NEW TECHNOLOGIES: WHAT'S AROUND THE CORNER?

HEARING

BEFORE THE

SELECT COMMITTEE ON ENERGY INDEPENDENCE AND GLOBAL WARMING HOUSE OF REPRESENTATIVES

ONE HUNDRED ELEVENTH CONGRESS

FIRST SESSION

JULY 28, 2009

Serial No. 111–7

Printed for the use of the Select Committee on Energy Independence and Global Warming

globalwarming.house.gov

U.S. GOVERNMENT PRINTING OFFICE

62–450 WASHINGTON : 2010

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
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NEW ENERGY TECHNOLOGIES: WHAT'S AROUND THE CORNER?

TUESDAY, JULY 28, 2009

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

The committee met, pursuant to call, at 9:37 a.m. in room 2172, Rayburn, Hon. Edward J. Markey (chairman of the committee) presiding.

Present: Representatives Markey, Blumenauer, Cleaver, Hall, Salazar, Speier, Sensenbrenner, Blackburn and Capito.

Staff present: Jonathan Phillips.

The CHAIRMAN. Welcome, ladies and gentlemen, to the Select Committee on Energy Independence and Global Warming. Today's hearing is entitled, "New Energy Technologies: What's Around the Corner?"

Today we look to the future. We look to the future of how our country and our world will be powered. We do so by examining new ways to run our homes, vehicles, and businesses. We need to change because the status quo, sending billions of dollars to countries that don't like us much, and sending billions of tons of greenhouse gases into the atmosphere, is not sustainable. We need to develop technologies that will lead us to even greater prosperity and a cleaner and more secure world.

We are at a watershed moment in the history of energy production, and the choices we make at this juncture will shape our national and economic security in the next several decades and determine the fate of our planet. Between now and 2030, over $20 trillion will be invested in new energy infrastructure worldwide, and an estimated $1.5 trillion will be invested in the U.S. power sector alone. This new infrastructure is long-lived and costly, so we need to get it right.

The decisions made in the next decade will set the course of the global and U.S. energy system, and of the global climate for the next century and beyond. This transition also presents an unprecedented opportunity for economic development and job creation in the clean energy technology sector. But the United States must act now if it is to be a leader in the rapidly developing global market.

A few weeks ago, the House of Representatives took a giant legislative leap in America's historic effort to win the next great technological revolution, the clean energy race of the 21st century. On June 26th, the House passed the first comprehensive clean energy and climate bill in our Nation's history, the Waxman-Markey American Clean Energy Security Act.

The bill would, for the first time, put a cap on carbon pollution that causes global warming; and establish ambitious policies for the development and deployment of clean energy and efficiency; invest nearly $200 billion in the next 15 years to make America once again the leader in energy technology. We need to pass this bill because, for the past decade, we have fallen badly behind in the clean energy race.

Of the top 30 clean energy companies in the world, only six are American. Portugal, Spain, and Denmark produce 9 percent, 12 percent, and 21 percent of their electricity from wind respectively. America produces about 1 percent of its power from wind.

But I am an optimist. I am a technological optimist, and I am an optimist about America's ingenuity and the American entrepreneurial spirit. I know that we can and that we will win this race.

We have witnesses here before us that are engaged in developing the technologies that we need. We could have invited other technology companies, but today I wanted to focus on businesses that are forward-leaning on solar technologies and on ways to find a path forward on coal. Their solutions range from developing higher solar efficiency to manufacturing innovations that would reduce the cost of solar cell production, to capturing the CO_2 from power plants and putting it under the sea bed or combining CO_2 with sea water to make cement.

I have no idea whether these companies will succeed or fail, or whether other companies with better ideas or more inspired execution will win. That is not our job, to pick the winners and the losers, to know which technology will capture the day and which will fall by the wayside.

But I do know if we put the right policies in place, we will unleash the greatest force for change on the planet: American entrepreneurialism and ingenuity. This was the lesson from the 1990s in the communications and information-technology revolution. I believe that the situation is no different with clean energy.

I look forward to hearing from today's witnesses. We now turn and recognize the ranking member of the committee, the gentleman from the State of Wisconsin, Mr. Sensenbrenner.

[The prepared statement of Mr. Markey follows:]

THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

Opening Statement of Chairman Edward J. Markey

Hearing Before the Select Committee
On Energy Independence and Global Warming
"New Energy Technologies: What's Around the Corner?"

July 28, 2009

Today we look to the future. We look to the future of how our country and our world will be powered. We do so by examining new ways to run our homes, vehicles and businesses.

We need to change, because the status quo – sending billions of dollars to countries that don't like us much, and sending billions of tons of greenhouse gases into the atmosphere -- is not sustainable.

We need to develop technologies that will lead us to even greater prosperity, and a cleaner and more secure world.

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But I do know that if we put the right policies in place, we will unleash the greatest force for change on the planet: American entrepreneurialism and ingenuity.

That was the lesson from the 1990s and the communications and information technology revolution. I firmly believe that the situation is no different with clean energy.

I look forward to hearing the witnesses' testimony.

Mr. SENSENBRENNER. Thank you, Mr. Chairman.

Today's hearing on clean energy asks, what is around the corner, and focuses on two types of energy production, clean coal technology and solar power. These power sources should compete with each other in an open market with other sources, like nuclear power, wind energy, hydro power, and other advanced technologies.

Competition will drive technological advancement, and technology will improve our energy security and reduce our CO_2 emissions. Congress cannot choose winners and losers in the competition. Experience in the market must dictate which of these technologies are viable and what mix of them can best power our economy.

What is best for D.C. may not be what is best for my district in Wisconsin, which is why Republicans called their energy policy "all of the above." "All of the above" means allowing all technologies a fair opportunity to compete. Competition between businesses drives economic growth.

But if bureaucratic carbon emission schemes, like the cap and tax, become law, new technology will compete for government subsidies and emissions credits, and not for new consumers. GM and Chrysler are examples of what is to come. These companies accepted government bailout funds to stay in business and then invested it in lobbying the Federal Government on climate change legislation, not an example of what the people want their tax dollars to be working for.

While perhaps lucrative in the short term, government subsidies cannot sustain our economy.

Coal accounts for half of all electricity generated in the United States. We cannot keep the lights on throughout our lifetime without it. Finding a way to use it cleanly is therefore critical. Clean coal technology has some promising developments recently.

In June, researchers in my State announced the successful carbon capture test at the We Energies' Pleasant Prairie facility. Their researchers were able to use chilled ammonia technology to capture nearly 90 percent of the target carbon dioxide emissions.

I recognize Gary Spitznogle of American Electric Power, who is here to tell the Select Committee about his company's 20-megawatt test project at the Mountaineer power plant in New Haven, West Virginia. This project is larger than the Pleasant Prairie test project and utilizes the same chilled ammonia technology. Hopefully, this is the next step forward in the development of carbon capture and storage technology.

While this process could be the next step in development of this technology, it is not the final step. The Mountaineer power plant is a 1,300-megawatt plant. The 20-megawatt test project is capturing just a small fraction of the carbon emissions that could be stored. With its aggressive cap on carbon, policies like cap and tax could lead utilities and researchers to abandon carbon capture and storage technology before it advances. Many utilities will be tempted to move onto natural gas or other technologies that will help meet their carbon cap. This could end development of clean-coal technology and potentially leave America's most affordable and abundant source of energy out of the mix. Let us hope that that is not what lies around the corner.

Clean coal is showing promising technological developments. Coal can and must remain a central part of a diverse energy portfolio that includes renewable technologies, like wind and solar, and other carbon-neutral technologies, like nuclear and hydro power. I look forward to learning more about these technologies and how government policy can encourage the development of a diverse portfolio of energy production that strengthens both U.S. security and the environment.

I yield back the balance of my time.

The CHAIRMAN. The gentleman's time has expired.

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

Mr. BLUMENAUER. Thank you, Mr. Chairman.

Most assuredly, Congress doesn't have to pick winners and losers, but it is important to provide a framework. That is what we have done historically with the development of energy resources. We have had government policies that have dealt with coal, oil, timber. Nuclear energy has received the most lavish of subsidy and has been part of a rather intense comprehensive government framework.

What has happened with the enactment, at least in the House, of the landmark energy legislation is providing a framework for the future. I look forward to having the record develop here today about what the possibility is for innovation in our country moving forward. The innovation is going to be much accelerated if in fact we do have a framework that deals with carbon emissions, that deals with providing subsidies for energy supplies for the future rather than focusing on those in the past. Most important, this is where the world is going. And we have seen example after example. And you mentioned some of those, Mr. Chairman, in your opening statement. This is the economy of the future. Hopefully, we are able to get our priorities straight, our signals aligned so that we can tap the potential that is being described here by the witnesses today, and that we will be positioned to take advantage of it.

Last but not least, this is what is going to drive down the prices in the future. The evidence suggests that there is actually minimal costs associated with the legislation that we just enacted. But more important, it didn't take into account the potential for innovation, which we will hear about today. Thank you very much.

The CHAIRMAN. The gentleman's time has expired. The Chair recognizes the gentlelady from West Virginia, Ms. Capito.

Mrs. CAPITO. Thank you, Mr. Chairman, and thank you for hosting today's very important hearing.

Last month, the House passed the American Clean Energy and Security Act. While I did not support that legislation because I believe that it stood to push energy prices upward and threatened an economy that is already in trouble; I believe that instead of taxing West Virginia families and companies and picking winners and losers, which I believe the bill does, we need to do more to maintain global competitiveness of our U.S. industries and support and accelerate the development of advanced clean-coal technologies, including carbon capture and storage technologies.

Here in the United States, we know coal is the our Nation's most abundant domestic resource, with recoverable resources sufficient to last approximately 250 years. Coal currently fuels more than 50 percent of all electric generation. In my home State of West Virginia, 98 percent of our electricity comes from coal. It supports hundreds of thousands of additional jobs throughout the supply chain.

Additionally, West Virginia is the second largest coal-producing State, so the economic implications of our energy policy to my State cannot be overstated. Carbon capture is important to West Virginians in ensuring our national energy independence. Without it, we deprive ourselves of the most effective tool for addressing CO_2 emissions from coal. We need to continue to press CCS and other clean-coal technologies. We need to provide sufficient funding and incentives, which are included in the bill, to accelerate the development, demonstration, and broad commercial deployment of CCS.

I am very happy to today to have Gary Spitznogle here from the AEP Mountaineer plant, which is engaged now in a CCS project. That plant is in my district. I know many of the fine folks who work at the Mountaineer plant. I have visited the facility, and also seen where the demonstration will take place. I look forward to hearing from him and the other witnesses on this important blueprint for commercial-scale facilities. I welcome him as well as a representative of AEP, constituents in my district.

The implementation will not only benefit a State like mine with jobs and revenue, but it will also benefit our Nation by making clean coal a reality.

I look forward to the testimony from the panel. Thank you.

[The prepared statement of Mrs. Capito follows:]

Shelley Moore Capito
Select Committee on Energy Independence and Global Warming
"New Energy Technologies: What's Around the Corner?"
July 28, 2009

- Mr. Chairman, thank you for hosting today's important hearing.

- Last month, the House passed the American Clean Energy and Security Act. I did not support the legislation because I believe it stood to push energy prices upward and threaten an economy that is already in trouble.

- I believe that instead of taxing West Virginia families and companies, we need to do more to maintain global competitiveness of U.S. industries and support and accelerate the development of advanced clean coal technologies, including carbon capture and storage technologies (CCS).

- Here in the United States, coal is our nation's most abundant domestic energy resource - with recoverable reserves sufficient to last approximately 250 years. Coal currently fuels more than 50% of all electricity generation in the United States. <u>In my home state of West Virginia, 98% of our electricity comes from coal.</u> It supports hundreds of thousands of additional jobs throughout the supply chain.

- Carbon capture is important to West Virginians and ensuring our national energy independence. Without it, we deprive ourselves of the most effective tool for addressing CO2 emissions from coal. We need to continue to push CCS and other clean carbon technologies as hard and as fast as we can. We need to provide sufficient funding and incentives to accelerate the development, demonstration and broad commercial deployment of CCS technologies.

- The American Electric Power Mountaineer Plant located in New Haven, WV represents an important milestone in our efforts to bring CCS online. The facility is scheduled to begin operation in September and will capture and store 100,000 metric tons of carbon dioxide. The Mountaineer Plant is the first demonstration of CCS from an existing coal-fueled power plant. If successful, it will serve as a blue-print for commercial scale facilities.

- The implementation of CCS technology will not only benefit a state like mine with jobs and revenue, it will also benefit our nation by making clean coal a reality.

- I look forward to hearing the testimonies from the panel.

The CHAIRMAN. The gentlelady's time has expired.

