits and other financial incentives and by performance guarantees from IGCC technology vendors. Even with these measures, however, it is unlikely that IGCC plants will replace conventional coal plants in large numbers or that those plants which are built will capture and store CO_2. There are two reasons for this.

First, even cost-competitive new technologies are usually not adopted rapidly, particularly in a conservative industry such as the utility sector, where the new technology is different from the conventional technology. This is the case with IGCC plants, which are indeed more like chemical plants than traditional coal-fired plants.

Second, there is now no business motivation to bear the cost of CCS systems when selecting new generation technologies even though the cost of electricity from IGCC plants is in fact lower than from SCPC plants once CCS costs are taken into account. This is because plant owners are not required to control greenhouse gas emissions and CCS systems are unnecessary for the production of power. The upshot: IGCC units (with and even without CCS capability) will lack a competitive edge over SCPC units unless all plant developers are responsible for cost-effectively abating their CO_2 emissions. No such requirement exists today.

A New Policy Framework to Stimulate the Adoption of CCS Systems

This paper considers how best to change the economic calculus of power plant developers so they internalize CCS costs when selecting new generation technologies. Five policy tools are analyzed:

- Establishing a greenhouse gas cap-and-trade program
- Imposing carbon taxes
- Defining CCS systems as a so-called Best Available Control Technology for new power plants under the Clean Air Act's New Source Review program
- Developing a "low carbon portfolio" standard that requires utilities to provide an increasing proportion of power from low-carbon generation sources over time
- Requiring all new coal power plants to meet an "emission performance" standard that limits CO_2 emissions to levels achievable with CCS systems.

Each of these tools has advantages and drawbacks but an emission performance standard for new power plants is likely to be most effective in spurring broad-scale adoption of CCS systems.

In the current U.S. political environment, a cap-and-trade system is unlikely to result in a sufficiently high market price for CO_2 (around $30 per ton) in the early years of a carbon control regime to assure that all coal plant developers adopt CCS systems. At lower carbon prices, plant developers could well conclude that it is more economical to build uncontrolled SCPC plants and then purchase credits to offset their emissions. A carbon tax that is not set at a sufficiently high level likely would have the same consequences.

An emission performance standard for new power plants is likely to be most effective in spurring broad-scale adoption of carbon capture and storage systems

A low carbon portfolio standard would be complex and difficult to implement because of the wide variations in generation mix between different regions. Moreover, unless the standard sets stringent targets for low carbon generation, it would not preclude construction of uncontrolled coal plants.

Although the recent Supreme Court decision defining CO_2 as a "pollutant" has opened the door to controlling new power plant emissions under the New Source Review program, legal uncertainties may prevent the Environmental Protection Agency from defining CCS systems as the Best Available Control Technology under current law. Individual states could also reject CCS systems during permitting reviews. Moreover, the New Source Review program would not allow flexible compliance schedules for installing and operating CCS systems, nor would it provide financial incentives to offset the increased cost of electricity.

How Emission Performance Standards for New Coal Plants Would Work

In contrast to other approaches, an emission performance standard that limits new plant emissions to levels achievable with CCS systems would provide certainty that new coal plants in fact capture and store CO_2. To provide a clear market signal to plant developers, this standard would apply to all new plants built after a date certain, although some flexibility would be allowed in the timing of CCS installation so that the power generation industry can gain more experience with various types of capture technology and underground CO_2 storage. For example, all plants that begin construction after 2008 could be subject to the standard and would be required to implement carbon capture technology by 2013, and then to meet all sequestration requirements by 2016.

An emission performance standard for new coal plants should be accompanied by a cap-and-trade program for existing power plants, with the cap starting at 100 percent of emissions and progressively declining over time.

To provide additional flexibility while CCS technology is being perfected, plant developers during the first three years in which the new performance standard is in effect could have the option to construct traditional coal plants that do not capture and sequester CO_2 if they offset on a one-to-one basis their CO_2 emissions by taking one or more of the following steps:

- Improving efficiencies and lowering CO_2 emissions at existing plants
- Retiring existing coal or natural gas units that generate CO_2 emissions
- Constructing previously unplanned renewable fuel power plants representing up to 25 percent of the generation capacity of the new coal plant.

In 2011, this alternate compliance option would sunset and all new plants subsequently entering construction would need to capture and sequester their emissions.

An emission performance standard for new coal plants should be accompanied by a cap-and-trade program for existing power plants, with the cap starting at 100 percent of emissions and progressively declining over time. A declining cap would encourage greater efficiencies in operating existing plants and incentivize the retirement of higher emitting existing plants. This would assure that an emission performance standard for new plants does not simply prolong the useful life of older plants. In addition, as the cap declines, retrofitting existing plants with CCS systems could become a viable option.

Mitigating Electricity Price Hikes

If legislation requiring an emission performance standard for new coal plants is enacted, then Congress should simultaneously take steps to offset the additional costs of installing CCS systems and provide relief from electricity price increases. This would prevent disproportionate costs from falling upon consumers who live in regions heavily dependent on coal for power generation. By reducing the financial risks and uncertainties of building power plants with CCS systems, it would also encourage investments in such plants by developers and their financial backers.

One approach would be to create a fund to "credit" utilities for all or part of the price increase that consumers would otherwise bear if they receive power from plants with CCS systems. Alternatively, financial incentives could be offered to plant developers which, in combination, offset a significant portion of the incremental costs of installing a CCS system as opposed to operating a coal-fired plant that does not control CO_2 emissions. This new incentive program would replace current incentive programs for IGCC plants and other coal technologies that do not include CCS systems.

Assuming that government incentives cover 10 percent to 20 percent of total plant construction costs and that they apply to the first 80 gigawatts of new coal capacity with CCS systems built by 2030, these incentives could cost in the range of $36 billion over 18 years. Although $36 billion is a large sum, it is only a fraction of the $1.61 trillion that the International Energy Agency predicts will be invested in new power plants in the United States between now and 2030.

Building a Technical and Regulatory Foundation for CCS Systems

Once the nation commits to a rapid timetable for requiring CCS systems at all new coal plants under an emission performance standard, then all of our regulatory and research and development efforts should be focused on implementing CCS technology as effectively as possible. This would require:

- An enhanced R&D program for capture technologies at both SCPC and IGCC facilities to reduce the costs of capture as quickly as possible
- An accelerated program to gain large-scale experience with sequestration for a range of geologic formations
- A comprehensive national inventory of potential storage reservoirs
- A new regulatory framework for evaluating, permitting, monitoring, and remediating sequestration sites and allocating liability for long-term CO_2 storage.

Maintaining the Viability of Coal in a Carbon-Constrained World

Although an emission performance standard that requires CCS systems for all new coal plants would pose a daunting technological and economic challenge, it will ultimately assure coal a secure and important role in the future U.S. energy mix. Such a standard would establish a clear technological path forward for coal, preserving its viability in a carbon-constrained world and giving the utility industry confidence to invest substantial sums in new coal-fired power generation. In contrast, continued public opposition and legal uncertainties may cause investors to withhold financing for new coal plants, placing the future of coal in jeopardy.

If the United States is successful in maintaining the viability of coal as a cost-competitive power source while addressing climate concerns, our leadership position would enable U.S. industries to capture critical export opportunities to the very nations facing the largest challenges from global warming. Once our domestic marketplace adopts CCS systems as power industry standards, the opportunities to export this best-of-breed technology will grow exponentially.

This will be critical to combating the massive rise of coal-derived greenhouse gas emissions in the developing world. Boosting exports while also helping China, India, and other developing nations reduce emissions and sustain economic growth would be a win-win-win for our economy, their economies, and the global climate.

Global Warming and the Future of Coal

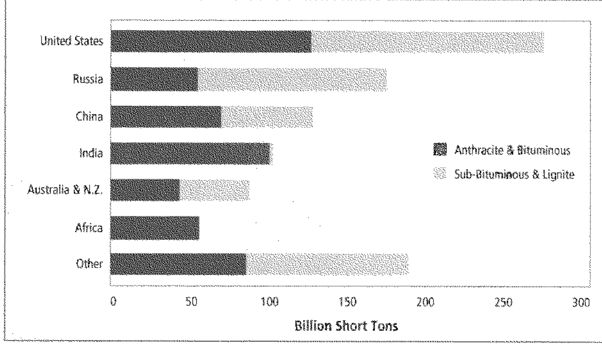
New Coal-fired Power Plants Threaten All Other Efforts to Combat Global Warming

For the last 15 years, most new power plants built in the U.S. have been fueled with natural gas. Today, however, coal is again emerging as a fuel of choice for the power sector as natural gas prices hit historically high levels worldwide and as demand for natural gas overtakes available supplies. In the U.S., coal is abundant, representing 27 percent of the world's known reserves,[5] and is less subject to price volatility and supply constraints than petroleum and natural gas (see Figure 1). Because demand can be met from domestic sources, coal also offers important energy security benefits to the United States.

While only 11 gigawatts of new coal-fired plants were built in the U.S. from 1991 to 2003, and virtually none from 2001 to 2005,[6] the National Energy Technology Laboratory of the U.S. Department of Energy now estimates that 145 gigawatts of new coal-fired plants will be built in the U.S. by 2030 (see Figure 2).[7] Utilities and other power plant developers have already announced plans to build 151 coal-fired plants with a capacity of 90 gigawatts.[8] Outside the U.S., the projections are more dramatic. Estimates of the worldwide total new construction of coal-fired plants by 2030 are around 1,400 gigawatts.[9]

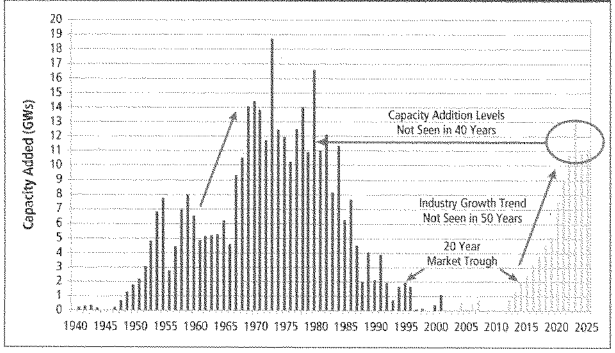
Few of these new plants in the U.S. are likely to replace existing less efficient coal-fired plants. The U.S. government's Energy Information Administration predicts that by 2030 electricity demand in the U.S. will increase by approximately 40 percent,[10]

FIGURE 1: RECOVERABLE COAL RESERVES



Source: James Katzer et al., *The Future of Coal: Options for a Carbon-Constrained World*, Massachusetts Institute of Technology Interdisciplinary Study.

FIGURE 2: U.S. FORECASTS LARGEST COAL GENERATION CAPACITY IN 40 YEARS
U.S. Coal Capacity Additions, 1940–2025



Source: U.S. Department of Energy NETL & Annual Energy Outlook 2005.

creating a need for increased power generation, and estimates that only about 3.6 gigawatts of coal power plants will be decommissioned by 2025.[11] In the developing world, where economic growth will be higher than in the U.S., almost all of the new coal-fired plants will represent an expansion, rather than a replacement, of capacity to meet soaring energy demand. China, for example, has the world's third largest coal reserves,[12] and is in the process of implementing a massive increase in coal-fired generation to meet growing energy needs.[13]

A serious drawback of coal-fired power generation is the formation of high levels of CO_2 during coal combustion—this CO_2 is then released from the stack and contributes to atmospheric buildup of greenhouse gases. Existing coal-fired power plants account for about one third of U.S. CO_2 emissions and make a substantial contribution to the total worldwide accumulation of CO_2 emissions in the atmosphere.[14]

A major expansion of worldwide coal generation would dramatically increase greenhouse gas emissions. A new 1,000 megawatt (1 gigawatt) coal power plant using the latest conventional pulverized coal technology produces about 6 million tons (5.4 million metric tons) of CO_2 annually.[15] In the absence of CO_2 emission controls, the new coal plants projected to be built globally would generate as much as 8.4 billion additional tons (7.6 billion metric tons) of CO_2 each year (assuming 1,400 gigawatts of new coal-fired plants are constructed). This represents an increase of approximately 30 percent over current total annual world emissions of 25 billion metric tons of CO_2 from the consumption of fossil fuels (see Figure 3).[16] Worldwide emissions from these new plants between now and 2030 would be equal to between 50 percent of all fossil fuel emissions during the past 250 years (see Figure 4).[17]

In the United States alone, 870 million tons (790 million metric tons) would be

FIGURE 3: PROJECTED WORLD-WIDE CO_2 EMISSION INCREASES WITHOUT EMISSION CONTROLS (1990–2030), IN METRIC TONS OF CO_2 EMISSIONS

	1990	2004	2010	2015	2030	2004–2030*
Power Generation	6,955	10,587	12,818	14,209	17,680	2.0%
Industry	4,474	4,742	5,679	6,213	7,255	1.6%
Transport	3,885	5,289	5,900	6,543	8,246	1.7%
Residential and Services**	3,353	3,297	3,573	3,815	4,298	1.0%
Other***	1,796	2,165	2,396	2,552	2,942	1.2%
Total	**20,463**	**26,079**	**30,367**	**33,333**	**40,420**	**1.7%**

* Average annual growth rate. ** Includes agriculture and public sector
*** Includes international marine bunkers, other transformation and non-energy use

Source: Int'l Energy Agency, *World Energy Outlook 2006*.

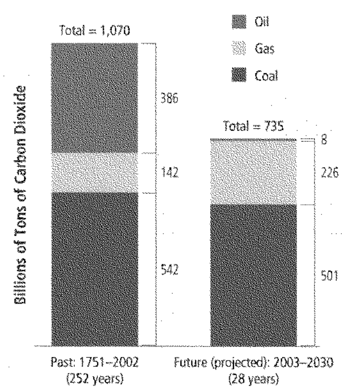
emitted if all of the currently proposed coal plants are built and do not control their CO_2 emissions.[18] This compares to 2005 annual emissions in the U.S. of about 6 billion metric tons of CO_2 and 7.15 billion metric tons of CO_2 equivalent greenhouse gases from *all* sources.[19] Moreover, new coal-fired plants, once built, will have a projected lifespan of up to 60 years. There will be powerful resistance to retiring them before investors have earned an acceptable return on their investment. These plants would therefore be high CO_2 emitters for decades to come.

In the U.S., there is growing public opposition to new coal plants that do not control CO_2 emissions. The recent proposal by private equity investors to cancel several coal plants originally announced by Texas utility TXU Corp. is evidence that public resistance may be strong enough to derail some new plants.[20] Yet in other parts of the world opposition to new coal plants is much less likely to prevent these plants from being built. The long-term increases in CO_2 emissions from new plants abroad would greatly impede the ability of developing nations such as India and China to moderate and ultimately reverse rapid greenhouse gas emission growth resulting from surging economic activity.

Even if no coal-fired plants are built between now and 2030, the world would face a daunting task in reducing global greenhouse gas emissions. But with greenhouse gas emissions from the power sector increasing due to the growth in coal-fired power generation, it will be almost impossible to reduce or even stabilize total emissions in the U.S. (not to mention the rest of the world) in the absence of aggressive CO_2 control measures. Between 1990 and 2005, for example, when few coal-fired plants were built in the U.S., emissions of CO_2 and other greenhouse gases increased by 16.3 percent,[21] including a 2 percent increase from 2003 to 2004.[22]

A dramatic increase in the rate of worldwide emissions growth due to new coal plants would make the goal of stabilizing atmospheric levels of greenhouse gases unattainable. Many experts support stabilizing atmospheric greenhouse gas levels at 450 parts per million. The 450 ppm goal is higher than the current greenhouse gas level of 380 ppm,[23] but hopefully is low enough to prevent precipitous increases in global temperatures.[24] However, only a sharp drop in worldwide emissions will bring the 450 ppm target within reach.

FIGURE 4: HISTORIC LEAP IN EMISSIONS



Lifetime CO_2 emissions from coal power plants projected to be built during the next quarter of a century will be roughly 50 percent of total CO_2 emissions from all sources during the past 250 years. The left column shows the cumulative CO_2 emissions produced by burning coal, oil and natural gas for all uses (including transportation and building heating) from 1751 to 2002, whereas that on the right depicts the lifetime CO_2 emissions from fossil-fuel power generation plants projected by the International Energy Agency to come online between 2003 and 2030. Coal-fired power plants are assumed to operate for 60 years and gas-fired power stations for 40 years.

Source: Scolow, "Can We Bury Global Warming?" *Scientific American*, July 2005.

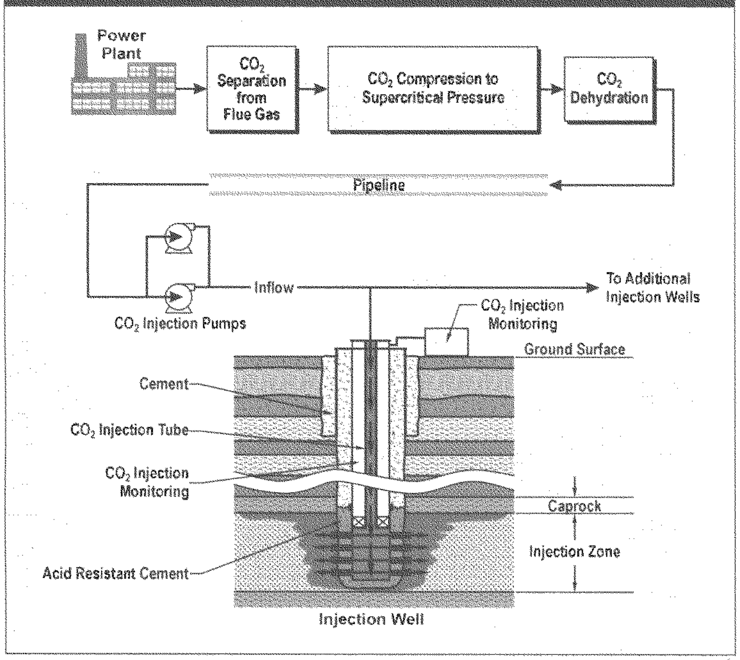
A Potential Path to Zero Emissions Through Carbon Capture and Storage

The threat to the global climate due to increased coal generation is urgent and serious, yet there is a potential technology pathway that would permit greater utilization of coal as an energy source without adding to existing global greenhouse gas emission levels. This path involves capturing and then sequestering CO_2 from coal-fired plants in secure underground repositories, effectively preventing its escape into the atmosphere. Government and the private sector are increasingly examining this new technology system, known as carbon capture and storage (or CCS), as a viable CO_2 emission control strategy for coal power plants and other industrial facilities that burn fossil fuels on a large scale.

During CCS operations, CO_2 is compressed to a supercritical liquid, transported by pipeline to an injection well and then pumped underground to depths sufficient to maintain critical pressures and temperatures. The CO_2 seeps into the pore spaces in the surrounding rock and its escape to the surface is blocked by a caprock or overlaying impermeable layer. In some types of formations, the CO_2 may dissolve in water and react with minerals in the host rock to form carbonates, becoming permanently entrained (see Figure 5).

Long-term sequestration of CO_2 is possible in depleted oil and gas reservoirs, unminable coal seams, basalt structures, and deep saline aquifers. The latter are believed to be ubiquitous at depths generally below one kilometer and are estimated to underlie at least one-half of the area of inhabited continents.[25] These deep saline formations have the greatest capacity to store CO_2 and would play a critical role in any large-scale CCS program (see Figure 6).

FIGURE 5: CARBON CAPTURE AND STORAGE: HOW IT WORKS



Source: Battelle Climate Research Institute, *Carbon Dioxide Capture and Geological Storage*, April 2006.

There is considerable experience in the U.S. with underground injection of liquids and gases.[26] Over 100,000 technically sophisticated and highly monitored injection wells are currently employed to pump fluids as much as two miles below the earth's surface.[27] U.S. CO_2 pipeline transmission is also well-established, with CO_2 pipelines in use since the early 1970s, the longest of which runs for approximately 500 miles.[28]

Similarly, CO_2 has long been pumped into the ground in oil and gas fields to improve extraction of these fuels. CO_2 injection has occurred extensively in the Permian Basin of West Texas and East New Mexico, plus several other areas of the U.S. and Canada, as part of enhanced oil recovery, or EOR operations. Currently 71 active CO_2-EOR projects inject, use and store 43 million tons/year of CO_2, 11 million tons/year (9.9 million metric tons/year) of which comes from industrial sources (see sidebar below). A Department of Energy-funded study examined 1,581 large reservoirs in the U.S. and concluded (assuming low-cost sources of CO_2) that up to 89 billion barrels of oil could be recovered using current EOR technology.[29]

To gain additional experience with injecting and storing CO_2, the U.S. Energy Department's seven Regional Sequestration Partnerships have initiated plans for conducting nearly two dozen pilot tests of injecting CO_2 into oil and gas reservoirs, coal seams and saline formations in the next three years.[31] The goal of this program is to achieve 99 percent storage permanence of CO_2 at less than a 10 percent increase in the cost of energy services by 2012.[32]

Although there is presently limited experience with capturing and sequestering CO_2 generated during the combustion of fossil fuels to produce electric power, a number of promising projects are on the horizon. Last August, for example, Midwest power producer XCEL Energy announced that it was committing $3.5 million toward developing a coal-generation facility in Colorado that would capture and sequester CO_2.[33]

BP and Irvine, California-based Edison Mission Energy announced plans in February 2006 to build a new 500-MW hydrogen-fueled power plant that will generate electricity using petroleum coke and will capture CO_2 for sequestration in nearby oil fields.[34] In addition, the proposed 1.2 Excelsior Mesaba Project in Minnesota plans to capture some of its CO_2 and transport it for sequestration through a pipeline that will likely be 265-to-450 miles long.[35]

Industrial CO_2 Storage

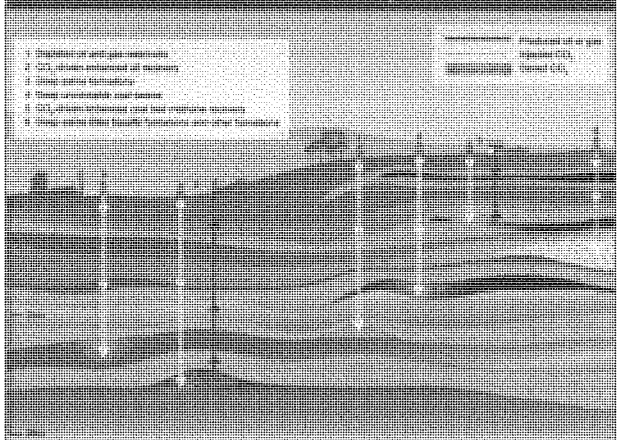
Industrial CO_2 is derived primarily from gas processing, fertilizer and coal gasification plants. Of particular note is EnCana's CO_2-EOR sequestration project in the Weyburn Field of Saskatchewan, Canada. The CO_2 is created in North Dakota and goes through a 200-mile pipeline to reach the Weyburn Field. The EnCana project in combination with the nearby Apache project currently injects 2.5 million metric tons of CO_2 annually into the Weyburn Field and expects to sequester a total of 51 million metric tons of CO_2 by project end.[30]

Overseas, the two most visible CO_2 capture and storage projects (not involving CO_2-EOR) are at the Siepner Field in the North Sea by Norway's Statoil ASA and the InSala Field in Algeria by Britain's BP plc. Each of these projects currently injects about 1 million tons of CO_2 per year into a saline formation either above or below the producing natural gas reservoir.