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

Mr. CLEAVER. Thank you, Mr. Chairman. Serving on the Financial Services Committee and listening each week multiple times to economists, along with the Fed Chairman Ben Bernanke and a host of other experts, it does not take much to convince me that we are in the most difficult economic time in half a century. Not since the Great Depression has the United States been in such an economic condition.

But I am also excited about the fact that during tough times, it appears as if the U.S. does its best work. Microsoft was developed during a recession. FedEx was developed during a recession. And I am absolutely convinced that we will be able to depend on the scientific ingenuity of Americans to come up with new technologies that will not only help rebuild the economy but will help save the planet.

One of the greatest tragedies of our little moment on this ball that revolves around the sun is if the United States does not provide the leadership in developing the new technologies that will in fact help save this planet. In Kansas City, we have created what we call a green impact zone. And we will be announcing on the 1st a smart grid for a 150-block area in the urban core. We are going to try to develop a whole new neighborhood using the very latest technologies.

Tom Carnahan, the brother of Russ Carnahan, one of our colleagues, has a wind farm not far from Kansas City, where I live. That is also proving to be one of the great moves economically in our community. So I am excited about the possibility of coming up with new technologies that will allow us to do things we have only thought about and looked at in science fiction movies. That day is rapidly upon us, and I look forward to interacting with our panel to find out their view of what we can do and what we must do. I yield back the balance of my time.

The CHAIRMAN. The gentleman's time has expired. The Chair recognizes the gentleman from New York State, Mr. Hall.

Mr. HALL. Thank you, Mr. Chairman, for holding this important hearing. And just regarding picking winners and losers, I would assume that my colleague, the gentlelady on the other side of the dais, is in favor of the billion dollars plus a year for research into carbon capture and sequestration that is in the bill that we passed; that is in fact trying to pick coal as a winner. And this country, as Mr. Blumenauer referred to, has been subsidizing nuclear power for 50-years through the insurance, making the taxpayer of this country the insurer, in fact the only industry I am aware of that has been wholly backed against catastrophic accident by public insurance.

Nonetheless, I am particularly interested in hearing about the potential for large scale solar power development. I have long been a supporter of solar power in the Hudson Valley and the entire country. Most recently, we have been creating a market for solar and wind technology in my district. Companies like SpectraWatt and BQ Energy have been creating new production lines, hiring more workers, creating jobs, taking advantage of R&D money that the Federal Government is providing to do this cutting-edge research. Mercury Solar in my district started 3 years ago with 5 employees; now employs 60 people, and hopes to be at 80 people by year's end.

SpectraWatt is starting with 150, hiring back IBM workers and NXP workers who were just laid off, and using 70,000 square feet of empty IBM facilities, which are a really good match for producing these kind of products, clean room, positive air pressure to keep dust out, used to handling thin wafers of fragile materials and putting micro circuits on them. It is the kind of thing that matches up the skill set of the workforce with the work space. And I think I have reason to be optimistic that my district and the Hudson Valley will join the rest of the country in leading in this direction as we go forward into the new energy economy of the 21st century, and I yield back the balance of my time.

The CHAIRMAN. The gentleman's time has expired.

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

Mrs. BLACKBURN. Thank you, Mr. Chairman. I thank you for that and want to welcome our witnesses. We are glad that you all are here. I think it is important that we look at new technologies. I think it is important that we hear from you. Of course where I come from in Tennessee, coal is going to play an important part in our look forward, as is nuclear and hydroelectric power, and making certain that the innovation and the usage is there. Knowing what is going to be coming at us is an important component of what we deal with.

We do have a great new company in Clarksville, Tennessee, that is working on some new technologies and—Hemlock, which is a part of Dow Corning. We are grateful that they are being an innovator in this, looking at how we move forward with carbon sequestration, and continue to build our energy infrastructure. And so I look forward to the questions, and appreciate your time being here today.

I yield back.

The CHAIRMAN. The gentlelady's time has expired. The Chair recognizes the gentleman from Colorado, Mr. Salazar.

Mr. SALAZAR. Thank you, Mr. Chairman, and good morning. I am a strong supporter of the renewable energy technologies, and I am looking forward to hearing the testimony today. We have many challenges before us and a wealth of technologies to explore.

Colorado and the Third Congressional District has great potential for solar. The Bureau of Land Management has identified southern Colorado as one of its solar energy study areas for the concentrated solar energy production. We currently have an 8.2-megawatt photovoltaic plant in the San Luis Valley, with another 17-megawatt plant planned and an additional 6,400-acre, 10 square miles of solar panels to be installed later in a few years.

The potential for solar power across the West is great. There are also many challenges associated with solar. As you know, water is a scarce resource in many western States, so we must be thoughtful of how we address the water needs for solar power. Clean coal and carbon sequestration is another technology that I am looking forward to hearing about today. Coal-burning power plants provide half of the electricity generated in the United States. Colorado depends upon coal for the majority of its electricity.

The current plan for cap-and-trade in my opinion places an undue economic burden upon Colorado energy users due to the amount of coal that we currently use in Colorado. If we could develop clean-coal burning technology as a viable and economic alternative, this will help Coloradans and the rest of the country become energy independent, while addressing climate challenges.

I am glad to see that two witnesses today are testifying about coal capture technology and discussing economically feasible ways to capture CO_2, as well as utilizing byproducts. I am also intrigued by the other uses that we can develop for CO_2 that put it in use rather than store it away in geological formations.

I want to thank you, Mr. Chairman, and I look forward to hearing the testimony today.

[The prepared statement of Mr. Salazar follows:]

Opening Statement
Congressman John T. Salazar
Select Committee on Energy Independence and Global Warming
'New Energy Technologies: What's Around the Corner?'
July 28, 2009

Thank you Mr. Chairman.

Good morning, I strongly support renewable energy technologies and am looking forward to hearing the testimony today.

We have many challenges before us and a wealth of technologies to explore.

We must address reducing carbon emissions all while becoming energy independent and maintaining a healthy economy across America.

Colorado, and the 3rd Congressional district, has great potential for solar.

The Bureau of Land Management identified southern Colorado as one of its 'Solar Energy Study Areas' for concentrated solar energy production.

We currently have an 8.2 mega-watt photovoltaic plant in the San Luis valley with another 17 mega-watt plant planned.

The potential for solar power across the west is great. There are also many challenges associated with solar. Some of those challenges are:

- **the energy and transmission grid system is frequently not where the solar energy is concentrated**

- **the large amount of water required for many concentrated solar energy production facilities**

- **the intermittency of the energy produced from solar and wind.**

I'm glad to see that we are addressing some of these issues today.

As you know water is a scarce resource in many western states.

We must be thoughtful in how we use this precious commodity.

Clean coal and carbon sequestration are other technologies I'm looking forward to hearing about today.

Coal-burning power plants provide half of the electricity generated in the United States.

Colorado depends upon coal for a majority of its electricity.

The current plan for cap and trade places an undue economic burden upon Colorado energy users due to the amount of coal we currently depend on for our energy.

If we can develop clean coal as a viable and economic alternative, this will help Coloradoans and the rest of the country become energy independent while addressing the climate challenge.

I'm glad to see that the two witnesses that are testifying about coal capture technology today are discussing economically feasible ways to capture CO2 as well as utilizing byproducts.

I'm also intrigued by the other uses we can develop for CO2 that put it to use rather then store it away in geologic formations.

Thank you for your testimony and time today.

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

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

Mr. INSLEE. I will reserve, Mr. Chair. Thank you.

The CHAIRMAN. Great. Then we will turn to our panel, our very distinguished panel of innovators.

STATEMENTS OF GREGORY P. KUNKEL, PH.D., VICE PRESIDENT FOR ENVIRONMENTAL AFFAIRS, TENASKA INC., OMAHA, NEBRASKA; BRENT CONSTANTZ, PH.D., CHIEF EXECUTIVE OFFICER, CALERA CORPORATION, LOS GATOS, CALIFORNIA; FRANK SMITH, CHIEF EXECUTIVE OFFICER, PURGeN One LLC, CONCORD, MASSACHUSETTS; GARY O. SPITZNOGLE, MANAGER OF IGCC AND GAS PLANT ENGINEERING, AMERICAN ELECTRIC POWER, COLUMBUS, OHIO; SEAN GALLAGHER, VICE PRESIDENT, MARKET STRATEGY AND REGULATORY AFFAIRS, TESSERA SOLAR, BERKELEY, CALIFORNIA; AND EMANUEL SACHS, CHIEF TECHNICAL OFFICER, 1366 TECHNOLOGIES INC, NORTH LEXINGTON, MASSACHUSETTS

The CHAIRMAN. And we will begin with Dr. Gregory Kunkel, who is vice president for environmental affairs at Tenaska, Incorporated. He helps to develop Tenaska's strategic responses to climate change, and is in charge of development and environmental permitting for clean energy projects.

Thank you for joining us today, Dr. Kunkel. Whenever you are ready, please begin.

STATEMENT OF GREGORY P. KUNKEL, PH.D.

Mr. KUNKEL. Thank you, Chairman Markey, Ranking Member Sensenbrenner, members of the Select Committee, for inviting me to speak to you about Tenaska's two pioneering carbon capture and storage projects: Trailblazer in Texas, and Taylorville Energy Center in Illinois.

These projects represent a new paradigm in the energy industry in a carbon-constrained world, linking electricity, carbon capture, and oil and gas production. Using distinct technologies, each project will demonstrate carbon capture at commercial scale, provide clean energy 24 hours a day, and promote rapid expansion of known domestic petroleum reserves through carbon dioxide-enhanced oil recovery.

My name is Greg Kunkel. I am vice president of environmental affairs for Tenaska, an energy company based in Omaha. Trailblazer in Texas is a 600-megawatt coal-fired boiler with scrubbers to capture 85 to 90 percent of its carbon dioxide emissions. Recent developments in the Trailblazer project are that Tenaska has selected Fluor Corporation as the EPC contractor. And the Texas legislature has enacted helpful tax incentives and their framework for regulating permanent geologic storage of carbon dioxide.

The great promise of post-combustion capture technologies like Trailblazer is that it can be applied to retrofit existing coal-fired power plants. In the United States, we have the additional opportunity to use the carbon-capture enhanced oil recovery paradigm to significantly expand our recoverable domestic oil reserves and production capacity, while eliminating emissions of carbon dioxide.

There is growing interest in this idea worldwide. Trailblazer and other post-combustion capture pioneers in Asia, North America, and Europe will open the door to retrofit some of the 5,000 power plants worldwide, and begin to eliminate the 10 billion tons of carbon dioxide emitted from such facilities each year. The remaining key to advancement of Trailblazer and its great promise is Federal emission reduction incentives. When such legislation is passed, our aim as the Trailblazer will be ready.

The Taylorville Energy Center in Illinois is a 500-megawatt coal gasification facility that converts coal to methane and then electricity. In the process, the project will capture about 60 percent of the carbon dioxide for use in oil production. Taylorville is the initial clean-coal facility under the Illinois Clean Coal Portfolio Standard. The Illinois law sets standards we must meet, including carbon capture; provides a mechanism for sale of electricity; and limits allowable rate impact. Construction will begin in 2011, after completion of current design work, final legislative review, and close of financing.

I am pleased to report that the Department of Energy has selected Taylorville for the negotiation phase of its loan guarantee program. Loan guarantees are now critical to capital-intensive energy projects, and will significantly reduce financing costs. Those reduced costs, as well as carbon dioxide sales revenues, will accrue to the benefit of ratepayers under the Illinois law.

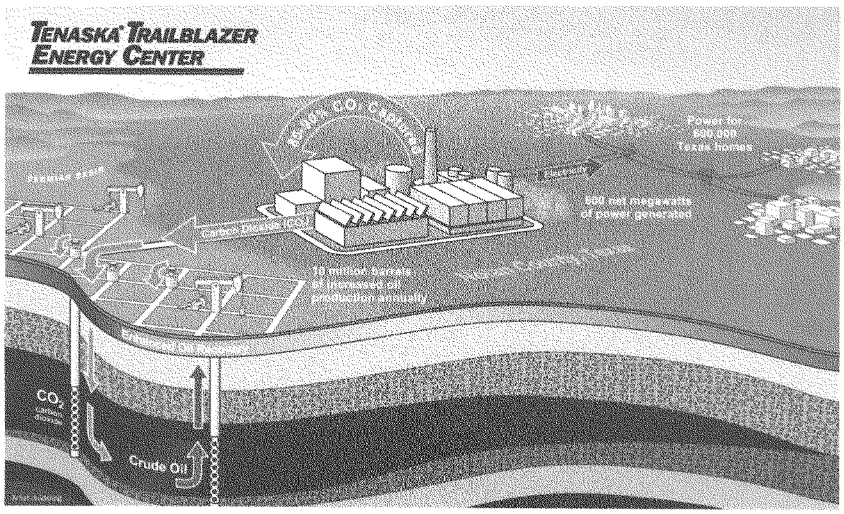
What additional government policies are needed? Perhaps the most important thing Congress could do is to provide regulatory certainty within a climate policy framework that promotes energy independence and emissions reductions. The emergence of the carbon-capture enhanced oil recovery paradigm, among other ideas such as efficiency, renewable energy and electrification of transportation, suggests that energy independence and emission reductions can be achieved simultaneously and economically.