Most recently, American Electric Power (AEP) of Columbus, Ohio, announced that it will conduct a small CCS "validation" project at a West Virginia pulverized coal, or PC, plant and, starting in 2011, capture 1.5 million tons (1.36 million metric tons) of CO_2 annually at an Oklahoma PC unit for sale to oil companies for EOR.[36] Likewise, as part of the proposed leveraged buy-out of TXU by private equity investors, the Texas utility has announced preliminary plans to build two plants using advanced Integrated Gasification Combined Cycle, IGCC, technology with CCS systems.[37]

Widespread implementation of CCS technology at coal-fired power plants would greatly expand the scale of CO_2 sequestration beyond the small number of projects underway today because of the massive

FIGURE 6: GEOLOGICAL STORAGE OPTIONS FOR CO_2



Candidate geologic reservoirs for storing CO_2 lie deep below the surface of the Earth at varying depths.

Source: The Australian CO_2CRC.

amounts of CO_2 that would be captured and then stored on a permanent basis. A one-gigawatt plant will require sequestration of 6 million tons of CO_2 per year (this is the equivalent of 50 million barrels of CO_2 per year).[38] If the 90 gigawatts of coal plants now in the planning stages are built, nearly 540 million tons (490 million metric tons) of CO_2 would have to be sequestered each year. In contrast, the EnCana project astride the North Dakota/Saskatchewan border, in combination with the nearby Apache project, is injecting only 2.5 million metric tons (2.7 million tons) per year into the Weyburn Field.

A critical challenge for industry, academia, and government will be to demonstrate that large quantities of CO_2 can be stored without leaks over long periods and under a range of geologic conditions. The large scale sequestration projects now underway provide reassuring evidence that leakage from CO_2 storage formations is unlikely. Long-term experience with EOR in oil and gas fields is also reassuring. The geology of these fields is well-known and their sealing potential well-established; they have been storing oil and gas for millions of years.[39]

Nonetheless, there remain open questions about deep saline aquifers, which are expected to provide the bulk of the required CO_2 storage capacity. These aquifers are largely untested structures and additional effort will be required to validate their storage capacity and integrity. The Energy Department's pilot sequestration program is focused on small storage sites and is unlikely to provide data on the performance of larger reservoirs storing CO_2 in the megaton quantities typical of emissions generation at baseload power plants.

Accordingly, the Pew Center on Climate Change says there is a need for four to six large-scale test projects at reservoirs with diverse characteristics in order to demonstrate the viability of carbon sequestration.[40] A recent study by the Massachusetts Institute of Technology similarly concluded that three to four large scale test projects "might be needed to demonstrate and parameterize safe injection."[41] The MIT study also estimated the cost of studying three sequestration basins at $500 million over eight years and at less than $1 billion for five large sequestration tests.[42] Legislation to build on MIT's recommendations by requiring rapid completion of large-scale sequestration testing has been introduced by New Mexico Senators Jeff Bingaman and Pete Domenici.[43]

Despite the importance of additional testing, experts are confident that large-scale sequestration will be safe, feasible, and cost-effective. Thus, after reviewing the key questions of subsurface engineering and surface safety associated with carbon sequestration, the MIT coal study concludes:

There do not appear to be unresolvable open technical issues underlying these questions. Of equal importance, the hurdles to answering these technical questions well appear manageable and surmountable. As such, it appears that geological carbon sequestration is likely to be safe, effective, and competitive with many other options on an economic basis.[44]

Establishing a Legal and Regulatory Framework for CCS

Even if CO_2 leakage concerns are remote, an effective regulatory framework and concerted public communication program will be needed to allay fears of catastrophic releases from in-situ storage formations and resulting harm to property and human health, similar to concerns associated with nuclear waste disposal sites. Although a large-scale concentrated release of sequestered CO_2 that could have toxic effects on nearby populations or cause contamination of water supplies is highly unlikely, it will be necessary to establish credible requirements for site characterization, risk assessment, permitting and long-term site monitoring that address these scenarios.

Reliable measurement of CO_2 leakage rates will also be necessary for implementation and enforcement of any CO_2 emission-reduction program premised on the long-term effectiveness of CCS systems. Since CO_2 injection at most sites will stop after two or three decades, clearly defined liability and ownership rules will be required to delineate who bears long-term responsibility for effective CO_2 storage and remedial action if leaks occur at these sites. Some states, such as Texas, have decided to transfer ownership of post-injection sites to government bodies,[45] but most other states have yet to set liability rules.

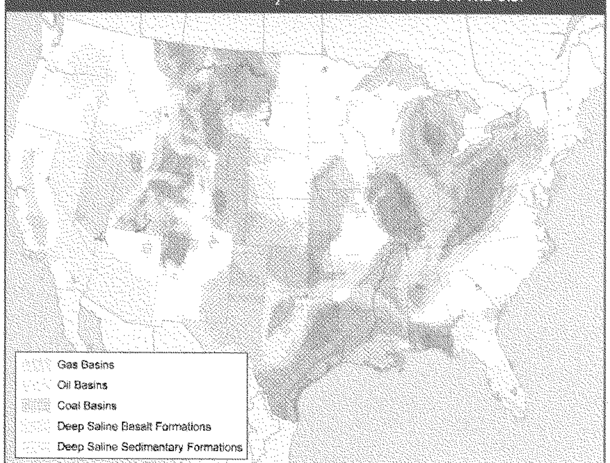
There has been some discussion of a government-funded insurance program (akin to the Price Anderson Act for nuclear plants) to protect private owners and operators against serious financial exposure in the event of CO_2 leaks. But there is no consensus as yet that such insurance protection is needed to encourage power generators to commit to long-term CO_2 capture and storage programs.[46]

The EPA has long regulated underground injection at oil and gas wells under the Safe Drinking Water Act and recently issued guidance for CO_2 injection at sequestration sites.[47] Yet it is unclear whether EPA's existing authority is broad enough to encompass all the issues raised by CO_2 injection under a carbon control regime. Thus, a new national legislative framework may well be needed to create long-term public confidence in CCS systems.[48] Among other issues, such a framework could address the complex regulatory and safety aspects of creating a dedicated interstate pipeline network to transport massive quantities of CO_2.[49] This framework should be in place well before CCS technology is implemented on a broad scale.

Available data also provide confidence that there is ample underground capacity in the U.S. and most other areas of the world to sequester the CO_2 output from projected levels of fossil fuel combustion (see Figures 7 and 8). The Department of Energy recently released its first Carbon Sequestration Atlas of the United States and Canada based on a preliminary survey of potential sequestration reservoirs by its seven regional sequestration partnerships. The Atlas concludes that approximately 3,500 billion tons of CO_2 storage capacity exists in North America (mostly in deep saline formations) at diverse locations across the country.[30]

A 2006 report by the Battelle Institute on U.S. sequestration capacity reaches remarkably similar conclusions, estimat-

FIGURE 7: POTENTIAL GEOLOGIC CO_2 STORAGE RESERVOIRS IN THE U.S.

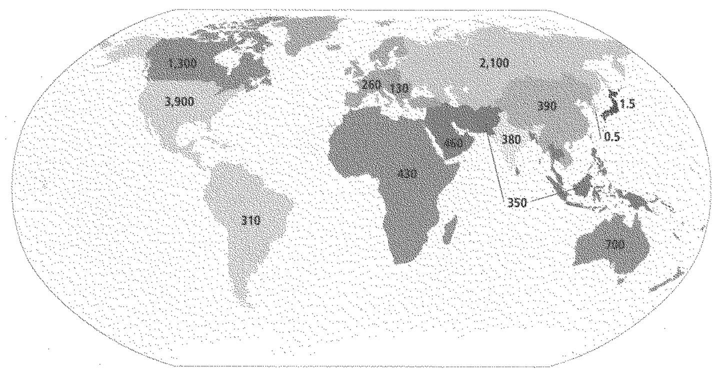


The United States is fortunate to have an abundance of theoretical CO_2 storage potential, well distributed across most of the country. Our preliminary and ongoing assessment of candidate geologic CO_2 storage formations reveals that the formations studied to date contain an estimated storage capacity of 3,900+ gigatons of CO_2 within some 230 candidate geologic CO_2 storage reservoirs.

- 2,730 gigatons in onshore deep saline formations, with perhaps close to another 900 gigatons of storage capacity in offshore deep saline formations
- 240 gigatons in onshore saline-filled basalt formations
- 35 gigatons in depleted gas fields
- 30 gigatons in deep unmineable coal seams with potential for enhanced coalbed methane recovery
- 12 gigatons in depleted oil fields with potential for enhanced oil recovery

Source: Battelle Climate Research Institute, *Carbon Dioxide Capture and Geological Storage*, April 2006.

FIGURE 8: GLOBAL CO_2 STORAGE CAPACITY (GIGATONS)



Initial assessments of theoretical global CO_2 storage capacity reveal an important and encouraging result: there is more than enough theoretical CO_2 storage capacity in the world to meet likely storage needs for at least a century, and in many key regions the storage capacity is in the right places to meet current and future demand from nearby CO_2 sources.

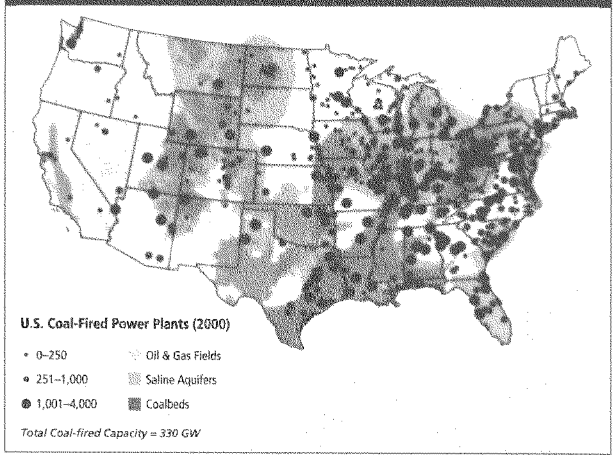
Source: Battelle Climate Research Institute, *Carbon Dioxide Capture and Geological Storage*, April 2006.

ing total U.S. capacity of 3,900 gigatons of CO_2 and finding that usable formations underlie parts of 45 states and two thirds of the land mass of the contiguous 48 states (see Figure 7).[51] This capacity would be sufficient to store the CO_2 emissions of the 145 projected new coal plants in the U.S. for several thousand years.

A third report published in 2005 by the Intergovernmental Panel on Climate Change, entitled *IPCC Special Report on Carbon Dioxide Capture and Storage* likewise concluded that there is considerable worldwide geological storage capability for CO_2 (see Figure 8).[52] The IPCC also concluded that it is likely that the CO_2 retained in underground formations will likely exceed 99 percent of the quantity injected over 1,000 years.[53]

It is widely agreed that a comprehensive survey of storage capacity is needed to improve the accuracy of existing estimates.[54] Notwithstanding uncertainties in estimation, there is little doubt that most regions of the U.S. are endowed with ample geological formations suitable for sequestration. Thus, underground CO_2 storage opportunities are likely to be within close proximity (zero to 250 miles) to the majority of coal plants that would be built, although some coal-dependent states may need to transport CO_2 for longer distances in order to sequester it (see Figure 9).[55]

FIGURE 9: LOCATION OF COAL PLANTS RELATIVE TO POTENTIAL STORAGE SITES



Source: James Katzer et al., *The Future of Coal: Options for a Carbon-Constrained World*, Massachusetts Institute of Technology Interdisciplinary Study.

CO_2 Capture at Coal Plants: the Promise of IGCC and Other Technologies

The separation and capture of CO_2 at large coal-fired power plants pose larger economic and technical challenges than the transportation and sequestration of CO_2. The dominant coal generation technology in the world today is pulverized coal, or PC in industry parlance, in which coal is ground to fine particles and then injected into a furnace with combustion air; the flue gas from the boiler contains CO_2 and other combustion byproducts, which are treated to remove certain pollutants (nitrogen oxides or NO_x, and sulfur dioxide or SO_2) and then released to the air.

Greater combustion efficiency (and lower CO_2 emissions per unit of energy output) can be achieved by supercritical and ultra-supercritical pulverized coal plants that reach higher steam temperatures and pressures. These designs, referred to in the industry as SCPC and USCPC, plants, respectively (for purpose of this paper both types of plants are referred to generically as SCPC), have been selected for many of the proposed new PC plants. The resulting CO_2 can be captured from flue gases following combustion at these plants by absorption into an amine solution, from which the absorbed CO_2 is then stripped via a temperature increase and cooled, dried, and compressed into a supercritical liquid (see Figure 11).

Research to optimize this post-combustion solvent "scrubbing" process is underway and may yield breakthroughs.[56] But post-combustion CO_2 capture using existing technology is now believed to impose a high energy penalty and create solvent degradation products that could have adverse environmental impacts.[57] Accordingly, there are significant disadvantages at this time to capturing CO_2 at SCPC plants, despite the historical dominance of PC generation technology in the power industry.[58]

A new coal-based generation technology known as Integrated Gasification Combined Cycle, or IGCC, offers more promise as a pathway to CO_2 capture and downstream sequestration at the present time. The CO_2 emissions from IGCC plants are somewhat lower than those from SCPC plants because of IGCC's higher thermal efficiency. More importantly, IGCC plants are able to capture CO_2 emissions more cost-effectively than SCPC plants using current technology because IGCC technology does not rely on direct combustion but instead converts the carbonaceous feedstocks, by way of gasification, into a clean gas called syngas (see sidebar below).

Although CO_2 capture is relatively straightforward technically, it poses a major economic challenge. Because of higher capital costs, greater fuel utilization, and lower electricity output, coal plants that capture CO_2 are projected to be more expensive producers of electricity than plants without capture capability. Carbon capture is estimated to account for 83 percent of the total cost of CCS

The Integrated Gasification Combined Cycle Process

Integrated Gasification Combined Cycle plants are able to capture CO_2 emissions more cost-effectively than SCPC plants using current technology because IGCC technology does not rely on direct combustion but instead converts the carbonaceous feedstocks, by way of gasification, into a clean gas called syngas (see Figure 12). Typical feedstocks for gasification are coal and a variety of refinery residuals such as petroleum coke and high sulfur fuel oil. The gasification process breaks down the feedstock into hydrogen, carbon monoxide, and smaller quantities of carbon dioxide by subjecting it to high temperature and pressure using steam and measured amounts of oxygen.

Minerals in the feedstock (rocks, dirt, and other impurities) do not react in the gasifier, and instead form a slag which can be disposed of, or converted to marketable solid products. After purification, the syngas, which is very similar to natural gas, can be burned in a conventional combined cycle power unit to generate electric power.

Historically, syngas from gasification has been used as a starting material for the production of chemicals and liquid fuels. At present, there are 117 gasification plants with 385 gasifiers operating around the world, with 35 additional facilities in various stages of development, design and construction, but most of these do not generate power.[59]

A phase shifter can be used to convert carbon monoxide gas to carbon dioxide in the presence of steam at the end of the syngas refining stage and to separate the CO_2 stream from the syngas before combustion (see Figure 13). Because CO_2 concentrations are higher and pressure is lower when CO_2 is captured pre-combustion, the energy required for CO_2 separation is smaller for IGCC units than for SCPC units.

The carbon capture rate at IGCC plants is currently believed to be around 85 percent. The Energy Department's research program has a goal of achieving a 90 percent carbon capture rate by 2012.[60] Likewise, the pilot FutureGen plant is designed to capture 90 percent of its carbon dioxide at the start of operations and subsequently increase to 100 percent.[61]

FIGURE 10: ESTIMATED ECONOMIC IMPACTS OF ADDING CARBON CAPTURE & SEQUESTRATION

	IGCC PLANTS			SCPC PLANTS		
	MIT STUDY	WISCONSIN REPORT	EPA REPORT	MIT STUDY	WISCONSIN REPORT	EPA REPORT
Increase in Capital Costs (%)	32%	35%	47%	61%	60%	73%
Decrease Total Efficiency (%)	19%	NA	14%	24%	NA	29%
Increase in Cost of Electricity ($ / MWh)[64]	NA	$ 18	$ 18	NA	$ 33	$ 35
Increase in Cost of Electricity (%)	25-40%	30%	37.5%	60-85%	60%	67%
Cost of Preventing CO2 emissions ($ per ton)	$ 24	$ 30	$ 28	$ 40	$ 45	$ 51

systems, with transportation and storage accounting for only 17 percent of such costs.[62] Figure 10 summarizes the results of three recent studies that estimated the economic and performance impacts of adding carbon capture technologies to IGCC and SCPC plants.[63] As Figure 10 illustrates, although capture costs will be high with both technologies, IGCC is currently perceived to have a marked advantage over SCPC.

The Electric Power Research Institute also recently estimated the effect of adding CO_2 capture to the cost of electricity and concluded that the cost would increase by approximately 40 percent-to-50 percent for IGCC plants and 60 percent-to-80 percent for SCPC plants.[65] However, EPRI also anticipates that these costs could be lowered as improvements are developed to decrease the energy penalty associated with carbon capture.[66]

Technology Leaders in Gasification

The major U.S. vendors of gasification technology are General Electric Co. and Conoco-Phillips Inc. Additionally, Royal Dutch Shell plc has proposed several IGCC projects in Europe and China, but has a limited U.S. presence. These companies have partnered with construction and engineering companies such as Bechtel Corp. and Fluor Corp. to offer a single project "wrap" that includes a firm price for engineering, procurement and construction as well as guarantees for construction completion and plant performance. These packages are expected to lead to greater standardization of plant design and equipment, reduce costs and shift some of the operational risks of IGCC from utilities to vendors.

Barriers to Commercialization of IGCC Technology

The greater cost-effectiveness of IGCC technology in capturing CO_2 emissions has stimulated heightened interest in its deployment as concern about climate change and the likelihood of future carbon constraints have grown. Vendors of IGCC plants (see sidebar below) have established a higher profile in the marketplace and have stepped up their marketing and R&D efforts. Some major utilities have announced plans to construct IGCC plants. And governments at the state and federal level have put in place financial incentives to encourage IGCC plants.

Currently, there are five IGCC plants in operation around the world, two of which are located in the U.S., one in Indiana and the other in Florida. After initial problems, the existing U.S. IGCC units have achieved improved reliability and are performing acceptably.[67] Now other utilities and power companies are stepping forward with proposals to build IGCC plants. The sidebar below identifies recently announced U.S. IGCC plants:[68]

It is encouraging that major utilities are pursuing IGCC plans. But a far greater number of proposed coal plants are *not* expected to employ IGCC technology. According to St. Louis, Missouri-based Peabody Energy Corp., the nation's largest coal producer, 36 traditional

Recently Announced IGCC Plants by Plant Location

Alaska
- Agrium US—350 MW

California
- BP & Edison Mission Energy—500 MW[69]

Colorado
- Xcel Energy—300-350 MW

Delaware
- NRG—630 MW

Florida
- Florida Power & Light—MW TBD
- Tampa Electric—630 MW
- Orlando Utilities Commission, Southern Co. & U.S. DOE—285 MW

Idaho
- Idaho Power Company—MW TBD
- Mountain Island Energy Holdings, LLC—250 MW
- Southeast Idaho Energy LLC—500 HW

Illinois
- Christian County Generation LLC—630 MW in Illinois[70]
- Erora Group—777 MW
- Rentech Development Corp.—76 MW
- Clean Coal Power Resources—2,400 MW
- Madison Power Corp.—500 MW
- Steelhead Energy Co. LLC—545 MW

Indiana
- Duke Energy—630 MW
- Tondu Corp.—630 MW Minnesota
- Excelsior Energy Mesaba Project—603 MW

Mississippi
- Mississippi Power Co.—600 MW[71]

Montana
- DKRW Energy of Houston, Bull Mountain Companies and Arch Coal—300 MW[72]

New York
- NRG Energy—680 MW

Ohio
- AEP—600 MW in Ohio
- CME International—600 MW in Ohio
- Global Energy—600 MW in Ohio

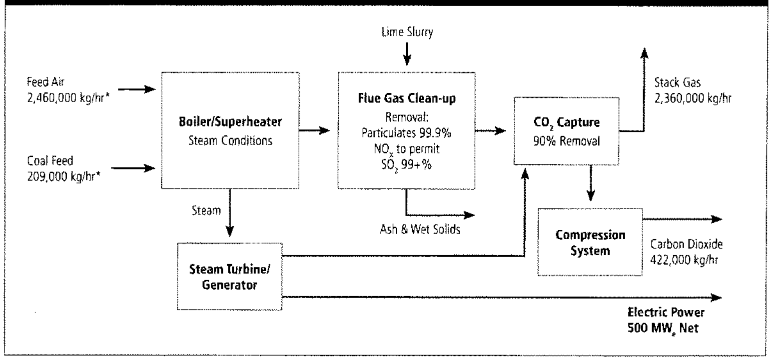
Washington
- Energy Northwest—600 MW

West Virginia
- AEP—600 MW in West Virginia

Wyoming
- Buffalo Energy—1,100 MW
- Rentech—104 MW
- DKRW & SNC Lavalin—200 MW
- PacifiCorp—450 MW
- Energy Expenditures Inc.—450 MW

Locations Pending
- Basin Electric Power Coop.—630 MW in North or South Dakota
- First Energy/Consol –Pennsylvania or Ohio, MW TBD

FIGURE 11: ULTRA-SUPERCRITICAL 500 MW_e PULVERIZED COAL UNIT WITH CO_2 CAPTURE



* Kilograms per hour.

Source: James Katzer et al., *The Future of Coal: Options for a Carbon-Constrained World*, Massachusetts Institute of Technology Interdisciplinary Study.

coal-fired plants will come online in 2009 and 2010, representing over 20,000 MW of capacity.[73] Moreover, as the sidebar on page 19 illustrates, of the approximately 145 new and proposed coal plants announced in the United States as of May 2007, only 34 are IGCC plants. While public resistance has derailed some notable SCPC projects, such as the well-publicized TXU proposal to build 11 new coal plants in Texas,[74] other proponents of SCPC plants have either been successful in avoiding public opposition or have defeated their opponents.

Assuming, then, that most utilities stick with their current plans, IGCC will not be the dominant technology for new coal plants for some time. Of equal concern, most of the announced IGCC plants will *not* have CCS capability.

Cost and Reliability Issues

What accounts for the reluctance of utilities to commit to IGCC plants with CCS systems? The current economics of IGCC projects, coupled with inadequate regulatory drivers and financial incentives, are creating significant obstacles to widespread adoption of IGCC in the power sector and discouraging investments in CCS systems even where IGCC plants are built.

First, IGCC plants must become price competitive and meet industry reliability standards. Currently, capital costs of the IGCC plants themselves are about 20 percent-to-25 percent higher for IGCC than SCPC plants, although this differential is expected to decline to 10 percent as the technology matures and vendors like GE and Bechtel work toward standardized plant designs and equipment.[75]

IGCC capital costs also vary widely with the type of coal used. Power plant performance is best with lower-ash, lower-moisture bituminous coals, but performance degrades with lower-rank and higher-ash coals, such as Western lignite and sub-bituminous coal. While this problem is likely to be overcome and some IGCC plants using sub-bituminous and lignite coal have already been proposed,[76] the higher cost and lower performance of IGCC plants using lower rank coals have given SCPC technology an additional edge in regions such as the Southwest, which rely on these types of coal.

Second, the lack of large-scale IGCC operating experience has created performance uncertainties and raised questions about the ability of IGCC plants to operate at levels of availability[77] that conventional plants can achieve. This is the case even though IGCC units achieve higher thermal efficiencies than the most advanced SCPC plants.

In the past, syngas production has resulted in excessive maintenance outages. Even with substantially better performance, existing IGCC plants have not yet consistently achieved 85 percent availability levels as compared to availability levels of over 90 percent with the most advanced SCPC designs. IGCC plants with spare gasifiers can achieve higher availability levels but will have higher capital costs. Should IGCC plants fail to meet availability goals, the result would be higher debt requirements to offset increased operating costs and greater reliance on less efficient peaking or baseload generation in the event of IGCC shutdowns. IGCC vendors can mitigate these risks to some extent with performance guarantees, liquidated damages provisions and project acceptance testing, but the combination of a cost premium and operational uncertainties will still be a deterrent to investment in the highly conservative power sector.

The higher capital and operating costs and lower availability of IGCC plants as compared to SCPC plants are projected to result in higher electricity costs to consumers. The current differential (without taking into account CCS deployment) is estimated to be about $5 per MWh for IGCC plants using Eastern coal and about $7 for IGCC plants using

FIGURE 12: INTEGRATED GASIFICATION COMBINED CYCLE SCHEMATIC

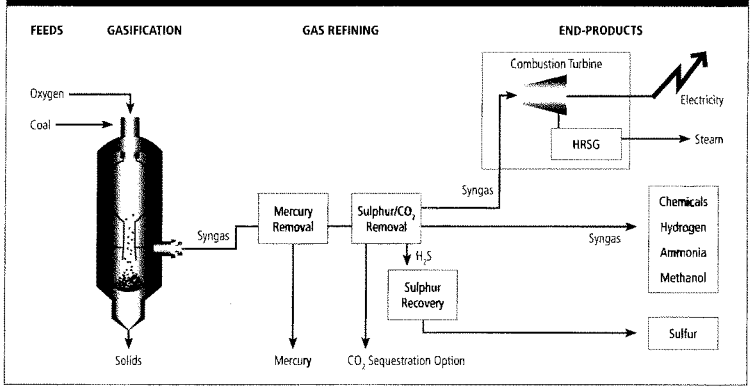


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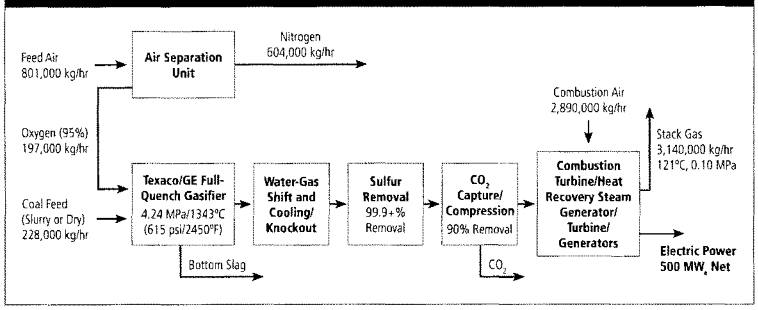
FIGURE 13: 500 MW_e INTEGRATED GASIFICATION COMBINED CYCLE UNIT W/ CO_2 CAPTURE



Source: James Katzer et al., *The Future of Coal: Options for a Carbon-Constrained World*, Massachusetts Institute of Technology Interdisciplinary Study.

Western coal.[78] Since a typical coal-fired baseload plant generally produces electricity for around \$55/MWh, this differential represents over 10 percent of power generation costs.[79]

When comparing the costs associated with SCPC and IGCC technologies, it is important to note that *the cost of electricity is likely to be significantly lower for IGCC plants than SCPC plants when the costs of capturing CO_2 emissions are taken into account.* This cost advantage is the reason why some policymakers are encouraging construction of IGCC plants, and why the IGCC option is receiving careful consideration by utilities concerned about the long-term costs of CO_2 control. At present, however, there is no *legal requirement* to capture and sequester or otherwise control CO_2 emissions from power plants.

In the absence of this requirement, the question is whether there are sufficient incentives to stimulate widespread adoption of IGCC despite its higher capital costs and performance uncertainties? To answer this question, we must examine the regulatory environment in which utilities operate and current government programs to incentivize IGCC plants.

The Regulatory Environment for IGCC Plants

Traditional utilities are regulated by state-level Public Utility Commissions, or PUCs, which approve the rates charged for electricity service. Utilities can generally recover the costs of their operations plus a reasonable return on investment, but only if such rates represent the "least costs" required to provide reliable service.

For major capital projects with large costs, utilities often seek PUC approval for rate increases to cover these costs before construction begins in order to minimize the risk that these costs will later be unrecoverable through their rate bases. PUCs, however, are generally reluctant to approve large environmental expenditures that are voluntarily incurred and not legally required. Since carbon capture and sequestration are not now mandated by law, the cost premium for IGCC plants could be unrecoverable under the "least cost" test.

As a result, utilities planning IGCC plants have needed to argue that these additional costs should be recoverable under a flexible interpretation of the "least cost" concept. For example, AEP has contended before the Ohio PUC that IGCC is a lower cost option than pulverized coal when long-term climate-related obligations are considered in the cost analysis. On April 10, 2006, the Ohio PUC allowed AEP to recover pre-construction engineering and design costs, but deferred allowing recovery for construction and operating costs. The PUC decision is being appealed to the Ohio Supreme Court by power-users opposed to any cost recovery.[80] Similarly, in Indiana, Duke Energy Corp. is seeking cost recovery for its proposed Edwardsport IGCC plant, but consumer groups and industrial users have opposed Duke on the ground that less expensive options are available and the long-term costs of carbon sequestration are unknown.[81]

This initial experience suggests that cost recovery requests for IGCC plants will be contested in many states and that divergent approaches may ultimately emerge around the country, with cost recovery available in some states but not others. Even more uncertain is whether cost recovery will be available for CCS system add-ons after the basic IGCC plant is built.

Merchant power generators—companies that generate power in a competitive market and sell the power to retail providers at market prices—face even greater risks than regulated utilities because they operate in an unregulated environment with no guarantee of cost recovery. After record levels of default on new plant construction projects in the 1990s, lenders are now reluctant to finance such plants in the absence of a long-term power purchase agreement between the merchant producer and power distributors or users.[82]

Some merchant power producers with the ability to negotiate such agreements have proposed to build IGCC plants. But it is an open question whether such projects will generate a sufficient return on investment to entice investors in the absence of subsidies and tax incentives that offset the higher costs of IGCC plant construction and greater operating uncertainties.[83]

Cost recovery requests for IGCC plants will be contested in many states, with recovery available in some states but not others

Federal and State Incentive Programs for IGCC Plants

Some states have created innovative incentive programs for IGCC plants. Indiana has offered a 10 percent tax credit for the first $500 million invested in an IGCC project and a 5 percent credit for amounts exceeding this level if the plant uses Indiana coal.[84] Kansas has established a similar program.[85] Colorado has enacted a law requiring proposed IGCC plants to sequester their CO_2 emissions and has allowed XCEL, the major utility in the state, to recover the costs of designing and building an IGCC plant through its rate base.[86] And Minnesota has enacted legislation granting Excelsior Energy eminent domain for its Mesaba IGCC plant, exempting it from certain regulatory requirements, and guaranteeing a long-term buyer (XCEL) for a portion of the plant's power output.[87]

At the federal level, the Energy Policy Act of 2005 contains a series of incentives for IGCC technology. These include:

- Cost sharing grants of $140 million per year from 2006 to 2014 that can cover up to 50 percent of the cost of IGCC demonstration plants and other gasification technology projects

- Allocation of $2.5 billion from 2006 to 2013 for advanced coal-based power with priority to technologies that are not yet cost competitive and which achieve greater efficiency and environmental performance

- A 20 percent investment tax credit up to a total of $800 million for property that is necessary for the gasification of coal, but not for the whole plant

- Loan guarantees for up to 80 percent of the individual loan amounts to an IGCC plant, but only if the Congress appropriates the needed funds.[88]

Even with greater government support that makes IGCC cost-competitive with SCPC plants, IGCC may still be resisted by risk-averse utilities

These incentives will definitely encourage some IGCC projects. For example, the 20 percent tax credit (if it were fully applicable to an entire project) would reduce (and perhaps eliminate) the capital cost differential between IGCC and SCPC plants. The loan guarantees will make it easier to obtain low-cost financing and increase the debt-to-equity ratio. Together with the revenues from the plant's ability to "securitize" these loans, utilities could build IGCC plans without necessarily increasing electricity rates (although ratepayers would bear the risk of construction delays or operational difficulties).[89]

Nonetheless, the impact of the Energy Policy Act programs is likely to be fairly modest. First, and most critically, the total amount of direct or indirect financial support available is limited. For example, on November 30, 2006 the Departments of Energy and Treasury granted $400 million in Energy Policy Act tax credits (half of the total amount authorized) to three IGCC projects, illustrating the limited availability of these credits to plant developers.[90]

Second, the Energy Policy Act programs (except for the investment tax credit) require follow-up appropriations. To date, Congress has not come close to providing full funding. And third, except for grants, the incentives do not help public power organizations that do not pay taxes or finance their facilities with debt.

Thus, the current incentives at best will help in the building of only a limited number of IGCC plants.[91] While providing useful operating experience at these plants, such incentives will not come close to addressing the urgent need to make IGCC plants broadly cost-competitive with PC plants now rather than many years in the future.

Would More Aggressive Incentive Programs Work?

Arguably, a more comprehensive program of grants, loan guarantees, and tax credits would provide a greater impetus for IGCC plant construction and, together with vendor guarantees and improvements in the technology, would minimize the disadvantages that IGCC now faces. Yet even with greater government support that makes IGCC cost-competitive with SCPC plants in the absence of CCS systems, IGCC may still be resisted by risk-averse utilities.

Why? New technologies, even after they become cost competitive, must cross the chasm described by Silicon Valley venture capitalist and technology writer Geoffery Moore in the opening quotation of this paper:

The point of greatest peril in the development of a high-tech market lies in making the transition from an early market dominated by a few visionary customers to a main-stream market dominated by a large block of customers who are predominately pragmatists in orientation. The gap between these two markets, heretofore ignored, is in fact so significant as to warrant being called a chasm.

In most cases, it takes a new technology many years to become accepted in the market. There exists an inherent inertia regarding new technology. Aside from early adopters, most businesses want to invest in productivity improvements for existing operations, not a new cutting-edge technology like IGCC. This is especially true in the energy sector where it is generally recognized that second and third generation plants are less expensive than first generation plants, and there are fewer problems associated with "debugging" the new technologies. One industry executive recently said that "IGGC is not for us," adding that "our industry is very intolerant of something that does not have extreme reliability and availability."[92] Another industry representative has described an IGCC facility as a chemical plant with a jet engine at one end—hardly a ringing endorsement. And an industry consultant with traditional coal-plant experience who strongly supports IGCC told one of the authors at a recent conference that "IGCC plants are spooky."

The time lag in the adoption of a new technology is reflected in the prevailing skepticism among industry analysts about the near-term outlook for IGCC plants. Despite the promising state of development of IGCC technology, almost all commentators assume that only a small percentage of new coal-fired plants built during the next 25 years will use IGCC technology. One estimate is that 1,205 of the 1,391 gigawatts forecasted worldwide for new coal plants will likely be built with conventional coal technology.[93] Another projection (using a slightly different estimate of the number of new worldwide coal plants to be constructed) is that only 144 gigawatts of new coal plants worldwide will use IGCC technology.[94]

What's worse, the Energy Information Administration assumes that under current policies *none of the new IGCC coal plants expected to be built between now and 2030 in the United States will capture and sequester carbon*.[95] Even the Bush administration's good faith effort to encourage the deployment of IGCC and

The Problem with Futuregen

The highly-publicized Bush administration FutureGen demonstration project, which aims to build a zero-emission coal plant, may actually delay rather than accelerate adoption of CCS technology if the coal industry waits for signs of its success from the side-lines.

FutureGen, which is jointly funded by Energy Department and several energy companies, is expected to be operational by 2012.[96] The FutureGen plant will employ IGCC coal gasification technology, and the resulting CO_2 emissions will be captured and permanently stored underground. The resulting syngas will be used to produce electricity, while the resulting hydrogen by-products will be recovered for industrial use.

FutureGen is likely to foster a belief in the power sector that until the new plant is successfully operating and its performance is proven, CCS technology is not ready for commercialization.[97] This attitude could discourage some utilities from proceeding with investments in these systems for at least another five to ten years. FutureGen should be looked at as a source of useful data that will enhance the efficacy of IGCC and CCS technologies, but not as a threshold demonstration project that must show success before IGCC/CCS systems are adopted on a commercial scale.

CCS technologies may be proving to be an impediment (see sidebar on previous page). The slow pace of development of CCS is simply not acceptable if the goal is to drastically reduce CO_2 emissions from the next generation of coal plants.

Even if the disincentives for IGCC technology were to be overcome, there would remain substantial barriers to investing in CCS capability. The reason: power plant owners are presently not required to control greenhouse gas emissions, and CCS systems are a costly add-on to the process of producing power. As a result, in the absence of a policy framework for greenhouse gas control, coal plants that capture and sequester CO_2 will never be on a level playing field with plants that don't because there would be no reward for incurring the costs of CO_2 emission control.

Even assuming utilities were to commit in large numbers to IGCC power plants, the odds of taking the next step and investing in CCS systems are small in the current economic and regulatory environment.[58] The consequence of delaying CCS installation and operation would be many billions of tons of additional CO_2 emitted to the atmosphere, whether or not IGCC or SCPC is the technology of choice for new coal plants.

Crossing the Chasm: A New Policy Framework to Push CCS Implementation Forward

If a program of financial incentives would be largely ineffective in promoting widespread adoption of CCS systems at new coal plants at the pace required to address climate change, then the only alternative is to consider more overt regulatory measures that change the economic calculus of new power plant developers. The goal of such a policy framework would be to force these developers to internalize CCS costs when selecting new generation technologies.

If this occurred, then the current competitive advantage of SCPC technology over IGCC technology would be eliminated because the costs of CO_2 abatement would need to be weighed along with the costs of plant construction and operation in selecting generation technologies. Power plants boasting IGCC technology with CCS capacity would then be more attractive on a total-cost basis unless cost-effective carbon capture technology could be developed for SCPC plants (see Figure 14).

Market-based mechanisms such as cap-and-trade programs are widely viewed as effective tools for reducing CO_2 emissions. Nonetheless, it remains questionable whether a cap-and-trade system for either utilities or a larger universe of emitting sources would assure that new coal plants adopt CCS systems within the next 10 years-to-15 years, when many new plants will be constructed. The political realities that will likely shape climate change legislation will probably not impose a sufficiently stringent cap in this initial stage of carbon control to create a market price for CO_2 (of around \$30 per ton) that would reliably incentivize construction of coal plants that capture and sequester CO_2 and foreclose higher emitting coal combustion technologies.

Four other strategies could potentially achieve widespread adoption of CCS systems and could be implemented either alone or in combination with a cap-and-trade program:

- Defining carbon capture and storage technology as the Best Available Control Technology, or BACT, for purposes of so called new source review under the Clean Air Act
- Adopting a "low carbon portfolio" standard that requires utilities to provide an increasing proportion of power from low-carbon generation sources over time
- Taxing carbon fuels or emissions
- Setting an "emission performance standard" that effectively requires all new coal plants built beginning in 2008 to capture and fully sequester CO_2 emissions by 2016.

Below, we discuss the implications of cap-and-trade approaches and then evaluate these four additional options (see Figure 15). This discussion concludes that an emission performance standard for new fossil fuel units, coupled with a cap-and-trade system for existing power plants, represents the most effective approach, although implementing it successfully will pose several challenges that need to be carefully addressed.

Encouraging CCS Systems with Carbon Caps and Trading Programs

One strategy for controlling emissions from new power plants is to rely on a mandatory CO_2 cap, with trading in CO_2 emission allowances as a compliance mechanism to incentivize electricity generators to choose CCS as the technology path for new coal plants. A number of states have adopted programs to regulate CO_2 emissions (see sidebar on page 30) but there are as yet no mandatory CO_2 controls at the national level.

FIGURE 14: COSTS OF ELECTRICITY PRODUCTION FROM IGCC AND SCPC WITH AND WITHOUT CARBON CAPTURE TECHNOLOGY

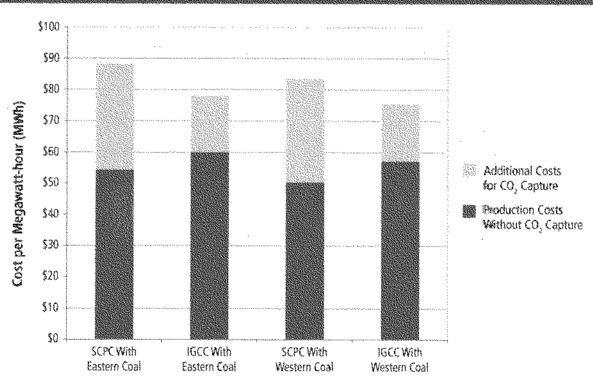


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FIGURE 15: OPTIONS TO PROMOTE CARBON CAPTURE AND STORAGE SYSTEMS AT NEW COAL PLANTS

OPTION	HOW IT WOULD WORK	BENEFITS	DRAWBACKS
Financial incentives for Integrated Gasification Combined Cycle plants, which are best suited for CCS systems	Increase grants, loan guarantees & tax credits for IGCC plants	• Would reduce cost differential between IGCC plants and existing plants • Would encourage more IGCC plants • Would provide more experience with IGCC technology	• Would not make IGCC fully cost-competitive • Would not overcome reluctance to adopt new technology • Would not result in CCS at new IGCC plants unless incentives are limited to plants with CCS systems
Cap-and-trade systems	Set mandatory cap on greenhouse gas emissions which declines over time Issue allowances to emitting sources and permit trading Allow sources to offset emissions from terrestrial sequestration or other projects in US or globally	• Would put a price on carbon emissions and create disincentives for constructing new uncontrolled coal plants • Would allow market forces to determine most cost-effective emission reduction strategy • Could result in IGCC/CCS systems at all new coal plants if carbon price exceeds $30 a ton	• Current legislation contemplates modest reductions in early years, with carbon price likely to be below $30 per ton • More stringent caps imposed at later dates (2030–2050) could increase carbon price to levels that would require CCS systems but Congress may not adopt such caps or condition them on future decisions • Broad access to offsets in US and globally will add to compliance flexibility but discourage CCS by creating low-cost compliance alternatives
Clean Air Act regulatory mandates	Based on determination that CO_2 is a "regulated pollutant", CCS systems could be defined as Best Available Control Technology (BACT) or Lowest Achievable Emission Rate (LAER) for new coal plants for purposes of the new source review (NSR) program under the Clean Air Act	• Could be implemented under existing law based on Supreme Court determination that CO_2 is a "pollutant" • Would avoid need for legislation • Would force consideration of CCS systems during permitting process for all new coal plants	• Legal uncertainties could invite litigation • States could reject CCS systems during permitting reviews • NSR program would not allow flexible compliance schedules for installing and operating CCS systems • Without legislation, no financial incentives would be available for new coal plants with CCS systems
Retail Low Carbon Portfolio Standard	Require retail suppliers of electricity to purchase an increasing portion of power from low-emitting sources (renewables, clean coal and perhaps nuclear)	• Would force power producers to convert an increasing portion of their generation to low-emitting sources over time • Some uncontrolled coal plants would be retired and could be replaced by coal plants with CCS systems	• Because the power mix varies widely by region, a uniform national goal for low-emitting generation would result in an unequal distribution of benefits and costs across regions • Adopting different portfolio standards for regions and even states would make it difficult to set a national emission reduction goal for the power sector • Unless the standard is very stringent, utilities could meet its targets for low carbon power while still building uncontrolled coal plants
Low Carbon Generation Standard	Require all coal plant owners in U.S. to dedicate a growing portion of their power production to low carbon generation Low carbon commitment could be met by building CCS-equipped plants, purchasing power from such units or purchasing emission credits from low carbon generators Low carbon commitment would start off at 0.5 percent of the plant owner's coal-based power output and increase to 5 percent by 2020 Generators could reduce the size of their commitment by retiring coal-fired assets	• If sufficiently stringent, would prevent construction of new coal plants without CCS systems because the existing coal fleet would have a collective responsibility to supply a certain portion of its power output from CCS-equipped coal units • Would spread the costs of building new plants with CCS systems over the entire industry, with utilities that do not build such plants subsidizing those who do by purchasing power and/or credits	• The revenue stream from CCS-equipped coal plants could not be guaranteed in advance because of market uncertainties and the possibility that multiple plants with CCS systems could be constructed simultaneously • The large financial risks to plant developers may deter them from building any new coal plants, making the standard impossible to meet • Once the standard's low carbon goals are met, there would be no bar to building additional coal plants without CO_2 controls

OPTION	HOW IT WOULD WORK	BENEFITS	DRAWBACKS
Carbon Tax	Impose a tax on fossil fuels based on their carbon content Could be imposed downstream (on fuel users) or upstream (on fuel producers/importers)	• Because a carbon tax would make higher carbon fuels more expensive, consumers would switch to lower carbon fuels or reduce fuel consumption • If the tax is imposed on CO_2 emissions, it would create incentives to avoid emissions by installing CCS systems	• An upstream tax based on the carbon content of fuel would simply discourage coal generation, not create incentives for new plants with CCS systems • At the levels under consideration, a carbon tax would not be high enough to ensure that all new coal-fired plants have CCS systems
Emission Performance Standards for New Coal Plants	Would require new plants to capture CO_2 emissions at the level (85 percent or more) achievable through the best performing CCS technology and then to sequester all captured emissions Would apply to all new plants that begin construction after a certain date (say 2008) These plants would need to be capturing substantially all their emissions by a second date (say 2013) and sequestering them by a third date (say 2016) As a transitional mechanism, new coal plants entering construction during an initial three-year period (say 2008–2011) could meet the performance standard by offsetting their emissions through improved efficiency, plant retirements and/or building renewable fuel power plants	• Would provide certainty that new coal plants are in fact equipped with CCS systems and therefore sequester their emissions • Because capture and sequestration would not be required immediately, there would be time to acquire additional experience with large-scale sequestration, improve capture technologies and create a legal/regulatory framework for long-term CO_2 storage • Plant developers would nonetheless be on notice of the requirement to capture and sequester their emissions and would factor CCS requirements into decisions on plant cost, financing, technology and siting	• The cost of electricity at plants with CCS systems would be increased by 20 percent to 40 percent, with these cost increases falling disproportionately on regions that rely heavily on coal • While there is agreement that large-scale carbon sequestration is probably viable, we need more data on the location of storage reservoirs and the effectiveness of different geological formations before embarking on a comprehensive national sequestration program • There may be areas of the country that are heavily dependent on coal but lack close proximity to sequestration sites • A national legal/regulatory framework addressing short-and long-term liability for carbon storage is needed before investors will finance new plants
Emission Performance Standard for New Coal Plants Coupled with Cap-and-trade System for Existing Plants	Cap emissions from existing power plants, with the cap starting at 100 percent of emissions in a baseline year and declining to progressively lower levels over time Use allowance trading systems as a compliance mechanism to implement the cap	• A declining cap would encourage greater efficiencies in operating existing plants and incentivize the retirement of higher emitting existing plants • With a sufficiently stringent cap, some generators may retrofit existing plants with CCS systems	• None
How to lessen economic impact of an emission performance standard	Create a national fund to provide "credits" against electricity cost increases from CCS-equipped plants Alternatively, provide plant developers with financial incentives (tax credits, loan guarantees and grants) that offset some or all of the incremental costs of new CCS-equipped plants Allowance auctions under a cap-and-trade program could provide a revenue source for CCS incentive programs	• The increased costs of an emission performance standard would be borne at the national level rather than by certain regions • Consumers would not experience large electricity cost increases that would undermine support for CCS requirements • Financial incentives would encourage early adoption of CCS systems and overcome investor resistance to financing new plants	• Offsetting the increased costs of new plants with CCS systems would require substantial government funding ($36 billion over 18 years if 10 percent to 20 percent of total plant construction costs are covered) • Since the costs of CCS-equipped plants are uncertain, a program of financial incentives could turn out to be insufficient to make these plants economically viable • The need to build lengthy pipelines to transport CO_2 to sequestration sites could increase the costs of CCS systems and require additional government support

OUR RECOMMENDATIONS

State Climate Change Programs

Three state programs to require CO_2 emission reductions have taken shape within the last year.