To put the American energy industry to work on these goals, we need a financial incentive for emission reductions that enables the carbon-capture EOR paradigm and other good ideas. The Waxman-Markey bill does much to advance the necessary policy and regulatory framework and supports the carbon-capture EOR paradigm specifically.

The written testimony I provide to you includes our suggestions on the bill, including optimization of the bonus allowance program to leverage private capital.

Thank you again for the opportunity to provide this overview of Trailblazer and Taylorville. I would be pleased to respond to any questions you have at the earliest opportunity.

[The statement of Mr. Kunkel follows:]



Testimony of
Dr. Gregory P. Kunkel, Ph.D.

Vice President of Environmental Affairs
Tenaska, Inc.

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

July 28, 2009

Thank you, Chairman Markey, Ranking Member Sensenbrenner and Members of the Select Committee for inviting me to discuss carbon capture and storage (CCS) technologies and Tenaska's two commercial-scale electric generation projects using CCS –Trailblazer in Texas (www.tenaskatrailblazer.com) and Taylorville in Illinois (www.cleancoalillinois.com).

My name is Greg Kunkel. I am Vice President of Environmental Affairs for Tenaska (www.tenaska.com). I am pleased to report two exciting recent developments: (1) the Department of Energy's selection of the Taylorville project in Illinois to proceed into the term sheet negotiation phase for a DOE loan guarantee, and (2) a new Texas law providing incentives and regulatory structure for Trailblazer and other CCS projects

Tenaska Background

Tenaska, headquartered in Omaha with offices in Dallas, Denver and Calgary, is one of the largest independent power producers in the United States. Guided by conservative business practices - which include securing long-term contracts for its generation facilities, Tenaska has developed approximately 9,000 megawatts (MW) of natural gas-fired electric generating capacity across the United States. Tenaska affiliates also market natural gas, electric power and biofuels. Additionally, our affiliates are also involved in private equity fund and acquisition management focused on the energy space, including renewable energy, infrastructure development, natural gas pipelines and storage, and electric transmission.

The company currently has more than 700 employees and 2008 gross operating revenues were $16 billion. Tenaska has grown steadily and now ranks among the top 25 largest privately-held US companies based on 2007 revenues.

In recent years, Tenaska has expanded beyond its traditional power production technology base.

- Tenaska Solar has invested in Soltage (www.soltage.com), a Jersey City, New Jersey-based full-service renewable energy company that develops and operates solar energy stations at client sites across the US. These power stations supply a significant portion of client long-term energy needs at below retail rates.

- Tenaska's employee-owners have invested in the Elkhorn Ridge Wind project which, at nearly 80 MW, is the largest wind project in Nebraska, producing renewable energy for about 25,000 Nebraska homes.

- Tenaska Power Fund owns InfrastruX Group, a leading national provider of utility infrastructure construction and maintenance service which is well-positioned to assist in strengthening US energy infrastructure. InfrastruX (www.infrastrux.com), is headquartered in Seattle, Washington, with offices in New Mexico, New York, Pennsylvania, Wisconsin and Texas.

- In recognition of Tenaska's modern electric generation fleet, the Natural Resources Defense Council ranks Tenaska as having the lowest carbon footprint of any of our peers – less than half of the national average emission rate of greenhouse gases.

As developers, rather than researchers or inventors, Tenaska is focused on environmentally responsible power projects that use available, reliable, cost-competitive technologies that are commercially financeable and that attract conservative investors requiring a reasonable assurance of success.

With this context in mind, I now turn to CCS and Tenaska's Trailblazer and Taylorville projects.

Carbon Capture and Storage in General

Commercial-scale CCS, utilizing geologic sequestration and enhanced oil recovery (EOR) technologies, has many important benefits, including:

(1) The US leads the world in proven coal reserves, and coal powers 49% of US electricity. Continued use of coal with CCS is necessary to meet US environmental, economic and national security objectives while providing inexpensive and reliable baseload power.

(2) The use of American coal by the power sector in an environmentally responsible way decreases overall demand for natural gas. This helps both hard-pressed manufacturers facing foreign competition that use natural gas as a feedstock and consumers in both coal-dependent and non-coal-dependent areas who choose clean-burning natural gas for heating their homes and other purposes.

(3) Enhanced oil recovery utilizing CO_2 boosts oil and gas reserves and production from existing US fields –strengthening US energy security,

reducing imports, and offering an attractive alternative to exploitation of new fields in environmentally sensitive onshore and offshore areas.

(4) Commercial-scale CCS may be the most effective way to curb greenhouse gas emissions in China, India and other coal-dependent developing countries, and its widespread adoption here in the US will make it possible for the US to lead the world in deployment of this technology.

President Obama summed up the case for CCS last year –

> *"... I am a big proponent of clean-coal technology and I want us to move rapidly in developing those sequestration technologies.... We're not going to immediately move off coal. A huge percentage of our electricity is generated by coal. What we need to do though is to put clean-coal technology on the fast track and that means money.... We're the Saudi Arabia of coal, and the sooner we can figure out how to burn it cleanly, not only are we going to benefit but we can license that technology to countries like China and India that are putting up new coal facilities every week."*

"Obama, Clinton Make Closing Arguments as Montana Primary Looms," Flathead Beacon, May 29, 2008

Tenaska's Carbon Capture and Storage Projects

I am pleased to report significant progress for the two CCS projects Tenaska has in advanced development – Trailblazer in Texas and Taylorville in Illinois.

Trailblazer is a 600 megawatt (MW) net-output coal-fueled, baseload power facility that, unlike any currently in operation anywhere, would capture 85 to 90 percent of its potential carbon dioxide (CO_2) emissions and deliver that CO_2 via pipeline for use in enhanced oil recovery operations and geologic storage in Texas' Permian Basin.

Taylorville in Illinois is a 500 MW net-output hybrid Integrated Gasification Combined-Cycle (IGCC) facility that will convert coal to methane either for sale into the natural gas pipeline system or for the generation of electricity. In the process, the project will capture 50 to 60 percent of the CO_2 that the facility otherwise would emit. Emissions will be comparable to a natural gas generation facility.

The two Tenaska projects may give the Select Committee some sense of the CCS projects that our nation's power sector can build with today's proven technologies.

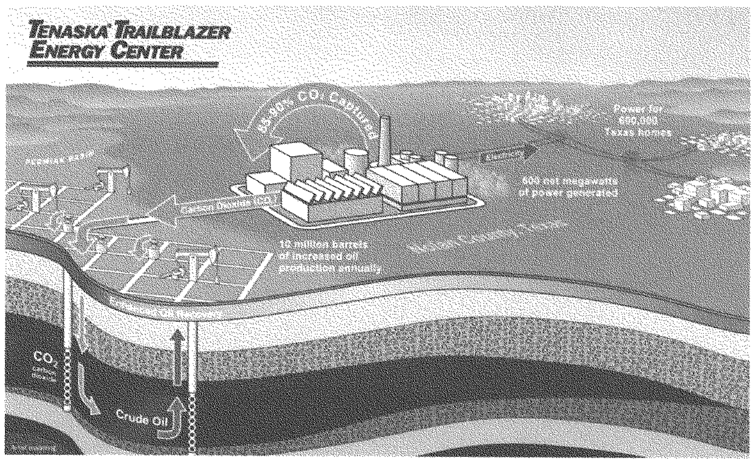
When Tenaska embarked on the process of developing these utility-scale CCS projects, high and volatile natural gas prices, combined with oversupply of natural gas generation facilities, encouraged us to consider the continuing need for baseload power facilities fueled by coal. At the same time, our management recognized that new federal, regional and state laws and regulations to control emissions of greenhouse gases from power facilities were certainly very likely during the 50-year life of these facilities. Given that new baseload projects cost as much as \$2-3 billion and the highly-publicized cancellations and postponements of many proposed conventional coal-fueled projects due to environmental and other challenges, we decided that we would only be comfortable if we tackled the climate issue directly.

The Supreme Court's Massachusetts v. EPA decision, the ensuing EPA endangerment finding, and federal and state law and legislation underscore the need for all of us in the power sector to come to grips with the climate change challenge.

Since we were not willing to invest in solid fuel projects without addressing the climate change challenge, the question before us was how to reduce greenhouse gas emissions in the design of projects today. To accomplish this goal, we needed to assure ourselves that carbon capture technologies are ready for utility-scale application, a secure home is available for captured CO_2, and the economics and long-term financing arrangements for such projects can work. I am pleased to report considerable progress in each of these areas.

Trailblazer Energy Center

On February 19, 2008, Tenaska publicly announced the Trailblazer Energy Center, a 765 MW gross-output and 600 MW net-output supercritical pulverized coal electric generation facility with the capability to capture and deliver to the enhanced oil recovery markets 85 to 90 percent of CO_2 produced in the boiler. On the same day, we closed the purchase of the site, filed an air permit application with the Texas Commission on Environmental Quality (TCEQ), and submitted a transmission interconnect request with the Electric Reliability Council of Texas (ERCOT). The Trailblazer idea is all about neighborhood. The strategically located site is near pipeline infrastructure that can connect the facility to the world's largest market for CO_2 – Permian Basin enhanced oil recovery. Two railroads serve the site, and the electrical interconnection is also nearby.



The Tenaska Trailblazer Energy Center would be the first coal-fueled power plant to capture the carbon dioxide it produces and transport it via pipeline for use in enhanced oil recovery and geologic storage.

The TCEQ issued Trailblazer's draft air permit on February 2, 2009, the public comment period on the draft air permit closed on April 17, and the TCEQ is working toward issuing a final permit.

A very significant development is our selection of Fluor Corporation as the engineering, procurement and construction (EPC) contractor for the facility. Tenaska has signed a memorandum of understanding with Fluor that is the basis of a joint Tenaska-Fluor limited engineering scope of work to support financial closing and initiation of construction as early as 2010, provided that there is an established economic price signal for CO_2. With construction requiring about four and half years, commercial operation could begin as early as 2015.

The State of Texas is doing its part as well. Earlier this year, Texas enacted legislation that provided state and local incentives, including tax incentives, for up to three power generating projects that capture and sequester at least 70 percent of CO_2 emissions and provide the captured CO_2 for enhanced oil recovery. The legislation also established responsibility for regulation of CO_2 sequestration and storage among state agencies. Still needed to make projects economically feasible is some form of federal incentive in addition to the existing commercial value for CO_2.

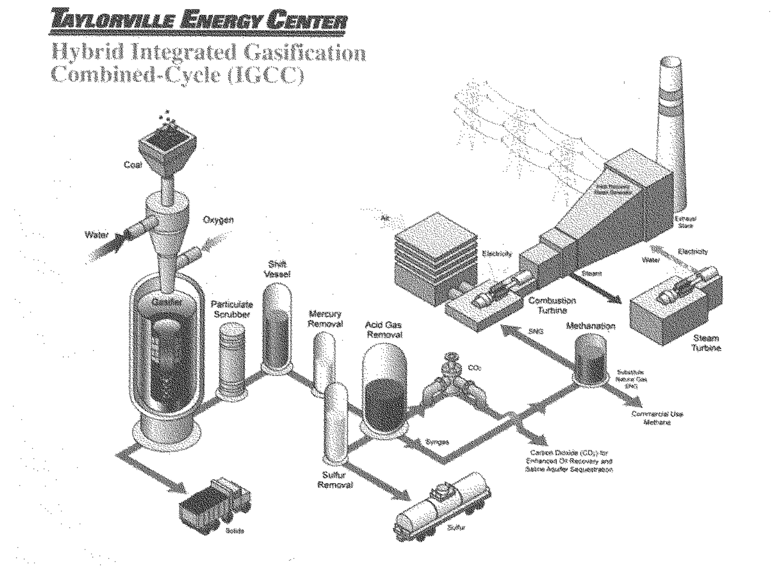
Tenaska is in the business of developing power generation facilities, and the Trailblazer project represents what we believe is a commercially viable approach to building a baseload project within current development parameters. However, from a more global perspective, the importance of a project like Trailblazer is that it will demonstrate that post-combustion capture technology can work – on a utility-scale – for many of the 5,000 existing coal-fueled power stations worldwide that currently contribute as much as 10 billion metric tons of CO_2 annually to global emissions.