One is a coalition of ten states in the Northeast, which have entered into a Memorandum of Understanding in support of a program known as the Regional Greenhouse Gas Initiative.[99] The RGGI plans to commence implementation of a cap-and-trade program in 2009 for power generators within the member states, which would stabilize power plant CO_2 emissions at current levels through 2015 and then require a 10 percent reduction from those levels by 2020. If the price of CO_2 allowances exceeds $7 a ton, then power plants could meet their obligations by purchasing offsets (up to a certain level) within the U.S. and (under some circumstances) abroad.

The second is a coalition of five Western states (California, New Mexico, Arizona, Washington, and Oregon), who signed an agreement establishing the Western Regional Climate Action Initiative in February of this year to reduce greenhouse gas emissions. Under the agreement, the five states will jointly set a regional emissions target within six months, and by August 2008 will establish a market-based system—such as a cap-and-trade program covering multiple economic sectors—to aid in meeting the target.[100]

The third is the recently enacted California legislation which seeks to return greenhouse gas emissions in California to 1990 levels by 2020, requiring a reduction of approximately 25 percent from current levels. In contrast to Northeast initiative, the California legislation potentially applies to all source categories, not simply power plants, and does not require an allowance trading system, although it allows the California Air Resources Board to establish one.

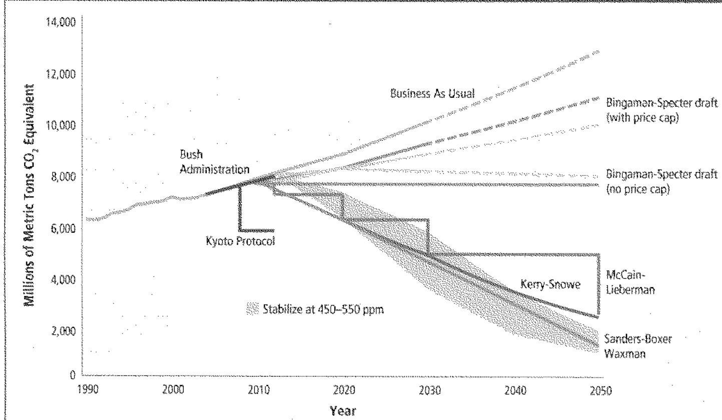
Legislation capping carbon emissions has been introduced in Congress, with a range of emission reduction targets, timetables and compliance mechanisms (see Figure 16). These bills generally impose modest caps in the early years, with successively more stringent caps taking effect by a series of deadlines extending to 2050.

The latest proposal (S. 280) from Sens. John McCain (R-AZ) and Joe Lieberman (I-CT) would apply to all economic sectors and would cap emissions at 2004 levels by 2012. The cap would be periodically lowered, declining to 66 percent of 2004 levels by 2030 (this is the equivalent of a 17.7 percent reduction from 1990 levels) and 33 percent of these levels by 2050.[101] S. 317, the Electric Utility Cap and Trade Act, introduced by Sens. Diane Feinstein (D-CA) and Tom Carper (D-DE), would apply only to utilities and would cap emissions at 2006 levels by 2011, and 2001 levels by 2015, with further reductions required at later dates.[102] Both of these bills would require allowance trading systems and would give regulated sources of carbon emissions generous access to offsets (including from non-U.S. sources and terrestrial sequestration projects) to meet their obligations.

Senator Bingaman (D-NM) has also proposed cap-and-trade legislation which would not limit emissions per se but would reduce greenhouse gas intensity—defined as the ratio of greenhouse gas emissions to economic output—by 2.6 percent annually from 2010 to 2020 and by 3.0 percent from 2020 to 2024, and would set a carbon price ceiling of $7 per ton in 2010 (rising by 5 percent annually thereafter).[103]

At the other end of the spectrum are two more stringent bills: one (S. 309) sponsored by Sens. Bernie Sanders (D-VT) and Barbara Boxer (D-CA) and the other (S. 485) by Sens. John Kerry (D-MA)

FIGURE 16: COMPARISON OF ECONOMY-WIDE CLIMATE CHANGE PROPOSALS IN 110TH CONGRESS 1990–2050



Dotted lines indicate extrapolations of Energy Information Administration projections. Modified May 10, 2007. Source: World Resources Institute.

and Olympia Snowe (R-ME).[104] These bills lack the modest early-year reduction targets of the other bills and instead would reduce economy-wide emissions to 1990 levels by 2020 (the California target), with additional reductions thereafter leading to a 2050 emission cap of 20 percent of current levels (S.309) and 38 percent of these levels (S. 485).[105] The Sanders-Boxer bill (S. 309) would authorize (but not mandate) allowance trading while S. 485 would require a cap-and-trade system. Neither of these bills contains the generous offset provisions in the other bills.

Importantly, under virtually all of the bills, the more stringent out-year targets do not apply automatically, but are instead subject to revision based on economic and scientific factors.[106] Moreover, as the legislative process progresses, it can be expected that less ambitious bills will be introduced that set even more modest early-year targets and do not impose any long-term emission caps.

The impact of emission caps on the selection of power generation technology for new plants depends on how stringent the cap is and the mechanisms by which it is implemented. These two factors will determine the cost to utilities of reducing CO_2 emissions by one ton, which in turn will set the market price of CO_2. As Figure 10 indicates, current estimates are that IGCC plants with CCS systems will be economic at a CO_2 price of around \$30 per ton, whereas SCPC plants with CCS systems would be economical at a CO_2 price of around \$55 per ton.

If the market price of CO_2 is above these levels, power plant developers would probably conclude that the only economically viable option for coal-fired plants is to construct such plants with CCS systems. Under current technology, these plants would be IGCC units, which capture carbon less expensively than SCPC units. But if the market price of CO_2 is lower than the cost per ton of reducing emissions with CCS systems, then other compliance strategies would be more desirable, including building new SCPC units without CCS systems, investing in other low-emitting generation, purchasing lower-cost credits on the open market or some combination of the three.

If the market price of CO_2 is lower than the cost per ton of reducing emissions with CCS systems, other compliance strategies would be more desirable, including building SCPC plants and offsetting emissions

A cap that reliably assures that the price of carbon is above $30 per ton would be one that sets a stringent emission-reduction goal (perhaps on the order of 25 percent from current levels) in the early years of a climate management regime and provides limited compliance options—either no trading or trading with little or no access to allowances from outside the utility sector. In this scenario, power generators would need to achieve sizable emission reductions either within their systems and/or through credits purchased from other generators; low cost credits from outside the power sector would not be available. Thus, the cost per ton for making the required reductions would be relatively high.[107]

Utility compliance strategies to achieve such a cap would of necessity involve reducing emissions from existing generation and meeting growth in electricity demand without adding capacity that offsets these emission reductions. Non-emitting strategies (demand-side management, greater utilization of wind, solar and other renewable power sources, building nuclear power plants) would thus receive close scrutiny both to displace existing fossil-fuel units and to accommodate system growth. The repowering of existing coal units with lower carbon fuels (principally natural gas) would also be a serious option to reduce emissions. Likewise, construction of IGCC plants with CCS systems would be attractive either to replace existing power plants (thereby eliminating their emissions) or to add capacity (without any increase in emissions). Such a strategy would also be less costly than higher-emitting options like IGCC or SCPC plants without CCS systems and perhaps even natural gas plants.

The difficulty, however, is the price of CO_2 would likely be well below $30 per ton with an emission cap that is relatively modest in the early years, and which is implemented with a flexible allowance trading system that provides broad access to low-cost credits outside the utility sector, and perhaps internationally. A number of the proposed bills fit into this category.

For example, S. 280 would cap emissions at 2004 levels by 2012, and S. 317 would cap emissions at 2001 levels by 2015. Although more analysis is needed to determine the cost impacts of the pending bills, the CO_2 price per ton of lowering emissions to meet these targets would likely be fairly low. EPA estimates, for example, that achieving the 2011–2015 emission reduction targets now reflected in the Feinstein-Carper bill would cost in the range of $1-to-$2 per ton.[108]

Even more problematic is the Bingaman carbon intensity proposal (and to a lesser extent the RGGI emissions initiative), which would protect generators against incurring costs above $7 per ton.[109] This is well below the estimated $30 per ton cost of carbon capture and storage at IGCC units. Under these proposals, construction of plants with CCS systems would not be a cost-effective compliance strategy. Indeed, the costs of compliance would probably be too low to discourage the construction of coal-fired power plants without CCS, even though owners of these plants would incur substantial costs to offset their emissions. Why? Because the costs of electricity generation are comparatively low when employing SCPC technology without CCS technology add-ons. Thus, it would be more economic to build an uncontrolled SCPC plant and purchase allowances to cover its emissions than to invest in CCS systems.

This is why many utilities may conclude that they can comply with a modest carbon cap with a combination of purchasing low-cost greenhouse gas offsets (from coal-bed methane recovery or terrestrial sequestration projects, for example) and constructing SCPC units to replace inefficient existing coal-fired plants and/or add generating capacity. An analysis by the Electric Power Research Institute illustrates this point, concluding that at a price of $25 per ton of CO_2, the cost of electricity is *lower* for SCPC power plants with no CO_2 controls than for IGCC plants with CCS systems.[110] That same analysis also concludes that at approximately $8 per ton, the cost of electricity for uncontrolled SCPC plants is equal to the cost of electricity for nuclear power plants and below the cost of electricity for combined-cycle-natural-gas, wind and biomass plants. Indeed, this analysis indicates that SCPC plants with no emission controls become more expensive than combined-cycle-natural-gas plants (assuming a natural gas floor price of $6/mmbtu) only at a CO_2 price above $30 per ton.

Some of the proposed bills would, as noted above, substantially reduce emission caps in 2020 and later years. It

Virtual Carbon Price Calculations

Today, in the absence of a cap-and-trade system, many utilities are including "virtual" prices for carbon in their decision-making processes for new power plants. These virtual prices assume that CO_2 emissions will eventually be regulated. Nevertheless, several utilities are choosing uncontrolled SCPC plants over IGCC plants because they are betting that IGCC plants with CCS systems will still be uncompetitive even when there is a price for emitting CO_2.

Underlying this bet is a "political" judgment—that the cost of CO_2 abatement under national cap-and-trade legislation likely to be enacted by Congress will be too low to support the economic viability of IGCC plants with CCS systems. Utilities building IGCC plants without CCS systems may be making the same bet, but "hedging" against the possibility of more stringent carbon controls in the future by preserving a cost-effective CCS retrofit option. This is why cap-and-trade systems that provide "flexibility" and "market-based" choices but do not send the right price signal run the risk of allowing utilities to pay for emitting CO_2 as opposed to investing in leading-edge technologies required to achieve dramatic emission reductions.

As happened under the European Union Emission Trading System, the inevitable political compromises that shape cap-and-trade systems may lead to status quo approaches—such as price caps, the issuance of too many emission allowances or broad availability of emission offsets—all of which achieve incremental emission reductions but fail to stimulate meaningful changes in technology. This would be the outcome under a U.S. cap-and-trade system in which the price of carbon is too low to motivate utilities to build coal power plants with CCS systems.

is therefore possible that SCPC plants with no emission controls that are cost-competitive in the early years of a cap-and-trade program could become uneconomic compared to plants with CCS systems as the market price of CO_2 rises in response to progressively more stringent caps. But if such caps are not built into the legislation enacted by Congress or are provisional and subject to later revision, then they may not be a factor in utilities' future planning. Indeed, utilities may be making this calculus right now (see sidebar on previous page)

If Congress fails to provide an aggressive long-term price signal to plant developers in its initial legislation, and if a substantial number of SCPC plants are then built, these plants will account for a large and constant stream of emissions during their operating lives of 60 years-to-70 years. These additional emissions will need to be offset by deeper cuts elsewhere in the economy. (See sidebar below) This will increase the overall costs of lowering emissions and pose a serious impediment to achieving a more stringent national emissions cap in later years.

A final limitation of cap-and-trade programs in driving power plant developers to embrace CCS systems is the unpredictability of how trading markets will work in practice. The success of a cap-and-trade program in spurring widespread CCS deployment depends on a wide range of factors that cannot be controlled or even predicted in advance. The cost of building and operating coal plants with and without CCS systems, the cost of natural gas, nuclear power and renewable sources of power, the cost of emissions offsets from outside the utility sector, and ultimately the market price of CO_2 itself are all variables that will dictate the decisions of future power plant developers. These variables are all highly uncertain from today's perspective and may create a set of economic drivers dramatically different from those anticipated by policymakers.

Impact of Uncontrolled New Coal Plants on Other Emissions Sources

cap-and-trade system that allows the construction of major new sources of emissions without carbon controls will place additional pressure on other emitting sources. For example, if Congress adopts a carbon cap that requires that emissions decrease by 30 percent from current levels by 2030, then the overall emission reduction necessary to meet that cap would be 2.1 billion tons (from 7 billion to 4.9 billion tons) of greenhouse gases per year, assuming no growth in emissions from new sources. Conversely, if greenhouse gas emissions increase by 900 million tons from new uncontrolled coal plants, then the needed reduction would increase from 2.1 to 3 billion tons per year or by over 40 percent.

If that happened, then existing emission sources would have to make deeper reductions (or purchase more emission offsets) to meet the carbon cap, raising the cost of CO_2 allowances as a result. The increased costs of these allowances would fall on every industry that is subject to the cap-and-trade system, creating additional opposition to the system. But if new coal power plants installed CCS systems, then there would be no net growth in emissions and the cost of allowances for other regulated sources would be lower.

All these considerations lead to one conclusion: If the goal of U.S. carbon policy is to assure early deployment of coal generation technology that captures and stores CO_2 emissions, then a legal framework that allows the marketplace to determine technology choices and the price of CO_2 emissions is a highly imperfect tool to achieve that goal.

Using the Existing Clean Air Act to Require CCS Systems for New Coal Plants

The Clean Air Act creates a rigorous permitting process for major new sources of pollution, including new power plants. In areas that are meeting air quality standards, major new emission sources are subject to the so called prevention of significant deterioration, or PSD, program and must install Best Available Control Technology, or BACT, at their facilities. In regions that are not attaining air quality standards, major new sources are subject to the new source review, or NSR, program and must meet the Lowest Achievable Emission Rate, or LAER, a somewhat more demanding standard than BACT.

This BACT/LAER framework compels developers of new facilities to undertake an analysis of emission control options utilized by similar sources. A BACT analysis starts with the most stringent control technology utilized in the industry and takes into account less stringent technologies as required by economic, energy and environmental considerations.[111] The statutory BACT/LAER provisions apply to "regulated pollutants," although there is some latitude to take into account the environmental impacts of unregulated pollutants.

The traditional focus of BACT/LAER reviews for new power plants has been such regulated pollutants as NO_x, SO_2 and particulate matter, with mercury and certain other toxics now receiving attention with the recent adoption of emission requirements under Titles II and III of the Clean Air Act.[112] CO_2 emissions have not previously been controlled under the NSR/PSD programs, perhaps because of uncertainty whether CO_2 is a "pollutant" under the Clean Air Act.

The Supreme Court, however, recently decided that CO_2 does meet the definition of "pollutant" under the Act and also directed EPA to determine whether the science of climate change requires the agency to regulate CO_2 emissions from motor vehicles under Title II of the Act.[113] Depending on the outcome of further EPA deliberations under Title II, CO_2 could become a "regulated" pollutant for purposes of the PSD/NSR programs for major new power plants.

A legal framework that allows the marketplace to determine technology choices and the price of CO_2 emissions is a highly imperfect tool to assure early deployment of CCS systems

This would open the door to consideration of whether BACT or LAER standards for CO_2 at new coal plants require CCS systems. In the event EPA adopts this position, CCS systems could then become a requirement for new coal plants without any further legislation. Before such a requirement were put in place, however, several legal hurdles would need to be overcome.[114]

Environmental groups, for example, have argued that IGCC should be considered BACT/LAER-compliant for new coal plants, but EPA has rejected this argument on the ground that IGCC units are fundamentally different in design from conventional coal plants and do not qualify as "similar" for purposes of

BACT/LAER determinations.[115] EPA might take the same position with respect to CCS systems.

There are also questions about whether CCS technology would be considered by EPA to be an "available" emission control technology for which CO_2 reductions are "achievable" given the lack of full-scale commercial deployment of CCS systems at any U.S. coal power plant.[116] Moreover, even if CCS systems are included in the BACT/LAER analysis, they could be rejected for economic, energy or other reasons by the permitting authority, which in many instances will be a state agency.

A proactive Environmental Protection Agency might aggressively promote CCS systems for carbon emissions at all new coal plants based on the recent Supreme Court ruling

Indeed, a few states have included IGCC technology in their BACT/LAER reviews for new coal plants but have ultimately allowed developers to select SCPC technology instead.[117] This outcome is not necessarily irrational in light of the lower cost and enhanced reliability of the latest SCPC designs and their ability to achieve emission limits for conventional pollutants such as NO_x, SO_2 and mercury which are not dissimilar to those achievable by IGCC units.

Despite the legal uncertainties, a proactive EPA might aggressively promote CCS systems as BACT- or LAER-compliant for CO_2 emissions at all new coal plants on the basis of the recent Supreme Court decision. Such a far-reaching initiative, however, could encounter legal challenges from the power industry and meet with resistance from states, which possess considerable discretion in making BACT/LAER determinations, and from Congress, which might feel that a CCS mandate for new coal plants should not be imposed administratively but (if warranted) adopted legislatively.

In addition, the NSR/PSD authorities in existing law provide no mechanisms to set flexible compliance schedules for implementing CCS systems, to determine what role these systems should play in an overall CO_2 cap-and-trade program or to use financial incentives to mitigate the costs of CCS deployment to utility ratepayers. These considerations suggest that a legislative framework for applying CCS systems to new coal plants would be preferable to invoking NSR/PSD programs under existing law.

Retail Low Carbon Portfolio Standard

The concept of retail low carbon portfolio standards has also received consideration as a tool for encouraging utilities to invest in clean coal generation. Such a standard, which would apply to retail suppliers of electricity, could be expressed in one of two ways—as a net CO_2 emission rate per kWh applicable to the power distributed by the supplier or as a percentage of the supplier's power derived from low greenhouse gas-emitting sources.

The latter approach would be similar to state renewable portfolio standards, which require retail electricity suppliers to derive a certain portion of their power (usually around 10 percent) from renewable energy source such as wind, solar, and biomass.[118] Retail low carbon portfolio standards would be broader than renewable portfolio standards, however, in that renewable energy would be combined with other low-emitting power sources, such as nuclear reactors and coal plants with CCS systems. This broader grouping would then be required to account for a certain minimum portion (say 30 percent) of the supplier's power portfolio.

As with renewable portfolio standards, power suppliers exceeding this percentage could "trade" credits with suppliers falling short of the minimum requirement. Under either an emission rate or percentage approach, the retail low carbon portfolio standard could become more stringent over time, requiring the generators supplying electricity to retailers subject to the standard to convert an increasing portion of their power production to low-emitting sources.

The idea behind retail low carbon portfolio standards is that they would force power producers to change their power generation mix by retiring high-emitting older plants and investing in low carbon energy sources. A complicating factor in implementing this approach, however, is that the relative dominance of different types of power sources now varies widely by region. Some Midwest and Southern states, for example, are heavily dependent on coal-fired plants. Northeastern states use little coal but substantial natural gas and nuclear-derived power. California has a similar generation mix while the Pacific Northwest is heavily dependent on hydroelectric power.

Because of transmission constraints, regions cannot readily change their mix of power sources by importing "clean" electricity in large volumes from other parts of the country. Thus, it would be impossible to set a uniform national target for "low-emitting" power portfolios without imposing disproportionate requirements on different regions. While a system of tradable credits could theoretically address disparities between utility systems and regions, in practice it would result in an unfair distribution of economic benefits and costs.

The alternative—setting separate standards for regions and even individual states—would be complex and controversial and make it difficult if not impossible to adopt and then implement an emission reduction goal for the power sector as a whole. That would defeat the principal purpose of a national emissions cap.

Moreover, how retail low carbon portfolio standards would affect technology choices by power generators would depend on how dramatically the standard alters the generator's existing power mix. Small changes would not necessarily spur investment in a significant number of CCS-equipped coal plants and could in fact permit large numbers of new plants to be built that do not capture or sequester CO_2.

An intriguing variation on the low carbon portfolio concept has been proposed by David Hawkins of the Natural Resources Defense Council and Professor Robert Williams of Princeton University in an effort to stimulate application of CCS systems at new coal plants.[119] The idea is that all owners of new and existing coal plants would be obligated to dedicate a certain portion of their power production to "low carbon" generation—defined as power produced from coal with an emission rate equal to the capture and sequestration effectiveness of current CCS technology.[120] This percentage would increase over time based on the projected increase in new U.S. coal generation capacity.[121] Plant owners could meet their low carbon commitment by generating power with a CCS-equipped unit, purchasing power from such units or purchasing emission credits from low carbon generators.

This proposal would spread the costs of building new coal plants with CCS systems over the entire coal plant universe by requiring utilities that do not invest in CCS generation to subsidize those who do. Since no coal plant owner would be required to construct a CCS-equipped plant, plant developers will need to decide whether to assume the risk of constructing such plants (costing around $1 billion) in the expectation of recouping their capital investment by selling power and/or credits to other generators. The size of this revenue stream, however, could not be guaranteed in advance since it would depend on future market prices for wholesale power and CO_2 allowances and on whether multiple developers build coal plants with CCS units at the same time.

Faced with an uncertain future revenue stream, investors and/or utility regulators could decide not to build any units with CCS systems. Moreover, even if some developers were to take the risk of constructing coal plants with CCS units, their total generating capacity may fall below the predicted levels on which the standard is based. In either event, coal generators would be unable to meet their low carbon commitments. Alternatively, if sufficient CCS capacity is built to fulfill each power generator's low carbon commitment, then additional coal plants could be constructed without controlling their CO_2 emissions.

In short, while the low carbon portfolio standard proposed by Hawkins and Williams has considerable potential, uncertainties about its actual operation raise questions about its effectiveness in assuring that all new coal plants are built with CCS systems.

Carbon Tax

A "carbon tax" is an excise tax on the sale of fossil fuels based on their carbon content. It could be imposed either "downstream" (where these fuels are consumed) or "upstream" (where they are imported, produced, or processed). Most experts favor an upstream tax because it could be collected from a relatively small number of entities while reaching virtually all the fossil fuel consumed by the U.S. economy.

Since it is the most carbon-intensive fuel, coal would be taxed at a higher rate than petroleum, which in turn would be subject to a higher tax than natural gas. Non-carbon fuels such as wind, solar, and nuclear would not be taxed at all. Because a carbon tax would make higher-carbon fuels more expensive, the intended outcome is that consumers would switch to lower carbon fuels or reduce their fuel consumption through energy efficiency and conservation. The result would then be declining CO_2 emissions.

After the ill-fated effort to adopt a tax based on the energy content (or Btu value) of different fuels and feedstocks in the early 1990s,[122] it is generally assumed that a carbon tax would receive limited support in Congress.[123] Even apart from its political viability, a tax based on fuel carbon content and not emissions would discourage coal consumption regardless of whether CO_2 emissions were captured and sequestered.

Under a carbon tax regime, power producers might burn coal more efficiently or shift to less carbon-intensive fuels because of the tax but would have no incentive to invest in low-emitting coal-based generation technologies. Perhaps this problem could be addressed by providing tax credits to utilities who build new plants with CCS capacity. It would be difficult, however, to assure that this credit would be large enough to not only offset the carbon tax itself but provide adequate inducements to invest in CCS systems as opposed to other options, including more efficient coal generation or plants that burn lower-carbon fuels such as natural gas.

A better alternative would be to directly tax emissions from power plants. By establishing a specific price for emissions, a tax would provide certainty to plant developers—a quality lacking under cap-and-trade programs, in which the market price of carbon will fluctuate and lack predictability. But the challenge for a tax on emissions is similar to the challenge faced by cap-and-trade systems—the tax may not be high enough to ensure that only coal-fired plants with CCS technology are built.

Recent carbon tax proposals have suggested tax rates beginning at \$5 and \$12 per metric ton of carbon and gradually increasing to higher levels.[124] This would be too low to offset the \$30-per-ton cost estimated for IGCC coal plants with CCS units. As with emission caps that are insufficiently stringent, a carbon tax that is too low would allow new high-emitting coal plants to continue to be built.

Emission Performance Standards for New Coal Power Plants

The most reliable strategy for assuring adoption of CCS technology at all new coal plants while reducing overall CO_2 emissions from the power generation sector is to require all such plants to meet an emissions performance standard. This standard would be most effective if coupled with a cap-and-trade program for existing power plants.

Elements of an Emissions Performance Standard

An emissions performance standard would require new plants to capture CO_2 emissions at the level achievable through the best performing CCS technology and then to sequester all captured emissions. The current capture capability is in the range of 85 percent but is projected by the Energy Department to increase to 90 percent by 2012, and to nearly 100 percent by 2015.[125]

The performance standard could be expressed as a ratio of the emissions rate to electricity output (CO_2 emissions per MWh), or as a percentage of total CO_2 generated. Senator John Kerry (D-MA) recently introduced a bill embodying the

Coverage of an Emissions Performance Standard

An emissions performance standard for new power plants could apply either to coal generation only or to all fossil fuel plants (coal, natural gas, and oil). A coal-only standard would arguably target the most carbon-intensive fossil fuel, thereby addressing the power-generation technology with the largest emitting potential. However, it would leave important emission sources uncontrolled and could create competitive imbalances between coal and other fossil fuels.

Natural gas, for example, is a lower-carbon fuel than coal, but it is still a significant source of CO_2 emissions.[127] Thus, applying emission performance standards to new natural gas plants may be necessary for the deep emission reductions that many consider essential as 2050 approaches. There are sound reasons for requiring CCS systems for new natural gas-fired power plants at the same time as new coal plants, but some lag-time might be appropriate to develop the technology and minimize increases in the cost of electricity.

former approach.[126] The standard could initially be applied to new coal plants but later extended to other large fossil fuel combustion facilities (see sidebar on previous page).

What are the benefits of an emissions performance standard for new power plants? Most importantly, it would explicitly preclude construction of new coal plants that are not designed to capture and sequester the plant's CO_2 emissions. This is in contrast to other approaches—such as a cap-and-trade program encompassing new and existing plants—that might seek to encourage CCS deployment but do not directly require it and leave open the possibility that large numbers of uncontrolled coal plants will be built.[128]

An emissions performance standard would be technology-neutral and thus would allow plant developers to choose IGCC or SCPC technologies (using the existing amine stripping process or the promising but undemonstrated Oxy-fuel process) that capture and sequester CO_2. Nonetheless, so long as the higher costs of carbon capture made SCPC uncompetitive in supplying electricity, plant developers would presumably opt for IGCC plants over SCPC plants as the more cost-effective coal-based generation technology.

Flexibility in the Timing of Implementing CCS Systems

There is general agreement among experts that carbon capture technologies—particularly when they are deployed at IGCC coal plants—are sufficiently well-developed to warrant widespread deployment in the relatively near term. Even so, an emissions performance standard requiring CCS technology for new coal plants could not take effect immediately because of the need for additional practical experience with large-scale sequestration, further technical refinement and cost-optimization of capture technologies, and creation of an effective legal and regulatory framework for long-term underground CO_2 storage.

How can the need for flexibility in the timing of CCS implementation be reconciled with the need to prevent substantially increased emissions from new coal plants constructed in the interim? One approach would be to require all new plants that begin construction after an initial date (say 2008) to be capable of capturing substantially all of their emissions by a second date (say 2013). Then, after a shakedown period of perhaps three years, all these new plants would need to capture and sequester those emissions at the required levels by a third date (say 2016). Over time, the three-year shakedown period would be reduced as the performance of capture and storage units becomes more reliable.

This three-phased approach would enable new plants to operate for an initial period while they work through the technical and operational challenges raised by capturing and sequestering their CO_2 emissions. It would also provide plant developers with enough lead time to investigate storage options, build pipelines or other systems for transporting CO_2 and install a carbon capture unit. Given the confidence of expert bodies that CCS systems will be ready for widespread commercial deployment by 2020,[129] a target date of 2016 for requiring CCS operation would be ambitious but achievable.

At the same time, because the emission performance standard would have an early effective date, the need for eventual CO_2 capture and storage would be clear to plant developers from the outset and would inform decisions about the cumulative capital and operating costs of the new facility, its efficiency and electricity output, how it will be financed and where it will be sited. Thus, plant developers would be encouraged to choose the generation technology that represents the lowest-cost CCS option—even if other technologies would be more cost-effective in the absence of CO_2 emission controls. Likewise, project developers would select plant sites with the best access to cost-effective sequestration opportunities, avoiding the risk that new coal plants will be sited in locations where underground CO_2 storage is not feasible or prohibitively expensive.

As an additional form of flexibility while CCS technology is being perfected, plant developers could have the option during the first three years in which the performance standard is in effect (from 2008 to 2011) to begin constructing traditional coal plants that do not capture and sequester CO_2 provided they offset on a one-to-one basis their CO_2 emissions by one or more of the following steps:

- Improving system-wide efficiency and lowering CO_2 emissions at existing plants
- Retiring existing coal or natural gas units that generate CO_2 emissions
- Constructing previously unplanned renewable fuel power plants representing up to 25 percent of the generation capacity of the new coal plant.

At the end of the three-year period, this alternate compliance option would sunset and all new plants subsequently entering construction would need to include CCS systems.[130]

Creating the Legal and Technical Foundation for CCS

Importantly, a national target date for capturing and storing CO_2 at new coal plants would focus and accelerate the research and development programs required for CCS to be successfully deployed on a widespread basis. One such program, as recommended in the MIT report, is to undertake a small number of federally funded demonstration projects for different carbon capture technologies at IGCC and SCPC plants.[131]

Another component of this effort, also recommended by MIT, would be a concerted demonstration program to determine the large-scale viability of different types of underground storage repositories to assess the likelihood and scale of CO_2 leakage. Coupled with a comprehensive inventory of potential storage reservoirs, such a program would be an essential precondition for building public confidence that large-scale geological sequestration of CO_2 will reliably prevent emissions over the long term without harm to human health, property, and natural resources.

In parallel, a regulatory regime would be developed that establishes guidelines for sequestration site investigation, selection and permitting, monitoring of emissions and modeling of underground CO_2 migration, issuance of permits to entities responsible for CO_2 transportation and storage, and liability for long-term sequestration.[132]

Legislation setting these activities in motion should be a top priority for Congress

A national target date for capturing and storing CO_2 at new coal plants would accelerate R&D programs necessary to ensure carbon capture and storage systems are successfully deployed on a wide scale so that a sound technical and legal framework is in place before the effective date for CCS operation at new plants.

It is possible that unexpected technical, legal, or financial complexities could be encountered in developing the necessary foundation for CCS deployment. To avoid premature implementation of CCS technology in such circumstances, the president or Environmental Protection Agency administrator might be authorized to extend the effective date for operating CCS systems for some reasonable period of time. However, the conditions for such extensions would need to be clearly spelled out in advance by Congress to assure that CCS implementation at new coal plants remains an urgent national priority and is not unduly delayed.

Unless emissions by existing plants are reduced, a stringent emissions standard for new plants might simply prolong the useful life of older plants

Capping Emissions from Existing Power Plants

Even with a goal of zero net emissions for new plants, greenhouse gas emissions from the power sector might continue to increase if existing plants were not controlled. Thus, an emissions performance standard would need to be coupled with an emissions cap for existing plants in order to achieve an overall decline in emissions for the power sector.[133]

This cap would encourage greater efficiencies in operating existing plants and incentivize plant owners to retrofit higher-emitting plants or retire them and build new low-emitting units. Unless emissions by existing plants are reduced, a stringent emissions standard for new plants might simply prolong the useful life of older plants and discourage new power generation—much as existing New Source Performance Standards under the Clean Air Act have encouraged continued operation of older power plants beyond their expected useful life.

As provided in several of the pending legislative proposals, a cap on existing plant emissions might decline over time—for example by starting off at 100 percent of emissions in a baseline year or average of years and declining to more stringent target levels in later years. This declining cap would make it more expensive to operate uncontrolled existing plants and reduce the cost-differential between these facilities and new plants with CCS capability.

A cap on emissions from existing power plants (in contrast to new plants) would best be implemented by an allowance trading program. This program would enable plant owners to seek out the most cost-effective emission-reduction opportunities within or beyond their own systems. For example, they could generate credits by replacing existing fossil-fuel generation with nuclear, clean coal or renewable power, by repowering coal units with natural gas, by improving the efficiency of existing units, or by reducing energy demand. Another important option under a cap-and-trade program would be to retrofit existing coal plants with CCS systems.[134]

New coal plants equipped with CCS technology should be excluded from the scope of a cap-and-trade program for existing plants and should not receive allowances except perhaps where they begin operating CCS systems earlier than required by law. If allowances were provided to new plants, they would necessarily be very large, representing the difference between their emissions (essentially zero) and the CO_2 emissions from a new state-of-the-art coal plant lacking carbon controls (which produces 6 million tons of CO_2 per gigawatt of energy).[135] Assuming that 145 gigawatts of power plants with CCS units were built in the United States, 790 million metric tons of allowances (about 13 percent of current total U.S. CO_2 emissions) would be allocated to owners of these plants. An equal number of allowances would then need to be withheld from other emitting sources to achieve emissions neutrality. This would impose considerable burdens on other sources, which would be required to reduce emissions by an additional 13 percent to offset the allowances granted to new coal plants.[136]

Economic and Regional Costs and Benefits

The benefit of a stringent emission performance standard for new coal plants is that it would eliminate the uncertainty associated with an open-ended cap-and-trade program and provide a high degree of assurance that new coal plants are in fact negligible CO_2 emitters. Given the urgency of achieving dramatic long-term emission reductions from the electricity sector in order to stabilize atmospheric CO_2 levels, the highest priority arguably should be preventing emissions from new power plants to the greatest extent feasible and reducing emissions from existing plants as quickly as possible.

Nonetheless, the stringency of such an emissions standard could have unwarranted economic consequences as well as undesirable impacts on some regions of the country. The biggest obstacle to the acceptance of an emissions performance standard is the projected increase in the price of electricity resulting from reduced plant efficiency and increased construction and operational costs associated with carbon capture technology. As shown in Figure 10, this increase is estimated by the state of Wisconsin, MIT, and the EPA to be on the order of 20 percent to 40 percent for IGCC plants with CCS units and considerably higher for CCS equipped SCPC units.[137]

It is hard to assess how accurate these estimates are, given the lack of practical experience with CCS systems. However, the predicted higher costs of electricity from plants with CCS units may be ameliorated by several factors. First, for some power plants, the injection of CO_2 in oil or gas wells will increase production of these fuels, creating a revenue stream that partially or totally offsets the increased costs of capture and storage. One recent estimate is that, with enhanced access to CO_2, the prevalence of enhanced oil recovery opportunities could increase significantly, which in turn would boost the business case for CCS deployment.[138]

Second, with advances in technology, IGCC and SCPC plants will achieve an even greater efficiency advantage over conventional PC plants now in service, offsetting a greater portion of the loss of efficiency from carbon capture. Similarly, the technology for capturing carbon will itself become more cost effective, imposing less of an efficiency penalty on electricity generation. The deployment of more plants with CCS systems would then be accompanied by cost reductions as capture technology matures.[139]

Third, in the initial years, new plants would provide only a relatively small portion of the power generated by the utility sector, with the balance coming from lower-cost existing plants. Moreover, power production costs represent about 60 percent of the electricity charges paid by consumers, with the remainder coming from the costs of transmission and distribution.[110] Thus the higher costs of producing electricity at an individual power plant with CCS capacity would be spread across utility rate bases, moderating the increase in electricity prices.[111]

Granted, more CCS-equipped plants would become a more significant part of the rate base over time, but the phased nature of this process coupled with cost-saving improvements in capture technology would likely cushion consumers from sharp price spikes.

Mitigating Economic Impacts

Because of increased costs of adding CCS units to either IGCC or SCPC plants, a strong case can be made for mitigating these cost differentials through incentives and other forms of financial support. This would serve a number of purposes.

First, the combination of a declining cap for existing plants and a CCS requirement for new plants would disproportionately burden generation systems that rely heavily on coal. Because coal use is concentrated in Midwest and Southern states, Texas and the Mountain West, ratepayers in those areas would pay a disproportionate share of the costs of CCS requirements. This disparity would be magnified if comparable emissions control costs are not required for other types of new power plants (such as natural gas units) and if plants with CCS systems replace existing coal plants that produce electricity more cheaply but are being retired to meet new greenhouse gas reduction mandates.

Indeed, if coal generation becomes uncompetitive because of CCS-related costs in some parts of the country, the economic costs could extend beyond ratepayers to coal-producing communities. This would quickly erode political support for CCS systems in these disadvantaged regions and perhaps even undermine public willingness to address global warming at all. Since the benefits of CCS systems in addressing global warming will be realized by all regions, the costs should arguably be borne equally at the national level and not be imposed solely on regions that produce or use coal.

Second, there is a strong imperative to develop CCS technologies as quickly as possible so that CCS plants can start replacing older coal-fired plants. Incentives that reduce the financial risks and uncertainties of building CCS plants in the early years can secure commitments from otherwise reluctant investors. This will not only accelerate emission reductions in the United States but, by making CCS technologies better accepted and more cost competitive, encourage their adoption in other nations as well (see sidebar on page 46). Such incentives can be scaled back as the technology matures and costs become more predictable.

There are two approaches that would reduce the economic impacts of a CCS requirement for new coal plants. One is to create a fund that could be used to provide relief to consumers whose electricity bills would otherwise increase because they receive power from plants with CCS. This fund could simply "credit" the utility for the amount of the increase so that consumers do not see higher charges on their electricity bills.

A second approach is to provide plant developers a combination of financial incentives, including tax credits, loan guarantees, and grants, that cover some or all of the added costs of building coal-fired power plants with CCS systems as compared to plants that lack such systems. The goal of these financial incentives would be to make plants with CCS systems more cost-competitive with uncontrolled coal plants, moderating price hikes to wholesale and retail electricity consumers and providing added inducements for the construction of CCS-equipped power plants.

These incentives would need to reflect not only the incremental cost of building the plant (if it is based on IGCC technology) but also cover the higher operating costs and reduced efficiency of plants with CO_2 capture technology as well as the costs of CO_2 transportation and storage. As these costs decline over time, the level of financial assistance to the plant developer would decline proportionately.

We propose that the incentives should be of sufficient magnitude to initially cover 20 percent of total construction costs (including the base-plant and add-on CCS capability) in order to offset a substantial portion of the currently estimated increase in electricity costs for coal plants with CCS units. This 20 percent cost recovery would be available for all new coal plants for which construction is commenced between now and 2012. The share of construction costs eligible for recovery would then drop 2 percent a year for the next eight years, at which point the incentives would be phased out.

In order to qualify for financial assistance, power plant developers would have to demonstrate that they are deploying the least costly CCS technology on a total $/MWh basis—a requirement that would initially favor IGCC plants (at least where they use Eastern coal) unless breakthroughs occur in post-combustion capture technology for SCPC plants.

The cost of such a program would likely be in the range of $36 billion spread over 18 years, or about $2 billion a year, based on projections that 80 gigawatts of new coal-fired capacity with CCS systems will be built between now and 2025.[142] This $36 billion estimate is based on the following assumptions:

- 40 gigawatts of the new coal capacity would qualify for incentives representing 20 percent of construction costs while the remaining 40 gigawatts would on average receive incentives at the 10 percent level

- Each gigawatt of new coal capacity with a CCS system would cost approximately $3 billion to construct.

Although $36 billion is a large sum, it is only a fraction of the $1.61 trillion that the International Energy Agency predicts will be invested on new power plants in the United States between now and 2030. (During this same period the total worldwide investment for new electricity generating capacity is predicted to be $11.3 trillion, with China making the single largest investment at $3 trillion in this same period).[143]

Moreover, with this new program of financial support in place, there would no longer be any basis for maintaining existing federal incentive programs for IGCC or SCPC plants without CCS capacity. Eliminating these programs would partially offset the increased outlays for new programs to incentivize new CCS-equipped plants.

We propose that financial incentives should be of sufficient magnitude to initally cover 20 percent of total construction costs in order to offset a portion of the increase in electricity prices

Cap-and-trade programs may provide a source of revenue to finance incentives for coal plants with CCS systems. A number of the proposed climate bills require the auctioning of emissions allowances, with the auction revenues used to fund new technologies or to offset the costs to industries and consumers of climate-related requirements.[144] One use for auction revenues could be to mitigate electricity cost increases for coal plants that employ CCS systems, and to provide financial incentives for building these plants.

Under a cap-and-trade program, owners of existing coal plants would be heavy allowance purchasers because of their large CO_2 emissions. Redistributing auction revenues to these owners if they build low carbon coal plants would serve the dual purposes of reducing their need for allowances (by helping to retire high-emitting plants) and providing economic relief to their customers (by cushioning them from increases in the cost of electricity).

In the absence of an allowance auction system, other funding mechanisms for an incentive program for low carbon coal plants could include implementation of a uniform per kilowatt "wires charge" on retail electricity sales implemented at the federal level or general tax revenues.

Both mechanisms would distribute the costs of financial incentives equally among all U.S. users of electric power—a fair and reasonable approach since CCS systems are being required because of a national commitment to reduce greenhouse gas emissions.

It is in the economic interest of China and India to adopt these technologies and systems because of the impact that climate change is likely to have on their economies and the greater cost and disruption that emission controls will impose if adopted later rather than sooner. Moreover, in the last five to 10 years, both China and India have arguably become sufficiently economically developed to

Setting the Standard for China and India

The coal-fired plants proposed for construction in the United States constitute only about 10 percent of the coal-fired plants currently projected for construction around the world, with most projections placing the vast majority of new coal fired plants in rapidly developing countries such as China and India. For instance, in its May 2007 report, the Intergovernmental Panel on Climate Change estimated that as much as three quarters of the projected increase in energy CO_2 emitted between now and 2030 will occur in emerging economies such as China.[145]

This is not surprising given that China possesses the third-largest reserve of recoverable coal worldwide, and China's coal consumption (in the absence of meaningful climate policies) is expected to increase to a level that is 52 percent greater than that of the United States by 2050, with precipitous increases also expected in India.[146] Thus, a decision by the United States to adopt a standard that requires CCS systems at new coal plants is unlikely to have a significant impact on climate change unless other nations, particularly China and India, follow a similar approach.

CCS technology is far enough along the development cycle so that, with the proper regulatory drivers and financial incentives, it can be successfully implemented not only domestically but also exported to other countries. Doing so will provide developing nations with sound and timely technological solutions as they accelerate their energy production capabilities in lockstep with their economic growth.[147] China and India are in fact currently developing internal standards to address climate change,[148] and promising geologic sequestration formations appear to exist within China and India.[149]

bear the cost of adopting these technologies. These countries' articulated (political) rationale for opposing greenhouse gas control measures is that the United States has not yet taken such action. This argument will vaporize once the United States incurs the cost and expense of developing CCS systems.

It is also in the economic interest of the United States to take the lead in developing the CCS technology and thereby speed its adoption by the rest of the world. Developing CCS technologies will create domestic jobs and give U.S. companies that develop these systems a leadership position in capturing the trillions of dollars that will be spent worldwide on coal plants between now and 2030.

Access to Underground Formations

Carbon sequestration, of course, requires a suitable underground reservoir to store the CO_2. The United States appears to be well endowed with geological formations with large CO_2 storage capacity, and these formations appear to be widely dispersed across most of the states. There will, however, be some areas currently reliant on coal power that may not have ready access to suitable sequestration reservoirs.[130] These areas could meet their power needs by importing power from other jurisdictions or investing in other types of power generation. Where coal is a particularly important economic resource, however, these alternatives could be unattractive.

Solutions for such regions might be to provide funding for CO_2 pipelines that exceed a certain length because there are no available sequestration formations within a defined distance of the project. A comparative survey of possible CO_2 sequestration sites across the country will better pinpoint areas where underground CO_2 storage is not a feasible option and thus the total pipeline investment necessary to provide access to sequestration sites to power plants in those areas.

Conclusion

One of the biggest challenges in addressing the risk of global warming is the potential for a dramatic increase in greenhouse gas emissions as a result of the construction of a new generation of coal-fired power plants. This challenge exists both in the United States, where abundant coal reserves are creating heightened interest in the construction of new coal plants, and in developing countries such as China and India, where demand for energy is growing at a rapid pace and coal-fired generation holds the most potential for meeting these increasing energy needs.

Fortunately, there is a potential pathway that would allow continued use of coal as an energy source without magnifying the risk of global warming. Technology currently exists to capture CO_2 emissions from coal-fired plants before they are released into the environment. And experts are confident that the captured CO_2 can be safely stored in underground geologic formations.

The great challenge, however, is ensuring that the widespread deployment of this technology happens on a timely basis. So far we are failing in that effort. This paper has considered policy options that would significantly increase the likelihood that all new coal plants are equipped with CCS systems.