In addition, and beyond the implications for CO_2 mitigation from coal, projects like Trailblazer will help the US maximize domestic oil and gas production from existing fields, thereby enhancing national fuel security. CO_2 captured at Trailblazer will increase Permian Basin oil production by more than 10 million barrels per year, strengthening the West Texas economy.

Not to be overlooked, Trailblazer will boost the local economy with more than $2 billion in construction spending out of a total estimated project cost of more than $3 billion, provide 1,500 to 2,000 jobs at peak construction, and create more than 100 well-paying permanent positions to sustain operations.

Taylorville Energy Center

The Taylorville Energy Center is a Hybrid Integrated Gasification Combined-Cycle (IGCC) electric generation facility. The developer is Christian County Generation, LLC (CCG) and Tenaska is the managing partner. The project will manufacture pipeline-quality substitute natural gas (SNG), which is methane, from Illinois bituminous coal. The SNG will fuel a power block with two combustion turbines, two heat recovery steam generators (HRSGs), and one steam turbine. The amount of SNG produced will significantly exceed the requirements of the power block, annually freeing up 10 billion cubic feet (bcf) of SNG for transport offsite via a natural gas pipeline for eventual sale to commercial and residential natural gas customers. The facility will use 2.5 million tons per year of Illinois coal, employ 1,500 construction workers, and create hundreds of permanent jobs in the coal and power sectors.



The Taylorville Energy Center will use hybrid Integrated Gasification Combined-Cycle (IGCC) technology to convert coal into methane, either to sell into the natural gas pipeline or to fuel power production.

Taylorville will capture 50 to 60 percent of the CO_2 that the facility would otherwise emit, remove moisture and sulfur compounds, and compress the CO_2 stream for pipeline transport either to nearby geologic sequestration wells in the Mt. Simon geologic formation (within Christian County, Illinois) or for use in EOR operations elsewhere. Tenaska and others in the power sector are working with the State of Illinois and the US Department of Energy on development of the Mt. Simon geologic formation, and on July 13 Denbury Resources announced a feasibility study for a pipeline transporting CO_2 from the Midwest to the oil patch (www.denbury.com).

The power island will have criteria pollutant emission levels equal to those of a combined-cycle natural gas generation facility. No electric generation facility utilizing coal or coal-derived fuel operating anywhere in the world approaches the proposed emission performance of the Taylorville Energy Center, yet the project relies exclusively on proven technologies for coal gasification, gas processing and power generation.

The Hybrid IGCC process of producing marketable SNG (methane) will result in greater operational flexibility than a more typical IGCC model, in which only synthesis gas is produced exclusively for consumption on site. In contrast, Taylorville's SNG production will enable its power generation function and gasification processes to operate more independently, creating the means to respond to electricity demand and commodity price volatility. By making CO_2 available for EOR, Taylorville offers important contributions to petroleum as well as electric and natural gas supplies. By demonstrating the technical and economic feasibility of coal-based power generation with CCS technologies, the project provides a model that the US power sector can replicate in support of our nation's domestic energy strategy.

I am pleased to report that DOE has selected Taylorville to proceed into the term sheet negotiation phase under the DOE Loan Guarantee Program. The amount of the guarantee will be up to $2.579 billion, depending on the final project costs and capital structure. Upon completion of due diligence and negotiations, the Taylorville project expects to receive a federal government guarantee of its debt, enabling financing and greatly reducing costs – resulting in significant savings that will accrue directly to Illinois ratepayers.

Because the Taylorville project makes a great deal of sense for Illinois, it has enjoyed a broad range of supporters, including the Illinois AFL-CIO, the American Lung Association, the Clean Air Task Force, the Illinois Citizens Utility Board and the Illinois Coal Association.

Perhaps the most important thing Congress could do to facilitate the development of Trailblazer, Taylorville and similar projects is to provide **regulatory certainty**, and in particular, a regulatory framework within which a market can develop that values greenhouse gas emission reductions. Absent regulatory certainty, we foresee an EPA rulemaking process with ensuing lengthy litigation. Without regulatory certainty, the financial markets will remain reluctant to provide necessary project financing, or the financing they do provide will remain at a very high cost, stifling investment in CCS deployment, as well as wind, solar and other innovative projects and related transmission necessary for our nation to move ahead.

The Waxman-Markey ACES bill as passed by the House addresses several needs facing the developer of clean coal projects with CCS. ACES advances the critical requirement for regulatory certainty, and includes important mechanisms that could materially benefit the development and utilization of CCS technologies.

- <u>Section 115 - Commercial Deployment of Carbon Capture and Sequestration Technologies</u> – The bonus allowance provisions of the legislation are among the most important to development of projects utilizing CCS. The range of allowance values should be adequate to create meaningful incentives for CCS project associated with a variety of technologies. Tenaska appreciates the leadership of Chairman Markey and others on section 115, and respectfully offers some suggestions to make the provisions even more effective in achieving the goal of encouraging early deployment of CCS.

First, consider expanding the current six gigawatts (GW) of generation eligible for bonus allowance treatment to perhaps ten gigawatts at current ACES values, and substitute additional tranches at declining pre-set values for the reserve auction mechanism to foster the development of an additional 62 gigawatts of CCS capacity.

Second, create a mechanism for reserving allowances that assures that projects meeting defined pre-construction permitting requirements are guaranteed a sufficient quantity of bonus allowances based upon successful project completion. Under the current structure, projects cannot count the value of bonus allowance toward their revenues for financing purposes, as there is no assurance the allowances will be available upon achieving commercial operation, making project financing much more difficult. Accordingly, one of the most significant benefits the bonus allowances offer – revenue support and certainty – may not be realized without a reservation system. A well-structured reserve mechanism, coupled with an expanded pool of allowances, would remedy this limitation.

- <u>Section 114 - Carbon Capture and Sequestration Demonstration and Early Deployment Program</u> – This program could prove to be useful in advancing CCS provided that the awards are available to all classes of applicants and that the projects receiving grants are of commercial scale and employ a variety of capture technologies and geologic sequestration settings.

Tenaska asks that, as the ACES legislation moves forward, the House and Senate work together on addressing the complex regulatory and tax structures needed to govern CO_2 sequestration. Protection of early mover projects deserves consideration while the issue of long-term liability at sequestration sites is under study. Tenaska has supported a variety of tax incentives for CCS, most importantly modifications to the existing Internal Revenue Code section 45Q sequestration tax credit to increase the number and value of the credits and enable reservation of a credit stream similar to the wind production tax credit, with an adjustment in the credit as the carbon emission allowance market develops within a cap-and-trade regime.

I want to express Tenaska's special appreciation to the members of Congress who represent our Nebraska headquarters, Trailblazer and Taylorville, as well as all the other Members on both sides of the aisle who have been supportive of our CCS efforts.

Thank you again for your interest and for the opportunity to discuss CCS technologies and provide this update on Trailblazer and Taylorville. I would be pleased to respond to any questions you may have.

TENASKA®

Greg Kunkel, Ph.D.
Vice President of Environmental Affairs

AS THE VICE PRESIDENT OF ENVIRONMENTAL AFFAIRS FOR TENASKA, DR. GREG Kunkel is engaged in development of the company's strategic responses to climate change and other environmental issues of primary concern. Tenaska is an independent energy company that develops, constructs, owns and operates non-utility generation and cogeneration plants; provides marketing services for natural gas, electricity, and biofuels; and provides acquisition management services for private equity funds in the energy sector.

Dr. Kunkel leads environmental permitting and development for Tenaska's clean energy projects, including: the Tenaska Trailblazer Energy Center in Texas, the first proposed coal-fueled facility to capture 85 to 90 percent of the carbon dioxide (CO_2) it produces for use in enhanced oil recovery; and the Taylorville Energy Center in Illinois, a hybrid integrated gasification combined-cycle plant (IGCC) that will convert coal into pipeline quality natural gas that will fuel power production or be sold, capturing at least 50 percent of its CO_2 emissions.

Dr. Kunkel supervises Tenaska's corporate environmental team to assure compliance with environmental requirements and directs environmental commodity transactions for Tenaska affiliates, including domestic and international carbon credits.

In 2008, Tenaska was listed in benchmarking studies by the Natural Resources Defense Council as having the best record among thermal US electric generation companies for fleetwide average emissions of CO_2.

Dr. Kunkel earned bachelor of arts and master of arts degrees from the University of Colorado at Boulder. He received his doctorate from the University of California at Davis.

The CHAIRMAN. Thank you, Dr. Kunkel, very much.

Our next witness is Dr. Brent Constantz, who is the chief executive officer of Calera Corporation. He is a consulting professor at Stanford University, researching and teaching carbon and mineral formation and global carbon balance.

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

STATEMENT OF BRENT CONSTANTZ, PH.D.

Mr. CONSTANTZ. Thank you, Chairman Markey.

I would like to say how much we admire the committee for their foresight in looking at these future technologies for carbon management. I am going to tell you this morning about a technology which takes CO_2 and transforms it into saleable building materials, including concrete in aggregate, and is currently in practice on Monterey Bay in California.

We have funded and are building, scaling up to a 10-megawatt equivalent plant next to the largest power plant on the West Coast right now. Just to frame things, fundamentally there are two approaches to removing carbon from raw flue gas as opposed to just taking carbon out of the air.

One is separation, and the other is conversion of CO_2. So, in separation and purification of CO_2, it is a chemical process which involves a high amount of energy, and typically takes about 30 to 40 percent of the power generated at say a coal-fired power plant just to do that separation step. And despite any amount of development, the theoretical maximum from the Harvard study shows that the best it could ever do is to take 25 percent of the power from the plant just to separate it. And when you are done, you are just left with liquid CO_2, which then has to be transported, compressed, and injected.

The other approach is to simply convert it to carbonate. This has been done for over a century to produce calcium carbonate, which is in the paper here. It is in the paint. It is in our morning calcium supplement. It is in your milk shake. Millions and millions, trillions of tons of calcium carbonate are produced every day. And it is a very well known, proven technology.

What Calera Corporation has done is develop a way to formulate the polymorphs of the calcium carbonate into useful cementitious materials. To understand the magnitude of the problem, the Kyoto Protocol is calling for 5 billion tons of CO_2 to be mitigated. Every year, there are 30 billion tons of aggregate sold worldwide. And here in the United States there are 3 billion tons of aggregate sold worldwide. Calera has the ability to sequester over 15 billion tons of CO_2 on an annual ongoing basis in aggregate, which can be sold into the concrete and the aggregate markets as well as Portland Cement Substitutes; 99 percent of all the carbon on the planet is in the form of limestone today. In fact, there are 70 million to 100 million billion tons of CO_2 in the form of limestone today. That is where most of the carbon in the planet; the hydrosphere the biosphere and the atmosphere have just a few hundred billion tons, a very small amount.

Calera's process involves driving raw flue gas through sea water in the case of Monterey Bay. In most cases, we are working inland, though, with the same geologic brines from saline reservoirs which are pumped up.

That forms a carbonate by adding base. Then we have a revolutionary low-energy base manufacturing process. We turn it to carbonate and calcium carbonates and magnesium carbonates. The products are what are called supplementary cementitious materials that are substituted for Portland Cement. And Portland Cement itself has a large carbon footprint in its production. So we are both trapping the CO_2 and avoiding the CO_2 from the Portland Cement.

We also make aggregate, as I mentioned, which is used in concrete and asphalt. And we are doing this every day. We are producing up to 5 tons a day in Monterey today. It is tested against ASTM standards and ACI standards. So this is a proven technology that is in practice today.

I guess the important thing to realize, though, is we are talking about the largest material mass movement in the history of the planet. Humans are producing 20 to 30 billion tons of CO_2 a year. And you need a reservoir that can take that sustainably. And the built environment is the ideal reservoir for the CO_2. Concrete is the most transferred material, other than water, in the whole world.

The infrastructure is already in place. Redi-Mix plants are pulling up to coal-fired power plants every day and picking up their fly ash and taking it to their Redi-Mix plants for mixing in concrete. There is no new infrastructure to develop here. We are doing it today. It is ready to move forward.

But going from our 10-megawatt plant, which we have funded in Silicon Valley and are building today, to the 1,000- and 1,500-megawatt plants that are necessary, it is going to take hundreds of millions of dollars of government funding to cross that chasm. Thank you.