To ensure widespread adoption of CCS systems, the paper recommends that Congress mandate a power emission performance standard that effectively requires all new coal plants to control emissions to the level achievable by CCS systems. This standard would be implemented in conjunction with an emissions cap-and-trade system for existing power plants. The standard would apply to all new plants for which construction is commenced after a date certain (say 2008), although flexibility would be allowed in the timing for CCS implementation so that the power industry can gain more experience with capture and sequestration technologies.

Bold action by the U.S. Congress to put in place an emission performance standard for new coal-fired power plants would demonstrate leadership in addressing climate change and build a technological and regulatory foundation that countries such as China and India could emulate as they attempt to tackle the risk of global warming without stifling economic growth. An emission performance standard that requires CCS systems for all new coal plants would pose a daunting technological and economic challenge. Yet achieving this goal would ultimately assure coal a secure and important role in the future U.S. energy mix by establishing a clear technological path forward for coal in a carbon constrained world.

Endnotes

1 Geoffrey A. Moore, *Crossing the Chasm: Marketing and Selling High-Tech Products to Mainstream Customers*, at 5 (1991).

2 A note about units of measure: the literature employs both metric and non-metric tons in relation to greenhouse gas volumes. We use metric tons except where the text relies on literature that is in non-metric tons. In this instance, we use the non-metric ton measure and for comparison purposes include the corresponding metric ton volume in parentheses.

3 Energy Info. Admin., Emissions of Greenhouse Gases in the United States 2005, at 13 and ix (Nov. 2006), *available at* ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057305.pdf [hereinafter EIA 2006 Report]. In addition to CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are considered greenhouse gases. Their impact is measured by converting the amount of each of these chemicals to CO_2-equivalent emissions. For example, one ton of methane emissions is considered the equivalent of 23 tons of CO_2 emissions. *Id.* at 29.

4 James Katzer et al., The Future of Coal: Options for a Carbon-Constrained World, Massachusetts Institute of Technology Interdisciplinary Study, at 36 (2007) [hereinafter, The MIT Study].

5 The Nat'l Coal Council, Coal: America's Energy Future, at xii, (March 2006), *available at* http://nationalcoalcouncil.org/report/NCCReportVol1.pdf. In 2005, U.S. coal consumption totaled 1.1 billion short tons. Energy Info. Admin., U.S. Coal Supply and Demand: 2005 Review, at 7 (April 2006), *available at* http://www.eia.doe.gov/cneaf/coal/page/special/feature05.pdf. In 2004, the United States accounted for nearly 20 percent of global demand, second only to China (approximately 34 percent). Int'l Energy Agency, World Energy Outlook 2006, at 127 (Nov. 2006) [hereinafter, WEO 2006] . The demonstrated coal reserve base—approximately 500 short billion tons---is projected to last for over 100 years, even at elevated consumption levels. The Nat'l Coal Council, Coal: America's Energy Future, at 2 (March 2006), *available at* http://nationalcoalcouncil.org/report/NCCReportVol1.pdf.

6 Ben Yamagata, Clean Coal Opportunities in Electric Power Generation (February 8, 2006) (unpublished PowerPoint presentation of the Coal Utilization Research Council) (on file with authors).

7 DOE Nat'l Energy Tech. Lab., Tracking New Coal-Fired Power Plants: Coal's Resurgence in Electric Power Generation (May 1, 2007) (unpublished PowerPoint presentation) (on file with authors), *available at* http://www.netl.doe.gov/coal/refshelf/ncp.pdf [hereinafter, the NETL Tracking Report].

8 *Id.*

9 WEO 2006, *supra* note 5 at 493 (Nov. 2006); Yamagata, *supra* note 7 (estimating 1400 gigawatts based on data from the International Energy Agency and Platt's database).

10 Energy Info. Admin., Annual Energy Outlook 2007, (Feb. 2007) at 82, *available at* http://www.eia.doe.gov/oiaf/aeo/pdf/trend_3.pdf.

11 Energy Info. Admin., International Energy Outlook 2005, at 51, *available at* http://www.stat-usa.gov/mischiles.nsf/85e140505600107b85256649006341 1d/d0d08407366b117d85257157006fae32/$FILE/IEO2005_ch007.pdf.

12 Energy Info. Admin., Energy Information Sheets: Coal Reserves (Aug. 2004), *available at* http://www.eia.doe.gov/neic/infosheets/coalreserves.htm.

13 Coal currently accounts for two-thirds of China's primary energy supply. Although the government has indicated its desire to decrease its coal usage, China is still predicted to drive over half of the growth in worldwide coal supply and demand in the next 25 years and coal will likely account for more than 50 percent of the country's energy supplies in the year 2030. *See* The MIT Study, *supra* note 4 at 63. *See also* The Fourth Assessment Report, Working Group III, Summary for Policy Makers (May 5, 2007). Prepared by the Intergovernmental Panel on Climate Change (stating that two-thirds to three-quarters of the increase in energy CO_2 emissions between 2000 and 2030 is projected to come from developing countries (e.g. those that are not "Annex I" countries or parties as defined in the IPCC report)) [hereinafter, IPCC Fourth Assessment Report].

14 EIA 2006 Report, *supra* note 3, at 23.

15 Robert Socolow, "Can We Bury Global Warming?," *Scientific American*, July 2005, at 50. *See also* The MIT Study, *supra* note 4, at ix (stating one 500 megawatt coal-fired power plant produces approximately 3 million tons per year of CO_2).

16 *See* International Energy Outlook 2006 Report, *supra* note 9 at 73. The total world emissions figure provided in this report is for CO_2 emissions from the consumption of fossil fuels only and relates to the year 2003.

17 Socolow, *supra* note 15, at 52 (estimating that coal plants accounted for 542 billion tons of CO_2 emissions from 1751–2002 and will account for 501 billion tons of CO_2 from 2002–2030).

18 EIA 2006 Report, *supra* note 3, at 13 and ix.

19 *Id.* at 29.

20 TXU initially proposed building 11 traditional coal-fired plants in Texas. In light of strong public opposition to the plants, TXU later cancelled plans for eight of these plants as part of the terms of a buyout deal with a private equity group led by Kohlberg Kravis Roberts and the Texas Pacific Group. It subsequently announced plans to build two IGCC plants in Texas. Kurt Fernandez, "TXU, Buyout Partners Announce Plans for Two Carbon Dioxide Capture Plants," *BNA Daily Environment Report*, Mar. 12, 2007, at A-9.

21 EPA, Executive Summary of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2005, at ES-4 (Apr. 2007), *available at* http://www.epa.gov/climatechange/emissions/downloads06/07ES.pdf

22 EIA 2006 Report, *supra* note 3, at ix–x.

23 Socolow, *supra* note 15 at 49. At the start of the industrial period, the concentration was 280 ppm, while the current concentration of 380 ppm is rising approximately 2 ppm per year. WEO 2006, *supra* note 5 at 144.

24 No one can know for certain what concentration of CO_2 would constitute a "safe" level, but many scientists have concluded that the CO_2 concentration in the atmosphere must not exceed 450 parts per million to prevent precipitous increases in temperatures. *See* David G. Hawkins et al., "What to Do About Coal," *Scientific American*, Sept. 2006, at 70.

25 Robert H. Williams, "Climate-Compatible Synthetic Liquid Fuels from Coal and Biomass with CO_2 Capture and Storage," Princeton Envtl. Inst., Princeton Univ., at 7 (Dec. 19, 2005) (unpublished PowerPoint presentation) (on file with authors), *available at* http://www.climatechange.ca.gov/documents/2005-12-19_WILLIAMS.PDF.

26 Except as otherwise indicated, the facts about sequestration were provided by Vello Kuuskraa of Advanced Resources International, Inc. ARI is the lead consultant on the EnCana project described in the text.

27 EPA Underground Injection Control Program, http://www.epa.gov/safewater/uic/whatis.html (last visited March 27, 2007).

28 *See* http://www.kindermorgan.com/business/co2/transport_cortez.cfm.

29 DOE Office of Oil and Natural Gas, Project Facts: Recovering "Stranded Oil" Can Substantially Add to U.S. Oil Supplies, Ten Reports Examine Basin-Oriented Strategies for Increasing Domestic Oil Production (Feb. 2006), *available at* http://www.fossil.energy.gov/programs/oilgas/publications/eor_co2/C_-_10_Basin_Studies_Fact_Sheet.pdf.

30 Email from Vello Kuuskraa, President, Advanced Resources Int'l, to Kenneth Berlin, Partner, Skadden, Arps, Slate, Meagher & Flom LLP (Apr. 30, 2007) (on file with authors).

31 On October 31, 2006, DOE announced the Department's support of seven tests in North America to advance carbon sequestration technologies. DOE will provide more than $450 million over the next 10 years to validate that the capture, transportation, injection, and long-term storage of CO_2 can be done safely, permanently, and economically. *See* Press Release, DOE Nat'l Energy Tech. Lab., Department of Energy Advances Commercialization of Climate Change Technology (October 21, 2006; on file with authors), *available at* http://www.netl.doe.gov/publications/press/2006/06062-Carbon_Sequestration_Testing_Suppo.html. *See generally*, Nat'l Energy Tech. Laboratory, Carbon Sequestration Atlas of the U.S. and Canada (March 2007), *available at* www.netl.doe.gov/publications/carbon_seq/atlas/index.html [hereinafter, The NETL Sequestration Atlas].

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40 Sally Benson, "Carbon Dioxide Sequestration/Coal Gasification," Contributing Paper (Pew Center/NCEP 10–50 Workshop) at 17.

41 The MIT Study, *supra* note 4, at 53.

42 *Id.* at 53–54. The MIT study also concluded that about 10 projects would be needed to cover the range of important geological formations around the world. *Id.*

43 S. 962, introduced on March 21, 2007, would authorize $315 million through 2009 for up to seven large-scale sequestration tests, including one conducted internationally.

44 The MIT Study, *supra* note 4, at 43.

45 In 2006, Texas passed House Bill 149, which transfers ownership of the CO_2 generated by the FutureGen Alliance to the Railroad Commission of Texas once it has been captured and stored. Testimony by Jay B. Stewart, *Carbon Capture and Sequestration—An Overview: Hearing Before the Subcommittee on Energy and Air Quality of the H. Comm. On Energy and Commerce*, 110th Cong. (March , 2007).

46 Doug Obey, "Industry's CO_2 insurance plan seeks to block state waste rules," Inside EPA, May 12, 2006.

47 Cynthia Doughtery, Office of Ground Water and Drinking Water, and Brian McLean, Office of Atmospheric Programs. Using the Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects—UIC Program Guidance (UICPG # 83.) (March 1, 2007), *available* at http://www.epa.gov/safewater/uic/pdfs/guide_uic_carbonsequestration_final-03-07.pdf

48 Some states are moving ahead with legislation to establish a framework for regulating sequestration sites and to provide tax breaks for projects. *See* "States Proceed with CO_2 Storage Plans Ahead of EPA UIC Decision," *Inside EPA*, Apr. 27, 2007.

49 *See generally* Paul W. Parfomak et al., "Carbon Dioxide (CO_2) Pipelines for Carbon Sequestration: Emerging Policy Issues," Cong. Research Serv. (Apr. 19, 2007).

50 The NETL Sequestration Atlas, *supra* note 31.

51 Battelle Joint Global Change Research Institute, Carbon Dioxide Capture and Geologic Storage: A Core Element of a Global Energy Technology Strategy to Address Climate Change, at 26–27. (April 2006) [hereinafter the Battelle Report].

52 Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, at 11 (Ogunlade Davidson et al. eds., 2005). Both the NETL Sequestration Atlas, *supra* note 31 and the Battelle Report, *supra* note 51, provide higher estimates of CO_2 storage capacity than IPCC. For example, Battelle estimates worldwide storage capacity of 11,000 gigatons. More definitive inventories in the United States and globally will enable this range of uncertainty to be narrowed considerably. For comparison purposes, fossil fuel CO_2 emissions from 1400 gigawatts of new IGCC plants would total 8.4 billon tons per year (at 6 million tons per gigawatt). *See* Socolow, *supra* note 15, at 50 and the MIT Study, *supra* note 4, at ix.

53 IPCC Special Report on Carbon Dioxide Capture and Storage *supra* note 52 at 31.

54 Legislation has been introduced in both the Senate and the House (S. 731 and H.R. 1267, both introduced March 1, 2007) to require a more definitive inventory of U.S. sequestration capacity.

55 A Duke University study, for example, recommended that the most cost-effective way for North Carolina to sequester CO_2 was to build a pipeline that would run 2250 miles and support a CO_2 flow rate of 57 million metric tons of CO_2 per year, sufficient to handle captured emissions from 11 gigawatts of new coal-fired plants. The pipeline alone is estimated at a cost of $5 billion, and according to the study would be cost effective at a CO_2 price of $29 per ton. Eric Williams, et al., *Carbon Capture, Pipeline and Storeage: A Viable Option for North Carolina Utilities?* (Working Paper, March 8, ,2007), Nicholas Institute for Environmental Policy Solutions and Center on Global Change, Duke Univ. [hereinafter, The Duke Study]. *See also* Chris Holly, *Clean Coal's Future in North Carolina Hangs On Big Pipe*, 35 The Energy Daily 71, 1–2 (Apr. 16, 2007). A price of $29 per ton of CO_2 is consistent with estimates elsewhere in this article of the cost at which CCS becomes cost competitive.

56 Another technology, Oxy-fuel pulverized coal combustion, may be more cost-effective in capturing CO_2. The MIT Study concluded that the technology is in the early commercial development stage (with one 30 MW CO_2-free coal combustion targeting a start-up in 2008 and one a 24 MWe oxy-fuel electricity generation project under development) and that it appears to have considerable potential. The MIT Study *supra* note 4, at 31.

57 According to the MIT report, a 500 MW SCPC unit requires a 37 percent increase in plant size to accommodate the additional steam required for regeneration of the amine solution and, as a result, a plant with CCS is 9 percent less efficient than one without it. *Id.* at 24–25.

58 On March 15, 2007, however, AEP announced that it would experimentally retrofit two pulverized coal plants to capture carbon. AEP Press Release *supra* note 36.

59 Research Reports Int'l, Coal Gasification for Power Generation, at 10–11 (Sept. 2005).

60 The Roadmap, *supra* note 32, at 9 (2006).

61 John Fialka, "Kyoto Question as U.S. Moves on Coal—Energy Department Teams With Consortium to Build Model 'Clean-Coal Plant," *The Wall Street Journal*, December 6, 2006 at A2.

62 MIT estimates the cost of CO_2 capture and pressurization at about $25 a ton and CO_2 transportation and storage at about $5 a ton The MIT Study, *supra* note 4, at xi.

63 The MIT Study, *supra* note 4, at 30, 36; Mark Meyer et al., *Integrated Gasification Combined-Cycle Technology Draft Report*, Dep't of Nat. Res. Pub. Serv. Comm'n of Wisc. (June 2006), at 31–33 [hereinafter, the Wisconsin Report]; EPA, Environmental Footprints and Costs of Coal-based Integrated Gasification Combined Cycle and Pulverized Coal Technologies, at S-11–S-12 (July 2006) [hereinafter, The EPA Report].

64 The efficiency of IGCC plans is now lower with Western subbituminous and Texas lignite coals, at least with some gasification technologies. As a result, the MIT report indicates that the cost differential between IGCC and SCPC narrows when these coals are used. The MIT Study, *supra* note 4, at 36–37.

65 Testimony of Brian Hannegan, *Future of Coal: Hearing Before the S. Comm. On Energy and Natural Resources*, 110th Cong. at 5 (March 22, 2007).

66 *Id.* at 3.

67 The MIT Study, *supra* note 4, at 34.

68 Unless otherwise noted, these new plants were reported in the NETL Tracking Report, *supra* note 7.

69 BP Press Release, *supra* note 34.

70 Barry Cassell, "Illinois EPA Issue Draft Air Permit for Taylorville IGCC Project," SNL Energy Coal Report at 12, 13 (Dec. 4, 2006).

71 Wayne Barber, "Southern Utility Subsidiary Laying Groundwork for Mississippi IGCC Plant," SNL Energy Coal Report at 14, 15 (Feb. 19, 2007).

72 "Coal: Mont. Announces CTL, IGCC Plants," *Greenwire*, Oct. 3, 2006.

73 Barry Cassell, "Peabody Foresees Major Coal-fired Capacity Additions by 2019," SNL Energy Daily Coal Report at 1 (April 9, 2007).

74 Fernandez, *supra* note 20.

75 Statement of Edward Lowe, General Manager Gasification Market Development, GE Energy *CO_2 Capture and Sequestration: An Overview Hearing Before the H. Subcomm. on Energy and Air Quality*, 110th Cong. at 4 (March 6, 2007).

76 *See e.g.*, The NETL Tracking Report, *supra* note 7.

77 "Availability" is an industry term meaning the amount of time the plant is operating. Availability is reduced if there are lengthy outages for repairs and maintenance.

78 The Wisconsin Report, *supra* note 63, at 16.

79 *Id.* at 1.

80 The Public Utilities Commission of Ohio, 2006 End of Year Review, at 4 (December 26, 2006).

81 Press Release, "Citizens Action Coalition of Indiana, Consumer and Environmental Groups Join to Challenge New Duke/Vectren Coal Plant that Would Cost Indiana Rate Payers Billions," Nov. 29, 2006 (on file with authors), *available at* http://www.citact.org/newsite/

82 In Minnesota, even after the state passed legislation providing for the Mesaba IGCC project to enter into a power purchase agreement, the major utility, XCEL, and consumer groups have opposed such an agreement before the Minnesota PUC on the ground that it is too costly. *Inside EPA*, Jan. 12, 2007.

83 NRG was recently selected by New York State to build an IGCC facility but its management acknowledged that this facility would not be viable without significant financial support from government programs. Press Release, "NRG Energy Inc., NRG Energy Inc. Receives Conditional Award to Build Advanced Coal-Gasification Power Plant in Western New York: Will Enter into a Strategic Alliance with NYPA," December 19, 2006 (on file with authors), *available at* http://www.snl.com/irweblinkx/file.aspx?IID=4057436&FID=3211361 (last visited on Mar. 27, 2007).

84 IND. CODE § 6-3.1-29-15 (West Co. Rev. Stat. Ann. 2006).

85 Kansas Energy Council, Kansas Energy Plan 2007, at 3 (referencing Kansas House Substitute for S. 303 (passed in the 2006 Legislative session), *available at* http://kec.kansas.gov/energy_plan/energy_plan.pdf

86 C.R.S.A. § 40-2-123 (West Co. Rev. Stat. Ann 2006).

87 MINN. STAT. § 216B.1694 (West Co. Rev. Stat. Ann. 2006).

88 Energy Policy Act of 2005, 42 U.S.C.A. § 16511 (West 2007).

89 A similar approach was advocated in a 2004 report published by the Kennedy School of Government, which proposed a "3 Party Cnvenant" between the federal government, state utility commissions and equity investors to lower the cost of financing IGCC plants. William Rosenberg et al., Deploying IGCC in This Decade with 3 Party Covenant Financing: Overview of Financing Structure, Harvard Univ., at 1 (July 2004) (explaining that the 3 party covenant seeks to reduce the cost of capital, raise the debt equity ratio, minimize construction financing costs and allocate financial risk). Under the 3 party covenant "the federal government provides AAA credit [through loan guarantees], the state [Public Utility Commission] provides an assured revenue stream to cover cost of capital and protect the federal credit, and the owner provides equity and know-how to build the IGCC project with appropriate guarantees" from the vendor and construction firm. *Id.* at 8.

90 DOE, Fact Sheet: Clean Coal Technology Ushers In New Era in Energy (2006), *available at* http://www.doe.gov/media/cleancoaltaxcreditfactsheet.pdf. Subsequently, several utilities who had unsuccessfully sought tax credits expressed disappointment, saying that DOE's decision would slow commercialization of IGCC. *See* ARGUS AIR DAILY, December 11, 2006.

91 Case in point: Southern Company's 285 MW IGCC facility near Orlando, Florida, which is receiving $235 million from the Department of Energy. *See* DOE Office of Fossil Fuel Energy, Project Fact Sheet for Demonstration of a 285 MW Coal-Based Transport Gasifer (Project ID DE-FC26-06NT42391), *available at* http://www.fossil.energy.gov/fred/factsheet.jsp?doc=4884&projtitle=Demonstration%20of%20a%20285MW%20Coal-Based%20Transport%20Gasifier (last visited Mar. 27, 2007).

92 Carbon Price Key for IGCC, CCS Argus Air Daily, May 11, 2007.

93 Natural Resource Defense Council, Coal and Climate: Hitting the Wall (unpublished PowerPoint presentation) (on file with authors), *available at* http://www.aaas.org/spp/rd/Forum_2006/hawkins.pdf

94 WEO 2006 *supra* 5 at 141.

95 EIA Energy Outlook 2007, *supra* note 10 at 9. In the NETL Tracking Report, *supra* note 7, NETL lowers the estimate of new coal-fired plant generation capacity to 145 gigawatts.

96 Press Release, DOE, "FutureGen Industrial Alliance Announces Site Selection Process for World's First 'Zero Emissions' Coal Plant," February 8, 2006 (on file with authors), *available at* http://www.fossil.energy.gov/news/techlines/2006/06007-FutureGen_Site_Selection_Process.html

97 The MIT Study raised several concerns regarding the FutureGen project, including the continuing lack of clarity surrounding project goals, the incorporation of features extraneous to the commercial demonstration of CCS, the confusion of objectives caused by the inclusion of international partners, and whether the project will be bogged down by federal procurement rules and government cost auditing. The MIT Study, *supra* note 4, at 81–82.

98 Many companies building IGCC plants may believe they are "capture ready" and can be retrofitted with CCS capability if required to reduce CO_2 emissions under a future carbon management regime. However, the MIT Report questions whether such retrofits can be accomplished economically if the plant parameters are not initially designed with CCS in mind. The MIT Report, *supra* note 4, at 38.

99 The Regional Greenhouse Gas Initiative includes 10 states as of May 2007: Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Delaware, and Maryland. Information on the RGGI, including the Memorandum of Understanding, is *available at* http://www.rggi.org/index.htm.

100 Western Regional Climate Action Initiative, Ariz.-Cal.-N.M.-Or.-Wash., Feb. 26, 2007, *available at* http://www.climatechange.ca.gov/documents/2007-02-26_WesternClimateAgreementFinal.pdf. *See also* Press Release, "Office of the Governor for the State of Oregon, Five Western Governors Announce Regional Greenhouse Gas Reduction Agreement," Feb. 26, 2007 (on file with authors), *available at* http://governor.oregon.gov/Gov/pdf/letters/022607NGA.pdf

101 Climate Stewardship and Innovation Act of 2007 (S. 280), introduced on January 12, 2007. A similar version of this bill was introduced in the House as H.R. 620 by Representative Olver.

102 Electric Utility Cap and Trade Act, S. 317, 110th Cong. (2007). Very similar targets are reflected in utility-only bills introduced by Senator Carper (S.1177)(Apr. 20,2007) and Senator Alexander (S.1168)(Apr. 19, 2007), which regulate emissions of NO_x, SO_2, and mercury as well as CO_2. *See also, Cong. Res. Service Comparison of Key Provisions of Greenhouse Gas Reduction Bills Introduced in 110th Congress*, [38] BNA Environmental Reporter, No. 6, at 337 (Jan. 31, 2007) (comparing key provisions of the Greenhouse Gas Reduction Bills introduced in the 110th Congress) [hereinafter, Env. Reporter Comparison].