[The statement of Mr. Constantz follows:]

Brent Constantz, Ph.D.
CEO of Calera Corporation,
and Consulting Professor at Stanford University
Testimony before the United States Select Committee on Global Warming
July 28, 2009

Introduction

Chairman Markey and Members of the Committee, first, I would like say that I admire this Committee's vision and foresight in advancing solutions to climate change. Thank you for inviting me to testify on a carbon-mitigation sector that has been mischaracterized as "unproven" and "early stage", when in fact just the opposite is true: The conversion of carbon dioxide (CO_2) to mineral form for beneficial reuse has been practiced for over a century. It is one of the most common and important industrial processes now being applied to CO_2 sequestration, which I believe holds tremendous promise. CO_2 has been consumed to precipitate mineralized carbonates for inclusion in most common products we use every day, including the paper you're reading right now. Conversion of CO_2 to mineralized carbonates is broad in scope and represents a very large number of commercial enterprises, from the theoretical to the very mature and highly developed. Unfortunately, legislators have characterized all of these technologies as early stage and unproven.

This hearing comes at a critical time: Congress is debating climate change legislation; the President has promised a green energy policy that helps not hurts our economy; and almost 200 countries are preparing for the Copenhagen international climate change discussions. As these and other political decisions unfold against the backdrop of a global economic crisis, we must develop a broad array of cost-effective and preferably profitable methods to mitigate the release of CO_2 into the atmosphere.

My name is Brent Constantz, and I am the Chief Executive Officer of Calera Corporation, based in Los Gatos, California. Over the past 20 years, I have built three successful Silicon Valley companies based on innovative mineralization technologies, covered by approximately 70 issued U.S. patents I hold in this area. Additionally, I am a Consulting Professor at Stanford University, where my teaching and research are focused on carbonate mineral formation and global carbon balance.

My goal today is to urge Congress to think broadly in terms of the carbon capture and sequestration (CCS) technologies it supports to take full advantage of the opportunities these technologies can offer. The monies authorized and appropriated in past legislation need to be made available to promising technologies, and not reserved entirely for one concept, as is now the case. Past legislation has focused nearly entirely on the concept of geologic sequestration: chemical separation of CO_2 followed by injection into underground caverns or saline aquifers. Processes such as Calera's, based on CO_2 capture and conversion to carbonate minerals, have been denied access to tens of billions of dollars in grants, guaranteed loans, and tax incentives legislated exclusively for geologic sequestration.

Today, I call on this Committee to lead the way to making federal funds previously available for geologic sequestration *also available for alternative forms of capture and conversion* — as authorized under the *American Recovery and Reinvestment Act of 2009* (P.L. 111-5), the *Energy Independence and Security Act of 2007* (P.L. 110-140), the *Energy Policy Act of 2005* (P.L. 109-58) and related regulations, as well as the Climate Bill now under debate in the Senate.

It is not enough to simply provide money in new legislation for these technologies. The scope of the CO_2 problem and the rapidity with which mineralization processes can be scaled requires that money already authorized and appropriated be made immediately available to help fund multiple demonstration facilities in the 10MW to 80 MW scale. If we want to solve the climate-change problem, the U.S. Government must allocate resources in the timeliest manner to promising, potentially scalable technologies, and help bring them to the commercial scale that can provide significant reductions in greenhouse gas emissions.

My testimony will give you an overview of Calera and our CO_2-conversion technology; how it is possible to beneficially reuse CO_2 when it is converted to a mineral form; how our technology compares with other CO_2-capture options; and the commercial potential of beneficial CO_2 reuse. Finally, I will conclude with recommendations that not only align with this Committee's demonstrated commitment to CCS, but also help move beneficial CO_2-reuse technologies such as Calera's from pilot-scale to global innovation, thereby fostering other technologies that may be alternative or complementary to CO_2 separation and geologic sequestration.

Calera Corporation

Calera was founded with a promising vision to reverse global warming and ocean acidification by adapting and commercializing one of nature's oldest processes: carbonate mineralization. The precipitation of carbonate minerals by consuming CO_2 in aqueous solution is one of the oldest extraordinarily well proven industrial processes, as well as one of the most common. Products from this process are used in everything from paper to plastic, from milkshakes to wallboard. Calera has developed a transformational technology that converts CO_2 into green building materials like cement and aggregate. The process captures CO_2 emissions from power-plant flue gas, industrial smelters, refineries and cement manufacturing, and chemically combines it with a variety of natural dissolved minerals, water and solid waste materials to produce cementitious materials, aggregate and other related building material components. Thus, the process is more than CO_2 sequestration — it represents *permanent CO_2 conversion* from gas to solid mineral. The current market demand for these building materials is over *3 billion tons per year* in the US alone and over *30 billion tons per year* worldwide. This process has the potential to provide a positive use of the overwhelming majority of U.S. coal-fired power generation of CO_2 emissions.

Calera is backed by Khosla Ventures, a well-regarded venture capital firm specializing in "green" technology. With Mr. Vinod Khosla as a partner in this effort, Calera has been able to engage a formidable team of scientists and engineers to move beyond the laboratory and bench-scale research. We currently operate a continuous pilot facility that captures and converts CO_2 that we generate from burning 1 million BTUs per hour of coal. The facility is adjacent to a 1000 MW power plant in Moss Landing, California, on the coast of Monterey Bay. The continuous pilot facility allows us to test our technology with coals and fly ash from potential sites. We will soon be constructing a facility that scales our carbon capture and conversion technology to a 20MW scale. Located at Moss Landing, this facility will be operational in 2010, and it will make the step to a fully commercial facility relatively straightforward.

In less than a year Calera has grown from 12 to more than 80 employees, including more than 20 PhDs. Additionally, our pilot facility in Moss Landing is staffed with another 25 employees. Our senior executives possess hundreds of years of combined experience in power, water, environment, cement and concrete. Our technical staff holds well more than 100 U.S. patents, and our team of in-house patent attorneys and agents are filing patents on innovative ideas at the rate of one every day. Khosla Ventures has continued to provide the financing necessary for our growth and development.

But we have many milestones ahead to reach commercial scale, particularly in this difficult economic climate. Government support is necessary at this stage of development for demonstration facilities and early deployment in commercial plants. Coupled with commercial partner investment, this support will make the financial hurdle of financing these first scaled plants possible. Government policies that are directed toward mitigating carbon and stimulating the economy by the best available approaches will enable substantial progress for the profitable, beneficial reuse of CO_2.

Level the Playing Field for New Technologies:
Accurate Assessment of the Development State of Available Methods

The two primary methods for removing CO_2 from flue gases are 'purification via separation' vs. 'conversion to carbonate'. The first is energy intensive and costly and has not been proven for carbon sequestration (except in pending legislation), while the second consumes little energy, is inexpensive and is highly proven and dependable. I would like to underscore that CO_2 mitigation technologies are evolving rapidly. Calera is one of several companies focused on CO_2 conversion technologies with the potential for beneficial reuse. Yet, despite the promise of these technologies, funding for carbon mitigation has been narrowly focused on CO_2 separation and purification for geologic sequestration — a technology that is early-stage, unproven, and has never been demonstrated at any scale, and fraught with uncertainty and risk.

At best case, even if the technical challenges could be solved, which could take decades, CO_2 separation and purification for geologic sequestration would be economically infeasible for industry and will always require government funding. Despite the slim odds, the current legislative focus is proscriptive toward this one method, assuring that carbon reduction dollars will be directed only towards this method's narrowly defined pool of projects in hopes of making geologic CO_2-sequestration a viable option. This is especially vexing, considering that the Calera process and comparable CO_2-capture technologies largely avoid the economic burden, carbon balance, risk and permitting constraints that accompany geologic CO_2-sequestration.

We submit that taxpayer support and funding should be based on carbon reduction outcomes and seek to advance the most effective technologies. While CO_2 separation and purification for geologic sequestration is unproven and carries substantial and multiple formidable risks, it is still one important potential method in the carbon-capture toolbox. But we need to consider all of the potential solutions to address the volume of CO_2 at issue. Broad statutory language and corresponding federal funding are needed that encourage innovation, and rewards breakthrough technologies consistent with our goals as a free-market nation. The methods we implement should be selected by how we best arrive at the desired outcome, and not constrained to any one particular method for CO_2 mitigation.

I will come back to the crucial point of how the federal government can level the playing field for other technologies after providing you with an overview of Calera's CO_2-conversion technology.

The Calera Process: CMAP Technology and Low-Voltage Base Production

Calera's technology is called *Carbonate Mineralization by Aqueous Precipitation (CMAP).* The Calera process is unique in how it essentially mimics the natural carbonate mineralization of corals when making their external skeleton. This technology captures CO_2 emissions by converting CO_2 to CO_3 (carbonate) and effectively storing it in a stable mineral form. This mineral can then be used to replace or supplement traditional portland cement, offsetting emissions that would otherwise result from the CO_2-intensive manufacture of conventional cement.

The biggest hurdle to the mineralization concepts studied has been high-energy demand or extremely slow rates of reaction occurring over geologic timeframes. Calera's CMAP bypasses the limitations of previous mineralization approaches, but it has not been broadly pursued in the past due to the requirement for sustainable, unlimited chemical-base sources. Amongst the many technologies now possible are novel base-production methods that are low in cost, energy, and carbon footprint. These Calera innovations — fully described in many USPTO patent applications as well as three issued patents — revolutionize the technical feasibility, carbon-mass balance and economics of carbonate mineralization for CO_2 capture and conversion via aqueous mineralization.

Calera's mineralization process utilizes break-through, low-voltage chemical base-production technology that makes the conversion from CO2 to carbonate cost-effective and sustainable. Using approximately one-fifth the voltage of conventional base-production processes, Calera's base production has a very low carbon-footprint and is an alternative to natural or waste sources of chemical base. Therefore, the process can occur irrespective of any specific site location. Extensive mass and energy balance studies performed at Calera's continuous pilot plant indicate that parasitic loads on host power plants (the electricity used to run these processes that can't be sold elsewhere) where CO_2 is captured and converted to carbonate will be less than 20% — in many cases as low as 6%! This compares to a thermodynamic floor on parasitic load of 25% for the current state-of-the-art in carbon separation technology, based on a recently published Harvard study. This does not even include the need for sulfur compound control, which send the parasitic load of these technologies even higher.

Calera's technology uses aqueous minerals and CO_2 from power plant flue gas. The CO_2 in the flue gas is dissolved in a reactor, where it becomes carbonic acid converted to carbonate ions that form a slurry containing the suspended mineral carbonates. A solid-liquid separation and dewatering step results in a pumpable suspension. Calera employs spray dryers that utilize the heat in the flue gas to dry the pumpable suspension. Once dried, the Calera cement looks like white chalk and can be blended with rock and other material to make concrete. A graphic illustration of this process is attached.

Once it is hydrated, Calera's carbonate mineral cement behaves like traditional portland cement, and it can be used as a supplementary cementitious material to replace portland cement at various levels. A 20%-50% replacement has been tested extensively against ASTM C 1157 concrete specifications. Based on worldwide production estimates, approximately 1.5 billion tons of portland cement could be substituted with carbonate cement, and another 30 billion tons of aggregate used in concrete, asphalt, and road base could be substituted — each ton of carbonate aggregate and cement containing one half-ton of CO_2. Thus, some16 billion tons of CO_2 could be permanently converted to CO_3 per year on an ongoing basis – with not only lower cost than other means, but with the potential for significant profit in view of active carbon markets. The Calera product would be stable for geologic time frames, as published by National Energy Technology Laboratories, Albany Research Center, and Los Alamos National Laboratory.

The Department of Energy, the National Energy Technology Labs, and several academic institutions in the United States and other countries have evaluated several methods for accelerating the natural chemical weathering of minerals to produce carbonate minerals. Research has focused both on aboveground conversion of CO_2 to carbonate minerals, and the potential for carbonate conversion belowground in brine reservoirs, or at geologic sequestration injection sites. These investigations began in the mid-1980s with Reddy's investigation of techniques to accelerate the natural mineral carbonation process.

Since then, there have been many well known scientists working in this study area: Herzog at MIT, Halevy and Schrag at Harvard, O'Connor, researchers at the National Energy Technology Laboratory in Albany, and others, active in mineralization research. The focus of this research was testing of various base materials, reducing the massive energy consumption in the processing of these materials, and acceleration of the reaction rates. Current research has moved toward carbonation of coal-combustion fly ash and accelerated dissolution techniques of magnesium- and iron-rich silicates (so-called mafic minerals) used in carbonation processes.

Cost-efficiency

Every carbon-capture technology struggles with the issue of cost. The economic viability of our carbonate mineralization business model is significantly enhanced by the ability to sell captured-and-converted-CO_2 building materials into large end-markets. For each ton of CO_2 captured, about two tons of building material can be produced. This process provides the opportunity to transform an environmental liability into a profit center. The market for these newly created materials can be significant. Based on USGS data showing worldwide annual cement consumption of 2.9 billion tons, approximately 12.5 billion tons of concrete are used yearly. Additional aggregate usage for asphalt and road base nearly triples the potential for storing this captured CO_2.