103 The Bingaman draft bill was first developed in the 109th Congress and named the "Climate and Economy Insurance Act of 2005." The bill was never formally introduced. Senator Bingaman has circulated a slightly revised version of the bill in the current Congress. *See* Bingaman-Specter Discussion Draft on Global Warming Legislation, "Market-Based GHG Emission Trading 2007 Discussion Draft," *available at* http://energy.senate.gov/public/_files/DiscussionDraftSupportingInformation.pdf [hereinafter, the Bingaman Discussion Draft]. The original Bingaman proposal reflected 2004 recommendations by the National Commission on Energy Policy. The Commission recently issued revised recommendations which call for stabilizing emissions at current levels by 2020 and achieving a 15 percent reduction below these levels by 2030 and propose raising the starting price of the safety valve to $10 per ton of CO_2 and increasing the rate of escalation to 5 percent per year. National Commission on Energy Policy, *Energy policy recommendations to the president and the 110th Congress*, April 2007. It remains to be seen whether Senator Bingaman will adopt these recommendations, which are still considerably less aggressive than other carbon cap proposals pending in Congress.

104 S. 309 basically reintroduces Senator Jeffords' Global Warming Pollution Reduction Act from the last Congress. A similar bill (H.R. 1590) has now been introduced in the House by Representative Waxman and several co-sponsors.

105 A utility-only bill recently introduced by Sen. Sanders, S.1201 (Apr. 24, 2007) would cap emissions at 1990 levels by 2020 and Kyoto levels (7 percent below 1990 levels) by 2025.

106 For example, under S. 280, the targets must be reviewed biennially by NOAA, which must report its views and recommendations to Congress. Under the draft Bingaman bill, the targets are subject to interagency and Congressional review every five years. Similarly, under S. 317, EPA must review the targets every four years starting in 2015 and may make them more or less stringent.

107 For example, the Clean Power Act (S. 150) introduced by Senator Jeffords in the last Congress would cap utility CO_2 emissions at 2.05 billion tons in 2010, 21% below 2000 levels. U.S. Senate Committee on Environment and Public Works, http://epw.senate.gov/pressitem.cfm?party=dem&id=230866. As analyzed by EPA, the cost per ton of controlling CO_2 would be $16 in 2010 and $27 in 2020. James McCarthy and Larry B. Parker, "Cost and Benefits of Clear Skies: EPA's Analysis of Multi-Pollutant Clean Air Bills," *Congressional Research Service Report for Congress*, at CRS 14 (November 23, 2005).

108 *Id.*

109 Bingaman Discussion Draft, *supra* note 103, at 1.

110 *Generation Technologies for a Carbon Constrained World*, EPRI Journal, at 39 (Summer 2006).

111 *See* 42 U.S.C.A. § 7503 (LAER statutory provisions) and 42 U.S.C.A. § 7475 (BACT statutory provisions). The "top down" approach is described in the EPA 1990 New Source Review Workshop Manual. EPA, New Source Review Workshop Manual: Prevention of Significant Deterioration and Nonattainment Area Permitting at B.5–B.9, *available at* http://www.epa.gov/ttn/nsr/gen/wkshpman.pdf.

112 *See e.g.*, EPA, Fact Sheet: EPA's Clean Air Mercury Rule, *available at* http://www.epa.gov/air/mercuryrule/pdfs/factsheetfinal.pdf.

113 Massachusetts v. EPA, No. 05-1120, slip op. (U.S. April 7, 2007).

114 A thorough discussion of many of these issues is provided in Gregory Foote, *Considering Alternatives: The Case for Limiting CO_2 Emissions from New Power Plants Through New Source Review*. 34 ELR 10642 (July 2004).

115 EPA's position was conveyed in a December 2005 letter to an industry consultant which was later rescinded as an authoritative EPA interpretation of the CAA after being challenged by environmental groups because of the absence of public comment. *See* Letter from Ann Brewster Weeks, Clean Air Task Force, et al. to Stephen Johnson, Administrator—U.S. EPA (February 8, 2006), *available at* http://www.catf.us/advocacy/legal/BACT_LAER/Johnson_Letter.pdf. Nonetheless, EPA has not repudiated the approach embodied in the letter, leaving unresolved the issue of whether IGCC is BACT/LAER for purposes of PSD/NSR requirements.

116 These terms are included in the statutory definition of BACT and have been interpreted by EPA. *See* 42 U.S.C.A. § 7479 (definition of "best available control technology") and 42 U.S.C.A. § U.S.C.A. § 7501 (definition of "lowest achievable emission rate").

117 *See* e.g., Steven Cook, "Appeals Board Decision Seen as Setback For Use of Coal Gasification Technology," *Daily Environment Report*, September 14, 2006, at A-4; "Thoroughbred appealed over IGCC, Argus Air Daily, May 15, 2006, at 4; "Ky rejects IGCC for BACT," Argus Air Daily,April 12, 2006, at 1.

118 This approach is reflected in a draft bill widely circulated but not introduced by Senator Coleman of Minnesota on file with the authors. *See* Energy Info. Admin., Energy Market Impacts of a Clean Energy Portfolio Standard, at Appendix B (January 2007), *available* at http://www.eia.doe.gov/oiaf/servicerpt/portfolio/pdf/sroiaf(2007)02.pdf

119 Williams and Hawkins, Coal Low-Carbon Generation Obligation for U.S. Electricity. Review draft, August 7, 2005, *available at* http://phys4.harvard.edu/~wilson/energypmp/Hawkins&Williams.doc.

120 A version of this concept is reflected in section 709 (Low Carbon Generation Requirement) of the Sanders global warming bill (S. 309), under which an increasing percentage of generation from coal, lignite, coke, and biomass would need to meet a low carbon generation standard (250 pounds of CO_2 per MWh).

121 The low carbon commitment would start off at 0.5 percent in 2015 and increase to 5 percent by 2020. Subsequently, EPA could increase the commitment by up to 2 percent per year through 2025, and by up to 3 percent per year from 2026 through 2030.

122 In February 1993, soon after taking office, President Clinton proposed a broad-based energy tax for the United States as a means to tax the use of fossil fuels and decrease the nation's reliance on foreign oil. The tax was to be levied on the energy content of fuels (i.e. the number of "BTUs" they contain), with a substantially higher rate for petroleum fuels than for coal and natural gas. The three reasons in addition to deficit reduction that the administration cited for the tax were the reduction of environmental damage, energy conservation, and the alleviation of U.S. dependence on foreign energy sources. The tax was carefully designed to spread the revenue burden evenly across the country's diverse regions. The BTU tax would have reduced CO_2 emissions by encouraging greater efficiency in energy production, conservation, and use and by promoting development of renewable energy sources. Ultimately, the tax was defeated in the Senate, where the administration lost the support of several oil-state Democrats and failed to win over any moderate, pro-environment Republicans. The Senate chose a small increase in the gasoline tax as the alternative.

123 Nonetheless, legislation to impose a carbon tax has been proposed by Rep. Stark of California (H.R. 2069). This bill would initially tax coal, petroleum and natural gas at $10 per ton of carbon content when these fuels are either extracted or imported.

124 Craig Hanson and James Hendricks, Jr., "Taxing Carbon to Finance Tax Reform", Duke Energy and World Resources Institute Issue Brief at 3 (March 2006), *available at* http://pdf.wri.org/taxing_carbon_full.pdf.

125 Those are the goals set forth in the NETL Carbon Sequestration Roadmap and Program Plan—2006 and for the FutureGen project. *See* Roadmap, *supra* note 32 at 9; Fialka, *supra* note 61. Again, there might he some need to allow slight slippage of these goals.

126 S. 485 would amend the Clean Air Act so that each new coal power plant commencing construction on or after April 26, 2007 would be required to meet a standard of performance allowing the plant to produce no more than 285 pounds of CO_2 per MWh. CO_2 that is injected into a geological formation in a manner that prevents its release into the atmosphere would not be counted in applying this standard. The Kerry bill lacks some the flexibility elements described in this paper, such as a phased schedule for actually capturing and sequestering CO_2.

127 The Energy Information Administration estimates that natural gas produces 1.314 pounds of CO_2 per kilowatt-hour, compared to 2.117 pounds per kilowatt-hour for coal. Energy Info. Admin., Carbon Dioxide Emissions from the Generation of Electric Power in the U.S., at 2 (July 2000), *available* at http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2report.html. In 2005, CO_2 emissions from natural gas plants were 318.9 million metric tons, representing 13 percent of total emissions from the electric power generation sector. The EIA 2006 Report, *supra* note 3, at 16.

128 Section 708 (Emission Standard for Electric Generation Units) of the Sanders global warming bill (S. 309) contains a somewhat similar provision under which all electricity generation units which begin operation in 2012 or later must meet, by 2016, an emission performance standard that is "not higher than the emission rate of a new combined cycle natural gas unit." The standard would apply to all existing units by 2030, regardless of when they began operating.

129 *See e.g.* Testimony of Brian Hannegan, *supra* note 65 at 3.

130 Embodying a similar approach is a March 2007 settlement agreement between Kansas City Power and Light and the Sierra Club relating to the utility's 850 megawatt coal-fired plant under construction in Missouri. The agreement requires Kansas City Power and Light to offset the 6 million tons of CO_2 emissions from the new plant by installing 400 megawatts of new wind power, implementing measures to save 300 megawatts of energy demand and closing or upgrading an older coal-fired plant. Steven Mufson, "Electric Utility, Sierra Club End Dispute: Kansas City Power & Light Agrees to Offset New Coal-Fired Plant's Emissions, *The Washington Post*, March 20, 2007, at D03.

131 The MIT Study, *supra* note 4, at 100. Consistent with the MIT report, federal financial support for IGCC units without CCS would be phased out because IGCC already has strong commercial backing and the adoption of an emission performance standard requiring CCS will change the economics of new coal plants in IGCC's favor. *Id.*

132 Section 713 (Geologic Disposal of Global Warming Pollutants) of the Sanders utility-only bill, S. 1201, would authorize EPA to develop many of these program elements.

133 The performance standard could be implemented as a stand-alone provision (without a cap-and-trade program) if necessary to provide certainty to coal plant developers that uncontrolled plants will not be "grandfathered." Section 716(c) of the Feinstein-Carper bill (S. 317), for example, provides that no allowances may be allocated to any coal-fired unit unless it entered operation before January 1, 2007 or is powered by "qualifying advanced clean coal technology."

134 The MIT Report concludes that retrofits will be unlikely because of reductions in unit efficiency and output, unit downtime and increased on-site space requirements and that plant rebuilds to include capture technology appear more attractive, particularly if they upgrade low-efficiency PC units with high-efficiency technology. The MIT Study, *supra* note 4 at pages xiv, 28, 38 and 146–150. Nonetheless, AEP is investigating retrofit opportunities at two of its plants. AEP Press Release, *supra* note 36. Whatever the practical realities of retrofits, mandating them for existing plants (as is the approach under S. 309, which provides that all existing plants must meet emission performance standards by 2030) seems less desirable than a declining emissions cap, under which retrofits would be considered along with other options based on an analysis of cost-effectiveness.

135 Under existing Clean Air Act cap-and-trade programs for SO_2 and NO_x, utilities do not receive allowances for the emission reductions required to meet mandated limits on emissions except where such reductions exceed mandated levels. The same approach should be followed for greenhouse gases.

136 Put another way, the California Act requires reduction of 174 million tons of CO_2 per year by 2020. Assuming that California would permit its regulated companies to buy reductions from outside the state, this entire requirement could thus be met many times over by building new IGCC plants with CCS systems if credits for those plants (900 million tons on a nationwide basis) were permitted and business could otherwise continue as usual in California.

137 *See* The Wisconsin Report, *supra* note 63 at 32 (estimating that costs would increase to over $75 per MWh of energy generated with carbon capture, compared to between $50 and $60 per MWh without carbon capture); The MIT Study, *supra* note 4, at 36 (estimating that the costs for IGCC with carbon capture will be 30 percent to 50 percent over that of SCPC without carbon capture and 25 percent to 40 percent higher than IGCC without carbon capture); The EPA Report, *supra* note 63, at 5–11 (estimating $66 per MWh for IGCC with carbon capture versus $48 per MWh for IGCC without capture and $51 for SCPC without capture).

138 Michael L. Godec, Advanced Resources International, CO_2-EOR and Sequestration: Potential Opportunity for Coal Gasification (November 13, 2006) (unpublished PowerPoint presentation prepared for Pre-Conference Symposium: The Economics of Carbon Capture, Transport & Sequestration) (on file with authors).

139 EPRI estimates that the 30 percent energy efficiency penalty associated with CCS will be reduced to around 10 percent over the longer term. Testimony of Brian Hannegan, *supra* note 65 at 3.

140 David Hawkins of the National Resources Defense Council recently testified that a low-carbon generation obligation large enough to cover all forecasted new U.S. coal capacity by 2020 could be implemented with about a 2 percent increase in average U.S. electricity rates. Testimony of David Hawkins, *Carbon Capture and Sequestration—An Overview: Hearing Before the Subcommittee on Energy and Air Quality of the H. Comm. On Energy and Commerce*, 110th Cong. at 19 (March 6, 2007).

141 *Id.*

142 The estimate of 80 gigawatts assumes that some of the currently proposed 93 gigawatts of coal-fired plants would not have CCS systems but would offset their CO_2 emissions under the three-year alternative compliance option described in the text.

143 WEO 2006, *supra* note 5 at 148.

144 For example, under S. 280, the revenues for allowance auctions would be used to fund a Climate Change Credit Corporation, which must in turn support a climate technology challenge program. *See* S. 280, Title III. Similarly, S. 317 would use auction proceeds to fund a Climate Trust Fund which would in turn support innovative low and zero-emitting carbon generation technologies and clean coal technologies, among other activities. *See* S. 317, Section 717.

145 IPCC Fourth Assessment Report *supra* note 13 at 3.

146 The MIT Study, *supra* note 4, at 11.

147 Total electricity generation capacity in China increased by nearly a third in the last three years, and is expected to continue doubling each year for the next several years. *See* The MIT Study, *supra* note 4, at 63. India's growth in coal consumption is currently projected at 6 percent per year; it is expected to reach current U.S. coal consumption levels by about 2020 and will match Chinese usage by about 2030. *See* The MIT Study, *supra* note 4, at 74.

148 *See generally*, The MIT Study, *supra* note 4, Chapter 5 (summarizing environmental regulation in China and to a lesser extent in India). *See also*, "Chinese energy reforms may surpass U.S.'s," Greenwire, Apr 27, 2007, (stating that reforms adopted by China in 2001 are on track to cut 168 million tons (152 million metric tons) of greenhouse gases by 2010, and is focusing first on the dirtiest and largest energy consuming industries including coal-fired coal plants).

149 *See* The MIT Study, *supra* note 4, at 55 (stating that several small-scale sequestration studies are currently occurring in China and one small pilot project is underway in India, though concerted research and large-scale pilot projects are currently lacking).

150 *See generally* The Duke Study *supra* note 55. *See also* Figure 8 on page 15.

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Ken Berlin and Robert M. Sussman
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Performance Standard More Effective Than Bonus Allowance

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Introduction and Summary

The Low Carbon Economy Act of 2007 (S.1766), recently introduced by Sen. Jeff Bingaman (D-NM) and six of his colleagues, provides a useful framework for spurring greenhouse gas emission reduction and will contribute to the ongoing debate in Congress on climate change legislation. The bill reflects a recognition that carbon capture and storage, CCS, technology is essential for the continued viability of coal-derived electricity in a world of growing carbon constraints. The bill sponsors offer an approach to accelerate the deployment of CCS systems that deserves careful consideration. Under this approach, plant developers would not be required to install CCS systems at new coal plants; they would instead receive "bonus allowances" as *incentives* to adopt CCS. The idea is that the market value of these bonus allowances would offset the cost differential between plants with CCS and uncontrolled coal plants with the goal of making CCS-equipped plants a cost-effective option under the bill's cap-and-trade program for coal-burning facilities.

Our recent report "Global Warming and the Future of Coal" examines an array of options for achieving the goal of widespread CCS deployment at new coal plants. It analyzes whether CCS plants would be economically sustainable under the anticipated range of CO_2 allowance prices in the early years of proposed cap-and-trade programs and concludes that CCS would not be a cost-effective compliance option under these programs. In contrast to S. 1766, our report does not propose offering utilities allowances as incentives to adopt CCS. We instead propose that Congress set an emission performance standard for new coal plants based on the effectiveness of available capture and storage technology, with a phase-in process to allow time for further testing and improvement of the technology. The performance standard would be accompanied by financial assistance to mitigate the added cost of CCS and protect against electricity price hikes.

Our report did not examine the pros and cons of using bonus allowances under a cap-and-trade program as a tool to incentivize utilities to build new plants with CCS systems. To supplement our earlier options analysis, this report will examine the CCS incentive provisions in the Low Carbon Economy Act and compare them to the emission performance approach recommended in "Global Warming and the Future of Coal." We show that the emission performance approach is more effective and less costly than the bonus allowance program proposed in the Low Carbon Economy Act for the following reasons:

- Traditional emission control programs under the Clean Air Act and other laws set higher standards of performance for new sources of pollution than existing sources of pollution. New sources have generally been required to apply the best available emission control technology and have been subject to technology-based emission limits that supplement cap-and trade programs or other less stringent safeguards for existing sources. These stringent controls on new source emissions bave made emission caps achievable by preventing emissions growth from new sources that would negate reductions from existing sources. Such new source emission standards achieved significant pollution reductions at an affordable cost, as well as sped the development and deployment of new technologies.

- Application of the most advanced control technology to new power plants should be an essential element in an overall greenhouse gas emission strategy so that emissions growth from these plants does not jeopardize sector-wide emission reduction efforts. There is broad agreement that, while further testing and development are needed, CCS is the most promising—and probably the only effective—CO_2 control technology for coal power plants.

- An emission performance standard would ensure that all new coal plants capture and sequester their emissions rather than relying on bonus allowances that may or may not be sufficient to motivate plant developers to deploy CCS systems and could either provide inadequate incentives or unjustified windfalls to utilities.

- Bonus allowances must overcome non-price barriers to building plants with CCS, including the reluctance of conservative utility executives to invest in new and uncertain technologies and the belief that second generation plants are more economical and reliable than first generation plants. As a result, the subsidies provided under a bonus allowance program would likely be considerably larger than necessary to close the cost gap between plants with and without CCS system.

- One consequence of this is that the bonus allowance set aside could become so large that it reduces the size of the auction pool and/or shrinks allowance allocations to other regulated entities. Our calculations show that the bonus allowances awarded to utilities under S. 1766 could substantially exceed the 8 percent set aside, requiring a large transfer of allowances from the auction pool to utilities and reducing the revenues derived from the auction process.

- The most likely scenario is that utilities will not sell bonus allowances in the open market but would use them to offset emissions from existing plants or even from new plants without CCS systems. This would delay reductions from the utility sector, put upward pressure on allowance prices and increase emission reduction obligations and costs for other categories of allowance holders.

- These distortions of the cap-and-trade system would be avoided if an emission performance standard—and not a bonus allowance program—were the primary tool to achieve widespread deployment of CCS systems at new coal plants. While financial assistance would be available to plant developers, its purpose would be to protect consumers from undue energy price increases and not to create incentives for CCS deployment. As a result, such assistance could be precisely calibrated to reflect the carbon price differential between controlled and uncontrolled plants and could be adjusted over time as actual cost data becomes available. This would benefit energy users without providing a windfall to utilities.

Accelerating the Deployment of Carbon Capture and Sequestration Systems

What Does the Low Carbon Economy Act Propose?

The Low Carbon Economy Act would create a United States greenhouse gas cap-and-trade program that would reduce emissions to 2006 levels by 2020 and 1990 levels by 2030. Covered entities—mainly large coal-consuming facilities (primarily utilities), petroleum refineries, natural gas processing facilities, and fossil fuel importers—would need to submit allowances corresponding to the amount of CO_2 they emit or make payments into a special fund at a fixed price for each ton of CO_2 emitted. This "technology accelerator payment," or TAP, would start at $12 per metric ton of CO_2 equivalent in 2012 and increase by 5 percent per year above the rate of inflation. The TAP, which some have described as a safety valve, would provide regulated sources a cheaper alternative to purchasing allowances if the market price exceeds the TAP amount.

Emission allowances would be in part distributed by the government to the private sector for free, and in part sold at auction. The amount of auctioned allowances would become progressively larger over time and the amount of free allowances would diminish. Auction revenues would be used to fund new technologies, climate change adaptation, and assistance to low-income consumers unduly burdened by initial increases in energy prices.

Section 201(a)(1) of the Low Carbon Economy Act would require the government to set aside 8 percent of the total allowances it issues for a CCS bonus allowance program each year between 2012 and 2039. Under Section 207, facilities capturing and sequestering CO_2 would receive "bonus allowances" for each ton sequestered based on a set rate starting at 3.5 in 2012 and dropping to 1.9 in 2025 and ultimately to 0.5 in 2039. These allowances would be available for the first 10 years of the facility's operation.[1]

An Emission Performance Standard Will Better Ensure that New Coal Plants Employ CCS Systems at Lower Costs

In "Global Warming and the Future of Coal," we propose an emission performance standard which would require that new coal-fired plants deploy the best available CO_2 emission control technology—CCS—under a flexible implementation timeline. There is strong precedent for this approach under existing pollution control regimes, and it would offer several important benefits that the bonus allowance program in S. 1766 would lack.

Traditional emission control programs under the Clean Air Act and other laws set higher standards of performance for new than for existing sources of pollution. Congress has generally required new sources of pollution, such as new coal plants, to apply the best available emission control technology, taking into account cost-effectiveness and technical feasibility. Subjecting new sources to a higher level of control has served a number of policy objectives. First, where the goal of regulation is lower overall emissions, allowing new sources to operate without the most advanced technology adds unnecessarily to the emission inventory and makes emission reduction targets more difficult to achieve. Second, it is less expensive to install state-of-the-art control technology when new facilities are being constructed than to retrofit them after they commence operation. And third, an aggressive technology-forcing standard for new sources stimulates innovation and cost-reduction, accelerating the transition of new pollution control technologies from research and development to full commercial deployment.

The two-track approach for controlling new and existing sources is well-established for conventional air pollutants emitted by power plants. The Environmental Protection Agency has adopted cap-and-trade programs for utility emissions of sulfur dioxides, nitrogen oxides and, more recently, mercury. However, these programs are backstopped by the Act's rigorous new source review provisions, which require all new facilities emitting these pollutants to meet technology-based standards reflecting the most advanced emission controls available. Based on these requirements, nearly all new power plants have installed SO_2 scrubber systems, selective catalytic reduction units for NO_x and carbon injection systems for mercury. These stringent controls on new source emissions have made emission caps achievable by preventing emissions growth from new sources that would negate reductions from existing sources.