Test data has shown that we can capture and convert CO_2 at 90%+ efficiency with our current absorption configuration on flue gas typical of coal fired utility boilers (about 10%-15% CO_2). We have higher capture efficiencies for other industrial combustion sources, with higher concentrations of CO_2 such as cement kilns (about 20%-40% CO_2) and refinery operations (about 95%-100% CO_2). In addition to our high-capture efficiencies, we produce materials that offset other products that have large carbon emissions such as cement. When we include the "avoided" CO_2 of our capture and conversion into materials, this results in CO_2 efficiency greater than 100%.

We believe our CMAP technology can be cost-competitive and economically sustainable. Particularly advantageous as compared to traditional CCS methods, our conversion technology does not require CO_2 separation, which can be more energy, cost and carbon-intensive as the CO_2 gas becomes more dilute or compressed. Separating CO_2 emission from dilute streams, such as a coal-fired plant or a cement plant, is far more difficult than from a refinery that is almost pure CO_2, and in all cases is much more carbon intensive and expensive than conversion to carbonate. In addition, our process does not require transportation, injection, storage or monitoring. Rather than billions of dollars of pipelines for high-pressure liquid CO_2 transport, the only transportation infrastructure required will be additional rail spurs, material storage and loading facilities at each plant — a substantial reduction in the nation's investment in climate mitigation. Finally, it is important to keep in mind that as our plants grow and scale, we believe our costs will be largely off set by product revenues, enabling a more rapid and extensive scale-up to address large-scale CO_2 mitigation.

Pollutant Removal

Unlike other carbon-mitigation technologies, CMAP removes sulfur compounds and other pollutants. We are developing a multi-pollutant control option using the same basic absorption and conversion techniques we are using for CO_2. The basis of our process for SO_2 (sulphur dioxide) control is similar to seawater scrubbers that have been used in the world's largest power plants. We have generated data showing SO_2 capture efficiencies of greater than 95%.

We are also working on new systems that will control NOx compounds by converting NO (nitrogen monoxide) to NO_2 (nitrous oxide), serious greenhouse gases that are water-soluble and can be stabilized in our mineral product. A significant advantage of our carbonate mineralization technology is that scrubbing SO_2, NOx, particulate matter and other regulated air pollutants are not required in order for the process to capture CO_2. This robust feature is in sharp contrast to other CO_2-capture technologies such as those based on amine (MEA) and chilled ammonia, which require stringent control of SO_2 because it interferes with the absorption process. Therefore, to adequately compare carbonate mineral-CO_2 reduction to conventional CO_2-reduction methods would require that the cost and energy consumption of the additional SO_2 control be included with the conventional method for comparison sake.

Demonstration Plants

Calera's business model is focused on the global potential of our technology with a milestone-driven plan to demonstrate capture rate and scalability. Our plan calls for building electric power and cement plants that capture and convert flue gas CO_2. These projects will benefit the socioeconomic status of the local communities by creating new jobs and business opportunities. Each plant will create 200-300 construction jobs over a 2-year construction phase. Job types required include pipe fitters, electricians, operators, carpenters, laborers, steel workers, ironworkers, mechanics, bookkeepers, and bookkeepers, clerical staff, among others. The completed facility will also provide new permanent jobs.

We have completed a substantial amount of laboratory and scaled batch-process development, and we have been operating a continuous pilot plant at Moss Landing, Calif., producing an average of one ton of material per day (a photo of this site is attached at the end of this document). From there we can quickly scale up the process to 10-80 MW for demonstration at coal-fired, electricity-generating units and cement manufacturing plants. Though the capital expenditures on these demonstration facilities are lower than many other CO_2 mitigation technologies, they require investments in the tens to hundreds of millions of dollars. Hence, my testimony today in support of a more balanced legislative support to foster the commercial development and scale-up of innovative technologies such as ours — *and to ask for the utmost expediency in making those funds accessible.*

Our process converts CO_2 into carbonate minerals, thus permanently converting CO_2 into a stable mineral form. When compared to traditional CCS methods, this conversion technology does not require costly and carbon intensive CO_2 separation or compression. Like any other manufacturer, energy is required to produce this product. Unlike other processes, our technology has the flexibility to capture CO_2 and produce products continuously, while shifting a large fraction of the electrical power consumption to off-peak hours. The shifting of power consumption is accomplished through energy storage in chemical intermediates specific to the mineral sequestration chemistry. By producing and storing these intermediates during periods of low power demand, this process not only avoids straining the grid, but also better utilizes off-peak sources of power such as solar and wind.

Calera's technology also reduces energy consumption and carbon footprint by utilizing power plant waste-heat for product processing. The use of waste heat is enabled by the process chemistry, which requires only low temperatures — in contrast to the very high temperature processes employed in the manufacture of other building materials. As a further means of reducing environmental impact, advanced versions of the process employ recirculation of process water. Although recirculation of process water may be desirable in arid regions, other process options under development may exploit synergies between the mineralization process and desalination technologies, resulting in improved economics and lower carbon footprint for freshwater production.

Another key breakthrough of our technology is the capacity to incorporate solid waste normally bound for landfills into useful products. Waste (such as fly ash) or aluminum smelter by-products (such as red mud and other waste products) can be incorporated into this process.

Beyond Cement

Calera will be important and valuable to states producing and/or consuming coal as they attempt to meet future carbon capture and trading requirements. Calera projects will bring long-term benefits to the coal industry by allowing existing coal plants to continue their operations under new air compliance regulations and avoid shutting down plants producing electricity at the lowest cost. This will save jobs at coal plants, mining sites and in transportation. The low cost of implementing Calera's technology compared to other CCS technologies reduces the impact of new CO_2 regulations on the cost of energy and avoids leakage of U.S. operations oversees to countries that don't have CO_2 regulations.

By shifting the treatment of CO_2 from a pollutant that needs to be disposed at a high price, to a potential raw material for clean manufacturing, our process enables a sustainable and cost-effective capture of a significant portion of the anthropogenic CO_2. In fact, when factoring the long-term potential revenues, revenues from building materials, carbon incentives and water treatment using a carbonate mineral process will be offset by the cost of capturing a ton of CO_2.

Based on our current estimates for construction and operating costs, and our forecasts for the building material and carbon markets, we expect a capital cost payback period of less than 10 years. Furthermore, based on our experience we believe our costs will go down as we learn to build and operate our plants, to the extent that our payback period could be reduced to 7 years. In our two years of operation we have made significant progress in understanding the scientific and engineering tasks of building a full-scale plant. From a small one-liter batch process to a 1-ton per day continuous pilot plant, we have learned how to optimize our capture rates and reduce our footprint and costs. Our progress is supported enthusiastically by the scientific community, environmental groups, potential business partners and the public. However, as for any industrial large-scale process, the next step requires a large investment to build a full-scale plant confirming our commercial scalability. Furthermore, the urgency of the climate challenge calls for an accelerated development path that demands special investments and support.

Recommendations

Congress is working hard to address CCS and to rethink product manufacturing. We admire the Committee for acknowledging the importance of CCS and funding innovations in this area. However, past legislative language and government funding consistently targets separation and geological sequestration, which disadvantages other CCS options. While we acknowledge the remote potential value of geologic CO_2 sequestration, we recommend placing other more viable CO_2-sequestering technologies on at least an equal playing field with separation and geological sequestration. Lower risk, proven approaches like Calera's warrant more immediate funding schedules than separation and geologic sequestration. This leveling of the playing field to reflect real technical merit and reduced development risk should extend to recent authorizations limited only to separation and geologic sequestration programs.

It is our hope that your committee will also consider supporting an independent assessment by the National Academy of Sciences that reviews the opportunities and challenges of beneficial reuse and carbon conversion as part of the larger national CO_2-reduction strategy.

Calera is one of many breakthrough clean technologies that are evolving rapidly. Companies like ours need government funding to help move this process towards commercialization. It is in the best economic interest of our country to advance the most effective technologies by providing grants, loan guarantees, tax incentives and other sources of financial support. For this reason, I urge Congress to broaden its perspective and move beyond existing carbon separation and geologic sequestration approaches by enacting more expansive statutory language and provide federal support that encourages innovation and rewards breakthrough opportunities. Ideally, legislative language would not be prescriptive to any one method, targeting certain companies or sectors, as we see today toward separation and geologic sequestration.

Finally, we seek federal government support because — despite the promise of technologies such as ours, the capital requirements are high in an extremely challenging macroeconomic environment and the risk of any new business venture is significant. The market for CO_2-reduction solutions such as ours is tremendous, but our product will take time and considerable capital to develop sufficiently in order to offset our development costs. Thus we need to scale up rapidly.

On behalf of Calera Corporation and our stakeholders, I respectfully thank Chairman Markey and the Committee Members for your time and consideration. We see an important new option with the recovery funding, and we thank the Select Committee on Global Warming for providing us with this opportunity to explore with you the beneficial reuse of CO_2. The funding we seek could be both stimulating and transformative to energy policy, climate change, and the future of our economy. We look forward to working with the U.S. Congress and the appropriate committees of jurisdiction (i.e., Senate Energy, Senate Finance, and others) to ensure equitable policies are established that provide federal support of CO_2-beneficial reuse technology.

Background on Testimony Request

Leveling the Playing Field

In addition to the *American Clean Energy and Security Act of 2009*, the *American Recovery and Reinvestment Act of 2009* (P.L. 111-5), the *Energy Independence and Security Act of 2007* (P.L. 110-140), and the *Energy Policy Act of 2005* (P.L. 109-58) have authorized funds and programs for the research, development, and deployment of geologic sequestration projects. As Congress contemplates implementing an economy-wide cap-and-trade program, it is imperative that Members take the opportunity to level the playing field and make all forms of CO_2 capture, storage and use eligible for government financial support. The playing field must include dollars and programs already authorized and allocated in order to accelerate the scale-up of multiple carbon mitigation technologies. This will allow more rapid implementation of these alternatives to conventional CCS and will enable the U.S. to meet its climate change goals.

More Than One Carbon Sequestration Method Must Be Supported To Meet Climate-Change Goals

The carbon mitigation challenge facing the United States and the rest of the world will require a multi-faceted approach to rapidly reduce anthropogenic emissions of CO2. The United States possesses both a large coal-energy generation fleet and abundant coal reserves. Meeting climate change objectives, while maintaining a higher level of energy independence, requires that U.S. coal power be made clean power. The ability to retrofit the existing coal fleet in a timely manner is especially important to both of these goals. Establishing coal as a clean energy source has national security implications as well, given that ability to better utilize coal can substantially reduce U.S. dependence on foreign oil.

In the IPCC Fourth Assessment Report (AR4), Volume Climate Change 2007: Mitigation of Climate Change (chapter 4, page 285), industrial fixation through formation of mineral carbonates is referred to as having high energy usage and cost, and indicates that significant technological breakthroughs are needed before deployment can be considered. See Attachment A.

Technological breakthroughs since the 2007 report include Calera Corp.'s aqueous carbonate mineral precipitation process, as well as new technologies from other firms. The Calera process provides a low-cost, low-energy, low-carbon footprint means of capture and conversion of carbon dioxide into permanent mineral forms. A further benefit of the process is the ability to provide revenue through the use of captured CO_2 as replacements for portland cement and natural aggregates. This beneficial use improves the economic sustainability of the process, as well as providing (in the U.S. alone) a repository for as much as 1.5 billion tons of CO_2 per year in the built environment (roads, buildings, houses, etc.).

Calera's Request Benefits Multiple Sequestration Technologies

The following are other firms, spanning a large range of development, that are developing permanent sequestration or beneficial-use technologies that do not involve injection into geologic formations or conversion of CO_2 to fuels:

- Skyonic: formation of bicarbonate from flue gas
- Greensols: formation of carbonate from flue gas
- Carbon Sciences: formation of mineral carbonates from flue gas
- Novomer: polymers from CO_2
- Carbon Sense Solutions: mineralization; accelerated concrete curing, carbonation using flue gas

- Catelectic: electrolytic conversion of CO_2 to chemicals
- Mantra: conversion of CO_2 to formic acid
- Carbon 8 Systems: carbonation of industrial waste — atmospheric or with flue gas
- Novacem: atmospheric CO_2 absorbing cement

There is also a growing effort toward "biochar": pyrolysis of biomass to extract energy, but leaving much of the carbon in a stable form to use as a soil amendment. This constitutes another potential form of permanent sequestration that is excluded from support funding due to the narrow focus and definition of geologic sequestration. Carbonscape is an example of a firm working in this arena.

The Department of Energy Supports Mineral Carbonation

An excerpt from the Department of Energy's website indicates recognition of the advantages of mineral carbonation:

> ***Advanced Chemical and Biological Approaches***
> *Recycling or reuse of CO_2 from energy systems would be an attractive alternative to storage of CO_2. The goal of this program area is to reduce the cost and energy required to chemically and/or biologically convert CO_2 into either commercial products that are inert and long-lived or stable solid compounds.*
>
> *Two promising chemical pathways are magnesium carbonate and CO_2 clathrate, an ice-like material. Both provide quantum increases in volume density compared to gaseous CO_2.*
>
> *As an example of the potential of chemical pathways, the entire global emissions of carbon in 1990 could be contained as magnesium carbonate in a space 10 kilometers by 10 kilometers by 150 meters.*
>
> *See* http://www.fossil.energy.gov/programs/sequestration/novelconcepts/.

Carbonate Mineralization Mitigates Multiple Waste Streams

An additional advantage of the aqueous carbonate mineral precipitation process is that, at continuous process pilot scale, the process has been demonstrated to remove sulfur oxides (SOx). According to U.S. Energy Information Administration data (table 5.2 below), as of 2005 only 1/6th of the U.S. fossil fuel energy generation fleet was equipped with SOx scrubbers. Conventional CO_2 separation technologies, such as amine solvent or chilled ammonia systems, require extremely efficient SOx removal prior to the separation step. This adds significantly to the capital cost of retrofitting existing coal plants without SOx scrubbers, as these scrubbers must be added upstream of the CO_2 separation equipment. The ability to implement only a single process at lower capital cost to capture both SOx and CO_2 makes aqueous carbonate mineral precipitation a more viable alternative for existing coal plants without SOx scrubbers. This advantage makes rapid deployment of the aqueous carbonate mineral precipitation process in the existing coal-power generation fleet much more likely than rapid deployment of traditional CCS for these same plants.

The aqueous mineral carbonate precipitation process also utilizes solid waste such as fly ash that results from burning coal, red mud that results from aluminum ore (bauxite) refining, slags from smelting of steel, copper, phosphorus, and so on. Liquid waste streams such as geologic brine pumped in oil extraction, or brine discharge from desalination plants, can be a valuable part of the process as well. The ability to use these waste products — not only to capture CO_2, but also to convert them into cementitious materials that can be sold to build roads, hospitals and schools, and cleaner water — provides the most compelling example of *sustainability*. Providing such integrated sustainable processes with equal access to funding incentives now enjoyed by geological sequestration is critical to deploying technologies such as Calera's in a timely manner.

Carbonate Mineralization Is Moving Toward Commercial Scale

Many of the incentives authorized under the legislation listed in this document are aimed at taking proven technologies beyond research to full commercial scale. Calera has been operating a continuous pilot facility burning coal at a rate of one million BTU per hour for several months, capturing CO_2 from raw flue gas and converting it to carbonate minerals from which cementitious materials and aggregates have been made. A ten-megawatt (20MW) scale facility is under design, and construction is expected to start in the 3rd quarter of 2009, with operation to begin in 2010. Demonstrations on this large scale show that the technology is ready for the planning and design of mid-size (10-100 MW) and commercial scale (300+MW) facilities. The capital cost of these larger facilities, though less than many other carbon-capture systems, is substantial. This makes the availability of government financial incentives key to accelerating the deployment at scale of this important technology for mitigating climate change.

Attachment A

Excerpt from *IPCC Fourth Assessment Report (AR4), Volume Climate Change 2007: Mitigation of Climate Change*:

to large carbon point sources including coal-, gas- or biomass-fired electric power-generation or cogeneration (CHP) facilities, major energy-using industries, synthetic fuel plants, natural gas fields and chemical facilities for producing hydrogen, ammonia, cement and coke. Potential storage methods include injection into underground geological formations, in the deep ocean or industrial fixation as inorganic carbonates (Figure 4.22). Application of CCS for biomass sources (such as when co-fired with coal) could result in the net removal of CO_2 from the atmosphere.

Injection of CO_2 in suitable geological reservoirs could lead to permanent storage of CO_2. Geological storage is the most mature of the storage methods, with a number of commercial projects in operation. Ocean storage, however, is in the research phase and will not retain CO_2 permanently as the CO_2 will re-equilibrate with the atmosphere over the course of several centuries. Industrial fixation through the formation of mineral carbonates requires a large amount of energy and costs are high. Significant technological breakthroughs will be needed before deployment can be considered.

Estimates of the role CCS will play over the course of the century to reduce GHG emissions vary. It has been seen as a 'transitional technology', with deployment anticipated from 2015 onwards, peaking after 2050 as existing heat and power-plant stock is turned over, and declining thereafter as the decarbonization of energy sources progresses (IEA, 2006a). Other studies show a more rapid deployment starting around the same time, but with continuous expansion even towards the end of the century (IPCC, 2005). Yet other studies show no significant use of CCS until 2050, relying more on energy efficiency and renewable energy (IPCC, 2005). Long-term analyses by use of integrated assessment models, although using a simplified carbon cycle (Read and Lermit, 2005; Smith, 2006b), indicated that a combination of bioenergy technologies together with CCS could decrease costs and increase attainability of low stabilization levels (below 450 ppmv).

New power plants built today could be designed and located to be CCS-ready if rapid deployment is desired (Gibbins *et al.*, 2006). All types of power plants can be made CCS-ready, although the costs and technical measures vary between different types of power plants. However, beyond space reservation for the capture, installation and siting of the plant to enable access to storage reservoirs, significant capital pre-investments at build time do not appear to be justified by the cost reductions that can be achieved (Bohm, 2006; Sekar, 2005). Although generic outline engineering studies for retro-fitting capture technologies to natural-gas GTCC plants have been undertaken, detailed reports on CCS-ready plant-design studies are not yet in the public domain.

Storage of CO_2 can be achieved in deep saline formations, oil and gas reservoirs and deep unminable coal seams using injection and monitoring techniques similar to those utilized by

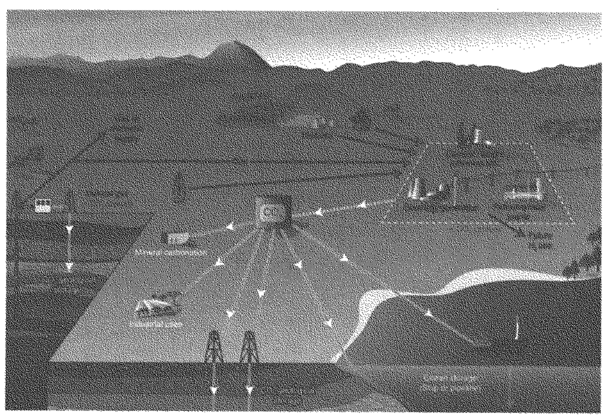


Figure 4.22: *CCS systems showing the carbon sources for which CCS might be relevant, and options for the transport and storage of CO_2.*
Source: IPCC, 2005.

Table 4.5: *Current cost ranges for the components of a CCS system applied to a given type of power plant or industrial source*

CCS system components	Cost range	Remarks
Capture from a coal- or gas-fired power plant	15-75 US$/t$CO_2$ net captured	Net costs of captured CO_2 compared to the same plant without capture
Capture from hydrogen and ammonia production or gas processing	5-55 US$/t$CO_2$ net captured	Applies to high-purity sources requiring simple drying and compression
Capture from other industrial sources	25-115 US$/t$CO_2$ net captured	Range reflects use of a number of different technologies and fuels
Transport	1-8 US$/t$CO_2$ transported	Per 250 km pipeline or shipping for mass flow rates of 5 (high end) to 40 (low end) MtCO_2/yr.
Geological storage[a]	0.5-8 US$/t$CO_2$ net injected	Excluding potential revenues from EOR or ECBM.
Geological storage: monitoring and verification	0.1-0.3 US$/t$CO_2$ injected	This covers pre-injection, injection, and post-injection monitoring, and depends on the regulatory requirements
Ocean storage	5-30 US$/t$CO_2$ net injected	Including offshore transportation of 100–500 km, excluding monitoring and verification
Mineral carbonation	50-100 US$/t$CO_2$ net mineralized	Range for the best case studied. Includes additional energy use for carbonation

[a] Over the long term, there may be additional costs for remediation and liabilities

Source: IPCC, 2005.

U.S. Energy Information Administration Report Excerpt

Table 5.1. Emissions from Energy Consumption at Conventional Power Plants and Combined-Heat-and-Power Plants, 1996 through 2007
(Thousand Metric Tons)

Emission	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996
Carbon Dioxide (CO_2).....	2,516,580	2,459,800	2,513,609	2,456,934	2,415,680	2,395,048	2,389,745	2,441,722	2,338,660	2,324,139	2,232,709	2,161,258
Sulfur Dioxide (SO_2)	9,042	9,524	10,340	10,309	10,646	10,881	11,174	11,963R	12,843R	13,464R	13,480R	12,991R
Nitrogen Oxides (NO_x)	3,650	3,799	3,961	4,143	4,532	5,194	5,290	5,638R	5,955R	6,459R	6,500R	6,474R

R = Revised.
Notes: • See Appendix A, Technical Notes, for a description of the sources and methodology used to develop the emissions estimates. • CO2 emissions for 1995 - 2000 have been revised to reflect the emission factors shown in Table A3.
Source: Calculations made by the Electric Power Division, Einergy Information Administration.

Table 5.2. Number and Capacity of Fossil-Fueled Steam-Electric Generators with Environmental Equipment, 1996 through 2007

Year	Flue Gas Desulfurization (Scrubbers)		Particulate Collectors		Cooling Towers		Total[1]	
	Number of Generators	Capacity[2] (megawatts)	Number of Generators	Capacity[2] (megawatts)	Number of Generators	Capacity[2] (megawatts)	Number of Generators	Capacity[2] (megawatts)
1996	182	85,842	1,134	352,154	477	166,749	1,299	377,144
1997	183	86,605	1,133	352,068	480	166,886	1,301	377,195
1998	186	87,783	1,130	351,790	474	166,896	1,294	377,117
1999	192	89,666	1,148	353,480	505	175,520	1,343	387,192
2000	192	89,675	1,141	352,727	505	175,520	1,336	386,438
2001	236	97,988	1,273	360,762	616	189,396	1,485	390,821
2002	243	98,673	1,256	359,338	670	200,670	1,522	401,341
2003	246	99,567	1,244	358,009	695	210,928	1,546	409,954
2004	248	101,492	1,217	355,782	732	214,989	1,536	409,769
2005	248	101,648	1,216	355,599	730	217,646	1,535	411,840
2006	NA	NA	NA	NA	NA	NA	NA	NA
2007	NA	NA	NA	NA	NA	NA	NA	NA

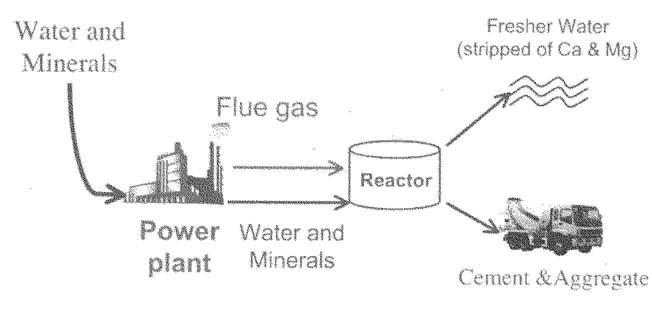
[1] Components are not additive since some generators are included in more than one category.
[2] Nameplate capacity
NA = Not available. Form EIA-767 data collection was suspended in the data year 2006.
Notes: • These data are for plants with a fossil-fueled steam-electric capacity of 100 megawatts or more . • Data for Independent Power Producer and Combined Heat and Power plants are included beginning with 2001 data. • Beginning in 2001, data for plants with combustible renewable steam-electric capacity of D megawatts or more were also included • Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-767, "Steam-Electric Plant Operation and Design Report."

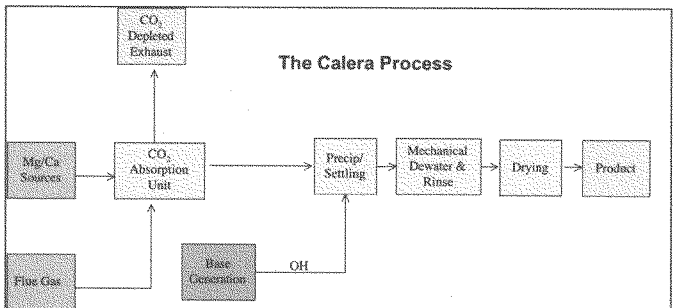
Table 5.3. Average Flue Gas Desulfurization Costs, 1996 through 2007

Year	Average Overhead & Maintenance Costs (mills per kilowatthour)[1]	Average Installed Capital Costs (dollars per kilowatt)
1996	1.07	128.00
1997	1.09	129.00
1998	1.12	126.00
1999	1.13	125.00
2000	.96	124.00
2001	1.27	130.80
2002	1.11	124.18
2003	1.23	123.75
2004	1.38	144.64
2005	1.23	141.34
2006	NA	NA
2007	NA	NA

[1] A mill is one tenth of one cent.
NA = Not available. Form FIA-767 data collection was suspended in the data year 2006.
Notes: • These data are for plants with a fossil-fueled steam-electric capacity of 100 megawatts or more. • Beginning in 2001, data for plants with combustible renewable steam-electric capacity of 10 megawatts or more were also included. • Data for Independent Power Producer and Combined Heat and Power plants are included beginning with 2001 data. • Totals may not equal sum of components because of independent rounding.
Source: Energy Information Administration, Form EIA-767, "Steam-Electric Plant Operation and Design Report."