The challenge of lowering overall emissions of greenhouse gases will be immeasurably more difficult if, in response to electricity demand growth, a new generation of coal-fired power plants is built which does not control CO_2 emissions. As "Global Warming and the Future of Coal" shows, the construction of 145 gigawatts, GW, of new coal generation capacity between now and 2030 could add 790 million metric tons of CO_2 to current U.S. CO_2-equivalent emissions of 7.15 million metric tons.[2] This would mean an 11 percent *increase* in emissions as compared to the *reductions* of 20, 50 and even 80 percent targeted between now and 2050 under the major legislative proposals. The emission stream from these new plants would remain constant over their entire operating life of 60 years to 70 years, requiring progressively deeper reductions from elsewhere in the economy to achieve a declining emission cap.

Application of the most advanced control technology to new power plants should be an essential element in an overall greenhouse gas emission strategy so that emissions growth from these plants does not jeopardize sector-wide emission reduction efforts. There is broad agreement that, while further testing and development are needed, CCS is the most promising—and probably the only effective—CO_2 control technology for coal power plants since it is capable of 85 percent to 100 percent emissions capture and storage. Without a higher standard of control for new than existing coal plants, however, widespread CCS deployment would be unlikely. The estimated cost of CCS is in the range of $24 to $30 per ton for Integrated Gasification Combined Cycle plants, and in the range of $40 to $51 per ton for Supercritical Pulverized Coal Plants.[3] This is well above the 2012 TAP of $12 per ton under the Low Carbon Economy Act and likely above the escalating TAP levels in subsequent years with the 5 percent annual increase. It is also above the projected carbon price that, according to the Environmental Protection Agency, would likely prevail until 2030 under the McCain-Lieberman cap-and-trade bill.[4] As a result, CCS systems would not be cost-competitive witb conventional coal generation technology for at least two decades and perhaps longer.

This "cost gap" could be bridged by special CO_2 performance standards for new coal plants akin to new source review requirements for conventional pollutants. Our report proposes "emission performance standards," wbich would require new plants to capture CO_2 emissions at the level achievahle by the hest performing CCS technology and then to store the captured CO_2. By contrast, the Low Carbon Economy Act takes the tack of setting aside bonus allowances to incentivize developers to build these plants while allowing continued construction of conventional uncontrolled coal plants.[5]

An emission performance standard coupled with financial assistance to protect consumers from electricity price hikes is a more certain and cost-effective tool to ensure that new coal plants will employ CCS systems than a bonus allowance program. An emission performance standard would send a clear signal to plant developers that CCS systems are a required feature of all new coal plants. This would also spur innovation and cost-reduction by technology vendors and utilities who would now have a powerful motivation to seek low cost and reliable CCS solutions. Under an incentive-based approach, by contrast, plant developers would have a range of choices and would be able to weigh several factors when deciding whether CCS-equipped plants represent the most economic option for new coal generation. Many of these factors are impossible to predict and control in advance, and therefore a system of bonus allowances could in practice create either insufficient or excessive incentives for investing in plants with CCS systems.

For example, if the market price of CO_2 is lower than anticipated, bonus allowances would offset a smaller share of the cost premium for a CCS-equipped plant and utilities would need to spend less to purchase allowances to cover the emissions of uncontrolled plants. This could tip the balance in favor of conventional coal generation technology. The same outcome would occur if conventional coal plants are less costly or more efficient than anticipated or, conversely, if plants with CCS are more costly to build or operate.

Bonus allowances must overcome non-price barriers to building plants with CCS, including the reluctance of conservative utility executives to invest in new and uncertain technologies, the lower operational and financial risks of building conventional coal plants and the belief that second generation plants are more economical and reliable than first generation plants. If bonus allowances are insufficient to overcome these perceived risks, developers might opt for conventional plants even though their nominal costs are no lower than those of plants with CCS systems. The subsidies provided under a bonus allowance program would therefore likely need to be considerably larger than necessary to simply close the cost gap between plants with and without CCS system. And even with a substantial premium, there is no guarantee that plant developers would choose the CCS path.

The unpredictability of a bonus allowance program could also result in incentives that are more costly than necessary to spur investments in CCS, even considering the need to overcome non-price barriers such as technology risks. For example, if the market price of CO_2 is higher than expected, the value of bonus allowances could be greater than anticipated, resulting in a windfall to the plant developer over and above the incremental costs of building a CCS plant, even with a risk premium.[6] Similarly, the high price of allowances coupled with the lower cost of coal compared to alternative fuels could spur construction of more CCS plants than anticipated, with the demand for allowances outstripping the allowance set aside.

Unintended and Adverse Consequences of the Low Carbon Economy Act

In addition to the inherent uncertainty in using bonus allowances to incentivize widespread CCS deployment, the bonus allowance provisions proposed in the Low Carbon Economy Act are likely to have a series of unintended consequences that could adversely affect the operation of the cap and trade system and make it more difficult and costly to achieve the bill's emission reduction targets. These consequences would not occur under an emission performance approach.

The number of bonus allowances awarded to utilities may substantially exceed the allowance set aside in the bill, which would require a large transfer of allowances from the auction pool to utilities and undermine the benefits of the auction process. Although the precise operation of the bonus allowance program in the bill is difficult to forecast, a calculation using realistic "worst case" assumptions illustrates the potential for "overcompensating" utilities who invest in CCS and diverting an excessive number of allowances from the auction pool.

According to the bill's sponsors, "the bonus allowance set aside can support the development of up to 150 GWs of advanced coal with carbon capture and storage by 2030."[7] The bill's sponsors are presumably assuming that these GWs represent new generation plants rather than retrofits of existing plants.[8] A one GW Supercritical Pulverized Coal plant using the latest technology produces around 5.4 million metric tons of CO_2 annually. Thus, 150 GWs of new generation without CCS would produce 810 million metric tons per year or 8.1 billion tons over a 10 year period.

The following table calculates the number of bonus allowances that new plant developers would be awarded if 25 percent of the expected 150 GWs of new plants with CCS begin operating—for example, capturing and sequestering 90 percent of their CO_2 emissions—in each of the years 2015, 2020, 2025, and 2030:[9]

TABLE 1: NUMBER OF ALLOWANCES PER YEAR ALLOCATED TO FACILITIES WITH CCS

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
2020	364.5	2.9	1,057
2025	546.5	1.9	1038.4
2030	728.5	0.9	655.7

Key: 1 allowance = 1 ton of CO_2 emissions

For each of these representative years, total bonus allowances awarded would be greater than the 8 percent set aside of 510 million metric tons in 2017—and double the size of the set aside in 2020 and 2025.[11] Under Section 207(a) (5), the shortfall would be made up by taking allowances out of the auction pool and transferring them to the bonus allowance program. Because the overall allowance pool would become smaller as the cap declines, the expanded set aside would represent a rising percentage of total allowances available, as shown in Table 2:[12]

The value of bonus allowances could exceed the incremental costs of building new plants with CCS and provide windfall revenues to utilities. What would allowances be worth to utilities and would they confer economic benefits beyond those required to subsidize the added costs of CCS? The background documents for S. 1766 indicate that, assuming a carbon price of $10 per ton in 2017, 3.5 bonus allowances would be worth $35.[13] However, another scenario consistent with the views of some analysts is that the actual carbon price

TABLE 2: PERCENT OF TOTAL ALLOWANCES IN SET ASIDE FOR FACILITIES WITH CCS

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
2020	6.188	1057	17.08%
2025	5.732	1038.4	18.00%
2030	4.819	655.7	13.60%

The diversion of allowances from the auction pool to the CCS set aside program would necessarily reduce the revenues to the government derived from the allowance auction and thus the funding available for supporting new technologies, climate change adaptation, and assistance to low-income consumers unduly burdened by initial increases in energy prices.

under the bill will equal the TAP, which is set at $12 per ton in 2012 and rises by 5 percent above the rate of inflation annually. Assuming a modest inflation rate of 2 percent per year, the TAP would rise by 7 percent per year. By 2017, the TAP could therefore rise by between 35 and 40 percent, or up to $16 to $17 per ton.[14] The value per ton of 3.5 allowances would then be \$56 to \$60 per ton in 2017—well above the projected \$30-\$35 per ton price necessary to make CCS competitive.[15]

The incentives for CCS arguably do not need to cover the full cost of a new plant with CCS to be effective; they need only to cover the differential between the market price of CO_2 allowances and the cost per ton of capturing and sequestering emissions because uncontrolled coal plants would need to purchase allowances at that price to cover their emissions. Because the market price of an allowance in this example will rise to \$17 per ton in 2017, the cost differential between CCS and uncontrolled plants would be \$18 per ton (assuming a cost per ton for CCS of \$35). A single bonus allowance worth \$17 per ton would be sufficient to close this gap. The additional 2.5 allowances would be a windfall, although perhaps necessary at least in part to overcome the "technology risk" premium for CCS.

Following this formula, the total dollar value of the CCS incentive allowances per year would be as shown in Table 3:[16]

to calculate their total dollar value to a developer planning a 1 GW facility with CCS. For various years between 2015 and 2030, this amount is as shown in Table 4 (on page 9).

For a CCS plant beginning operation in 2015, around \$2.5 billion would be generated from bonus allowances over 10 years. This would represent over 80 percent of the total cost of building the facility—assuming that a 1 GW new generation plant with CCS would cost \$3 billion in 2015.

Utilities Would Likely Use Bonus Allowances to Avoid Reducing Emissions from Existing and New Plants. What would utilities do with the bonus allowances they receive? One possibility is to sell these allowances at the market price, using the proceeds to cover the incremental cost of building and operating a new plant with CCS. However, a utility's first priority is likely to be ensuring that it has enough allowances to offset emissions from existing plants or from new plants constructed without CCS systems. Where a utility needs allowances to offset emissions from existing plants or from new plants without CCS, there would be no reason to sell bonus allowances that could be used for that purpose since they would then have to be replaced

TABLE 3: AGGREGATE VALUE OF BONUS ALLOWANCES

YEAR	TOTAL BONUS ALLOWANCES (MILLIONS)	TECHNOLOGY ACCELERATOR PAYMENTS	TOTAL VALUE OF ALLOWANCES AND CREDITS (BILLIONS)
[illegible]	[illegible]	[illegible]	[illegible]
2020	1,057	\$19.27	\$20.37
2025	1,038.4	\$27.03	\$28.07
2030	655.7	\$37.91	\$24.90

In short, bonus allowances would be worth in the range of \$240 billion for the 10- year period between 2020 and 2030.

Another way of looking at the economic significance of the bonus allowances is

TABLE 4: VALUE OF ALLOWANCES FOR 1 GW OF CAPACITY IN [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2020	4,860	2.9	14.1	$19.27	$271.71
2025	4,860	1.9	9.2	$27.03	$248.68
2030	4,860	0.9	4.4	$37.91	$166.80

on a one-to -one- basis with allowances purchased on the open market. Thus, unless the value of the bonus allowances exceeded the cost to the utility of actually reducing emissions at its existing plants,[18] the utility will likely keep bonus allowances for internal use and only sell the bonus allowances after all its internal needs have been satisfied. This could have a significant effect on the availability of allowances to other sectors of the economy. For example, with a bonus allowance rate of 3.5, a utility could offset 20 percent of the emissions at 15.75 GW of coal plants in return for building a 1 GW plant with CCS.[19] This would allow existing plants to continue operating at current levels without reducing or otherwise offsetting their emissions even though the cap under the bill would decline by 28 percent between 2012 and 2030. The burden of reducing emissions to meet the cap would therefore fall disproportionately on other regulated entities.

The reallocation of allowances from the auction pool to the CCS set- aside program could adversely disrupt operation of the cap-and-trade program and increase costs for other categories of allowance holders. Whenever allowances are removed from the general allowance pool and set aside to support a particular industry sector or technology, it can distort the forces of supply and demand under a market trading system.[20]

In this instance, a large portion of the allowance pool—18 percent in the peak year—would be transferred to the electric utility sector, substantially increasing the number of allowances guaranteed to this sector outside the auction process.[21] Although these allowances could prevent future emissions from up to 150 GW of new coal plants, they would not in themselves *reduce* existing emissions unless utilities also replace existing plants.[22] Thus, other regulated entities would need the same number of allowances to cover their emissions but would have access to fewer allowances from either the free industry allocation or the auction process. The result would be upward pressure on allowance prices, since fewer allowances are available, and larger costs to non-utility allowance holders who would need to purchase allowances from utilities or make investments to reduce their emissions.

As a consequence, there will be an increasing likelihood that the actual cost of allowances will exceed the TAP limits, with TAP payments substituting for actual emission reductions. This problem would only become more acute as the cap declines from 2006 levels in 2020 to 1990 levels in 2030. With utilities cushioned from reducing their emissions by bonus allowances and other sectors required to make correspondingly deeper reductions, the difficulty of achieving the overall emission caps would greatly increase.

Many utilities would receive direct financial assistance in addition to bonus allowances, increasing the windfall they receive over and above the incremental costs of constructing and operating plants with CCS systems. The Low Carbon Economy Act would provide financial incentives for constructing new coal plants with CCS systems in additional to bonus allowances. Part of the proceeds from allowance auctions would be dedicated to up to $25 billion per year in technology development and adaptation assistance. Of the amounts deposited in the new Energy Technology Deployment Fund, 45 percent would be used for a zero- or low-carbon energies technology program for which coal plants with CCS would be eligible. Another 28 percent would be used to carry out an advanced coal and sequestration technologies program that would be limited to coal plant demonstration projects employing CCS systems. Under the latter program, an eligible plant could receive either a loan guarantee, a grant for up to 50 percent of project costs, or production payments of no more than 1.5 cents per kilowatt hour of electricity output for a 10- year period. Up to 20 GW of new coal capacity would be eligible for this assistance.

Since the Low Carbon Economy Act's CCS bonus allowance program would be more than sufficient to eliminate the cost differential between new coal plants with CCS and those without it, an additional program of financial assistance for plants with CCS would be redundant and simply confer additional financial benefits on plant owners.

Conclusion

Why an Emission Performance Standard Is the Best Approach

"Global Warming and the Future of Coal" argues that, without emission controls, the added CO_2 emitted from new coal plants will make it much more difficult to achieve substantial net greenhouse gas emission reductions in the United States, particularly with a long-term emission reduction target of 80 percent by 2050—the amount that many scientists consider necessary to stabilize greenhouse gas levels in the atmosphere. Like the authors of the Low Carbon Economy Act and many others, we propose the widespread deployment of CCS systems at new coal plants to prevent the bulk of these plants' emissions from being released into the atmosphere.

The report also concludes that, at least in their initial stages, cap-and-trade programs are not likely to create a carbon price high enough to eliminate the cost differential between new coal plants with CCS and those without it. As a result, new coal plant developers are unlikely to capture and sequester their emissions. We, therefore, recommend adopting an emission performance standard for all new coal plants pegged to the capture efficiency of available technology. This new standard would be phased in over an eight- year period from the date of plant construction.[23] Recognizing the added cost of building new plants with CCS systems, we further propose a package of financial assistance for these plants that would prevent significant electricity price increases. The logical source of revenues for this program would be the proceeds of allowance auctions; in the absence of an anction, other sources might be tapped, including a national "wires' charge" on retail electricity sales.

Under our proposal, existing power plants would be subject to a cap-and-trade program, with declining caps over time, as in the Low Carbon Economy Act and other proposed climate change bills. The exclusion of new plants from the cap-and-trade program, coupled with a high standard of performance for these plants, would reduce the risk that emission increases from new sources would offset reductions from existing sources and slow progress toward achievement of the overall cap.

This approach is simpler, cheaper, and more effective than the bonus allowance program in the Low Carbon Economy Act because:

- An emission performance standard would assure that all new coal plants capture and sequester their emissions rather than relying on bonus allowances that may or may not be sufficient to motivate plant developers to deploy CCS systems and could either provide inadequate incentives or unjustified windfalls to utilities. By adopting a clear mandate to install CCS systems at new coal plants after an appropriate phase-in period, Congress would send a strong signal that CCS is the preferred technology path. This would accelerate improvements in the technology and reductions in cost.

- Since bonus allowances would not be awarded to utilities under the emission performance approach, there would be no possibility that utilities employing CCS would earn excess allowances that reduce the size of the auction pool and/or shrink allowance allocations to other covered entities without corresponding emission reductions. This would assure that the revenues from auctions are sufficient for their intended purposes of technology development, adaptation assistance, and protection for low income people from higher energy prices. In addition, the allowances available to other regulated entities would not be reduced, thus avoiding upward pressure on allowance prices.

- Under the emissions performance approach, utilities that build *new* plants with CCS would not be able to avoid or defer emission reductions at *existing* plants by using surplus allowances to cover their emissions. Since new plants would be subject to a separate emissions performance standard, the emission caps would apply only to existing plants, with appropriate reduction targets to incentivize plant owners to retire these plants, increase efficiency, or offset emissions. This would assure that utilities are diligent in pursuing reductions from the existing power plant fleet.

- Financial assistance would be provided to developers of new plants with CCS under both the Low Carbon Economy Act and our proposal. However, the purpose of this assistance under the emissions performance approach would not be to *incentivize* the construction of these plants, but rather to prevent consumers from experiencing undue energy price increases because of the greater cost of producing electricity at CCS-equipped plants as compared to uncontrolled facilities. Since this assistance would not seek to reward developers of CCS plants and would not take the form of allowances of inherently uncertain value, it would not need to include a premium to overcome non-price barriers to CCS, including technology risks. Instead, the level of support could be precisely calibrated to reflect the carbon price differential between controlled and uncontrolled plants and could be adjusted over time as actual cost data becomes available. We propose allowing new CCS plants to recover 20 percent of total construction costs, with the level of recovery declining by 2 percent per year as the cost-effectiveness of the technology increases.[24] This is substantially less than the effective value of bonus allowances that would be awarded under S. 1766. We welcome further analysis comparing this approach to others,[25] with the premise that the goal of cost recovery is not to reward utilities for building plants with CCS systems but to minimize adverse economic impacts on consumers.

Endnotes

1 Under Section 302, the facility would also receive "sequestration credits" equal to the total tons sequestered on a one-to-one basis; the allocation rate for these allowances would not change over time and they would be available for an unlimited duration. Although the materials accompanying the bill suggest that these sequestration credits would increase the total number of allowances provided to plant developers, Committee staff and its consultants informed us that these credits would simply be used to offset the facility's pre-capture emissions and would have no independent market value.

2 S. 1766 does not regulate all U.S. GHG emissions, so its cap is somewhat smaller than total emissions—for example, 6,653 million metric tons of CO_2 equivalent in 2012.

3 Ken Berlin and Robert M. Sussman, *"Global Warming and the Future of Coal,"* (Washington: Center for American Progress, 2007) at 17-18. S. 1766 assumes a somewhat higher cost per ton of $35 for new plants with CCS (perhaps because it did not differentiate between IGCC and SCPC units).

4 EPA Analysis of The Climate Stewardship and Innovation Act of 2007, at 3 ("In this analysis, while CCS is available starting in 2015, carbon allowance prices rise to a high enough level to make CCS cost-competitive in [about] 2030 and it is rapidly deployed thereafter").

5 Under Section 202(c), emission rate criteria would be set for new coal plants that commence operation after December. 31, 2006, "based on the lowest economically achievable carbon dioxide per kilowatt hour emission rate for a facility of that type." We assume that these criteria would reflect the operation of conventional coal generation technology without CCS.

6 This would not occur under S. 1766 because the TAP would set an upper limit on the price of allowances but could occur under other bills that lack a similar "safety valve."

7 Fact sheet entitled "Bonus Allowances for Carbon Capture and Storage."

8 The Department of Energy projects that around 150 GW of new coal capacity will be built in the United States by 2030. CCS retrofits of existing plants are definitely desirable but are believed to pose cost and technical challenges.

9 Only tons actually captured and sequestered would give rise to allowances. It is hoped that capture effectiveness will eventually exceed 90 percent, but we have assumed 90 percent as a conservative number.

10 The tons sequestered column was calculated by assuming that 90 percent of the 810 million metric tons of CO_2 produced by 150 GW of plants are captured and that, for example, in 2015, 25 percent of those plants are in operation. Thus 810x.90x.25 = 182.

11 Assuming a cap of approximately 6.4 metric tons in 2017, 8 percent would equal 510 million tons.

12 New coal plants would also get allowances under Section 202 as part of the allocation set aside for "new entrants." This allocation is 8 percent of the total allowance given to each industry sector. Initially, 54 percent of total industry allowances (1.9 billion tons) are allocated to the electric power generating sector. We estimate that the new entrant set aside for the utility sector would total 152 million allowances in 2012, declining to lower amounts as the industry allocation declines and the allowance pool increases in later years. A portion of these allowances would presumably go to new coal plants with CCS.

13 Fact sheet entitled "Bonus Allowances for Carbon Capture and Storage."

14 To determine the technology accelerator payment after 2012, we assumed a modest 2 percent inflation rate and compounded the resulting 7 percent increase per year, assuming two years of compounding prior to 2015 and five years of compounding for each subsequent year.

15 This is true even after adjusting for inflation. With a 2 percent annual inflation rate over five years from 2012-2017, the per ton cost of CCS would increase from the high-end projection of $35 to $38.64 in 2017.

16 Again, we assume that 25 percent of the expected 150 GWs of new plants with CCS begin operating in each of the years 2015, 2020, 2025, and 2030, and that 90 percent of their CO_2 emissions are captured and sequestered.

17 The total number of allowances was calculated by multiplying the number of metric tons captured (first column of the table) by the bonus allowance multiplier (second column).

18 This is unlikely for two reasons. First, there are no current technologies that enable substantial reductions without retrofitting coal plants to capture and sequester their emissions, and the cost of CCS retrofits would likely be greater than the value of the bonus allowances (see footnote 3 and accompanying text). Second, since there are currently no effective emission reduction technologies available for existing coal plants, the only way to reduce emissions is plant closure. Closure, however, is not as cost effective an option as obtaining allowances at many plants as shown by the expectation that, at least for many years, most coal plant operators will purchase such allowances, rather than close their plants, and then increase the cost of electricity to finance allowance purchases.

19 The allowances for one new CCS plant, assuming 90 percent capture and sequestration, equal 90 percent of the plant's potential emissions. These allowances could offset 20 percent of the emissions from 4.5 plants (90 percent divided by 20 percent). The 15.75 total is reached by multiplying 4.5 by the number of bonus allowances, which is 3.5 in this example.

20 In addition to the set-aside for CCS plants, S. 1766 contains set-asides for the coal mining industry and for energy-intensive manufacturing sectors.

21 Coal-fired utilities would be allocated 29 percent of total allowances in 2012 (54 percent of the total industry allocation of 53 percent) but the utility allocation would decline to 18 percent in 2025 (54 percent of the total industry allocation of 35 percent). Thus, the CCS bonus allowances awarded to utilities in that year would basically double the sector's share of total allowances.

22 It is likely that most if not all of the new plants would be used to meet projected increases in demand for electricity, which according to EIA will be approximately 40 percent by 2030. EIA estimates that only 3.6 GW of coal power plants will be decommissioned by 2035. See "Global Warming and the Future of Coal", at 6-7.

23 For example, it would require that all new coal plants built after 2008 be able to capture their emissions by 2013 and to sequester them fully by 2016.

24 Assuming that 80 GW of new coal capacity would be eligible for cost-recovery, our report calculates the cost of this program at $36 billion over 10 years. See "Global Warming and the Future of Coal" at 45.

25 Additional subsidies might be necessary to cover operating costs if these costs sufficiently exceed the cost of power from a plant that does not capture and sequester but which must buy allowances. This subsidy might take the form of a $/kW hour production tax credit that is adjusted over time.

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