The Calera Process: Mineral Carbonation





Basic Chemistry of the Calera Process

$$Ca^{+2} + 2OH^{-} + CO_2 \rightarrow CaCO_3 + H_2O$$

$$Mg^{+2} + 2OH^{-} + CO_2 \rightarrow MgCO_3 + H_2O$$

Excerpts from: *Mineral Sequestration Studies in US*

.....carbonates have a lower energy state than CO2, which is why mineral carbonation is thermodynamically favorable and occurs naturally (e.g., the weathering of rock over geologic time periods). Secondly, the raw materials such as magnesium based minerals are abundant. Finally, the produced carbonates are unarguably stable and thus re-release of CO2 into the atmosphere is not an issue.

The major advantages of CO2 sequestration by mineral carbonation are:

- Long Term Stability - Mineral carbonation is a natural process that is known to produce environmentally safe and stable material over geological time frames. The production of mineral carbonates insures a permanent fixation rather than temporary storage of the CO2, thereby guaranteeing no legacy issues for future generations.

- Vast Capacity - Raw materials for binding the CO2 exist in vast quantities across the globe. Readily accessible deposits exist in quantities that far exceed even the most optimistic estimate of coal reserves (~10,000 × 109 tons)

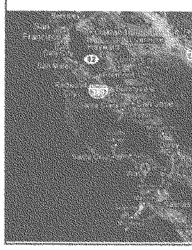
- Potential to be Economically Viable - The overall process is exothermic and, hence, has the potential to be economically viable. In addition, its potential to produce value-added by-products during the carbonation process may further compensate its costs.

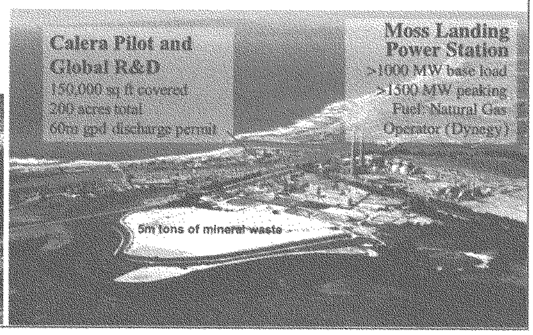
There are adequate mineral deposits to support mineral sequestration. Several ultramafic complexes in North America contain sufficient quantity of magnesium silicate mineral to provide raw materials for the mineral carbonation of all annual CO2 emissions for many years

National Energy Technology Laboratory
Philip Goldberg
Los Alamos National Laboratory
Hans Ziock
Albany Research Center
William O'Connor
Richard Walters
Science Applications International Corp
Zhong-Ying Chen

CA Pilots Validate Process, Product and Environmental Feasibility

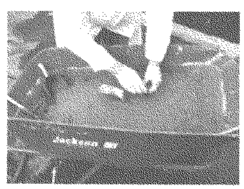
- Pilot plants running large-scale batch and continuous processes
- Flue gas simulator – Ability to test any type of coal and flue gas composition
- Producing material for product development and testing
- Demonstration of waste mineral utilization
- Monterey Bay Marine Sanctuary requires highest level of environmental performance





Carbon Footprint Basic Calculation

Embodied CO_2 of Ingredient x Pounds of Ingredient (per cubic yard) → Sum All Ingredients → Concrete Carbon Footprint



First Carbonate Mineral concrete – July 2008

Ordinary Concrete Emits ~537lb CO_2/yd³ Concrete

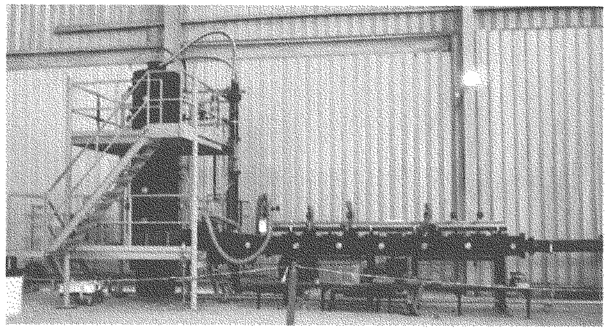
Net CO_2 Emissions Per Cubic Yard
100% OPC

Ingredient	lb CO_2 / lb ingredient	lb ingredient / yd³ concrete	lb CO_2 / yd³ concrete
Portland Cement	0.876	564	494.1
Water	0.01	282	2.8
Fine Aggregate	0.013	1,300	16.9
Coarse Aggregate	0.013	1,800	23.4
TOTALS		3,946	537

"Negative-carbon" Concrete

Ingredient	lb CO_2 / lb ingredient	lb ingredient / yd³ concrete	lb CO_2 / yd³ concrete
Portland Cement	0.876	338	269.1
Water	0.01	271	2.7
Fly Ash	0.045	113	5.1
Calera SCM	(0.450)	113	(50.9)
Calera Fine Agg.	(0.450)	1,250	(562.5)
Calera Coarse Agg.	(0.450)	1,800	(810.0)
TOTALS		3,885	(1,146)

Moss Landing Pilot Plant – Coal Boiler Simulator



•Capacity 1 MMBtu/hr
•Generates flue gas composition and temperature identical to full scale

The CHAIRMAN. Thank you, Doctor, very much.

Our next witness is Mr. Frank Smith. He is a founder and principal of SCS Energy and PURGeN One. There he oversees the development of energy facilities that, according to their company, lead the industry in environmental stewardship and climate change mitigation.

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

STATEMENT OF FRANK SMITH

Mr. SMITH. Thank you. Mr. Chairman and——

The CHAIRMAN. Could you move it over just a little bit closer?

Mr. SMITH. All right. Mr. Chairman and members of the committee, it is my pleasure to testify this morning about new technologies and business initiatives that address our Nation's energy and climate challenges.

At the outset, Mr. Chairman, I want to thank you and your colleagues for your leadership in this area. By using a market mechanism to put a value on CO_2, your bill and supporting energy policies will transform energy production in the same way that the Telecommunications Act of 1996 spurred a revolution in information technology.

SCS develops electric-generating plants. We do complicated, large capital projects, and we have been very successful. The PURGeN One project, located in Linden, New Jersey, promises to be even more so.

I want to make sure that the committee hears three core messages about carbon constraints and the state of technology. Using proven technologies available today, we can produce electricity, along with other basic commodities, at market prices while sequestering 90 percent of our CO_2. We can accomplish that with profitable commercial ventures that meet real market needs. And we can do all of that using domestic resources, resources that include not only coal and rail and capital, but the uniqueness of our offshore geology and the resourcefulness that 1,500 skilled union craftsmen will bring to building our plant.

The PURGeN One facility, which we are developing right now, is one example. The facility operates a hydrogen plant. That plant produces hydrogen gas from coal. Hydrogen is then used to make electricity and urea. In the process, the plant will capture 90 percent of the CO_2 it produces, over 4 and a half million tons per year. That CO_2 will be transported and permanently stored in sandstone formations deep under the ocean floor. PURGeN One does all of this in a dense urban setting, where it meets a real and growing market need for generating capacity.

This project is a price taker in both the electricity market and the urea market. The consumer will pay nothing extra for the commodities produced from this facility. You see, traditional single-purpose power plants operate for large periods of time and break even or worse. PURGeN is a manufacturing platform that shifts easily from producing electricity to producing urea. This both optimizes the revenues, and it uses the plant's capital stock more effectively. With the hydrogen plant as its base, this is relatively easy to do.

So we set out to solve sequestration, and along the way, we solved the fundamental problem in electricity generation. The new technology here is in the business model. Everything else is off-the-shelf, proven technology. Even the sub-seabed sequestration of CO_2 has been proven safe and effective. The oldest and largest ongoing sequestration project in the world is the Sleipner field in the North Sea. We will sequester in formations, well explored formations that are approximately twice as deep and under a much thicker cap rock than those at Sleipner. So PURGeN will be more reliable than the most proven large-scale sequestration field in the world.

One last point. We do not look at CO_2 sequestration as a cost; we look at it as a business. With the $20 per ton tax credit in the TARP bill and some cross-subsidization from the hydrogen plant, the bill operates at about break even. But the pipe has capacity for—what is this? Have I run out of time, sir?

The CHAIRMAN. No, you have not run out of time. It is just notifying us that the Members are being notified that the House is now in session. So it will not come off your time. So you have an additional minute to go.

Mr. SMITH. Okay. Thank you. One last point. We don't look at carbon dioxide sequestration as a cost. We look at it as a business. With the $20 per ton tax credit in the TARP bill and some cross-subsidization from the hydrogen plant, the business operates at about break even. But the pipe has capacity for an additional 5 million tons per year from other facilities. Operating at full capacity, we have a very successful business with a $20 tax credit and $5 to $10 per ton value to the CO_2.

PURGeN One has started the permitting process for an early 2011 construction start, but there are some challenges. First, big power plants are hard to finance in the best of times, but in the current financial crisis, Congress will need to expand DOE loan guarantee authority for first movers. The $20 tax credit provided by the TARP legislation is capped at 75 million tons. PURGeN could sequester upwards of 200 million tons in its first 20 years. Congress will need to raise this cap and provide assurance to investors that the credit will be there for the life of the financing.

Finally, Congress needs to make clear that offshore leasing of lands for sub-seabed carbon storage is not merely permissible but a national priority. We look forward to working with the Select Committee to address these issues and for final passage of H.R. 2454. Thank you, sir.

[The statement of Mr. Smith follows:]

United States House of Representatives
Select Committee on Energy Independence
Edward J. Markey, Chairman

July 29, 2009

Select Committee Hearing on New Energy Technologies

Testimony of Frank Smith, principal of SCS Energy LLC and PurGen One LLC

Mr. Chairman and Members of the Committee:

My name is Frank Smith. I am a principal in SCS Energy, LLC, and in an affiliated company, PurGen One, LLC. It is my pleasure to have the opportunity to appear this morning to testify about the new technologies and private initiatives that promise to meet our Nation's energy and climate challenges.

At the outset, Mr. Chairman, I want to thank you and your colleagues for your leadership on H.R. 2454, the "American Clean Energy and Security Act." Your bill and supporting energy policies will, if enacted, prompt a transformation of our Nation's energy platform as sweeping, potentially, as the information revolution spurred by the Telecommunications Act of 1996.

Our company, SCS Energy, develops electric generating plants, so we know the strengths and failings of the electricity system, and the implications of that system for global climate. We do large, complicated capital projects. The first phase of our last project, a combined-cycle natural gas plant in Astoria, Queens, New York, was financed at over $1 billion. The second phase of the project has brought the total financing to over $2 billion. The Astoria Energy plant raised the bar for plants of that type nationally, while creating new power generation to improve reliability and stabilize prices in the New York City metropolitan area market.

That project has been quite successful. The PurGen One project, located in Linden, New Jersey promises to be even more so. Both projects demonstrate that innovative companies can respond to the needs of our environment while meeting the needs of electricity consumers.

Recognizing that this Committee has been immersed in a national debate over the impact of climate policy on jobs and economic growth in our communities, I want to focus my testimony today on five core messages about carbon constraints and the state of technology.

- First, using *today's technology*, we can produce electricity and other energy commodities at market prices while sequestering 90 percent of our CO_2 using off-the-shelf carbon capture technology and a proven sequestration method.
- Second, by using an innovative business model, we can accomplish that profitably and through private initiative and capital.
- Third, we can do all of that using domestic resources -- resources that include not only coal and natural gas, but the domestic resource that our offshore geology provides for sequestration and the domestic labor resource illustrated by the 1500 skilled union laborers who will build our plant.
- Fourth, first-movers in carbon capture and sequestration (CCS) need help in overcoming the headwinds presented by the current market crisis and resulting credit crunch. Congress needs to act to make financing possible for otherwise

sound projects by expanding current incentives and making them permanent for first movers.

- Fifth, Congress must ensure that federal policy promotes the use of our offshore geologic resources for CCS.

I. SCS Energy's Background and Experience.

SCS has a record of successfully developing and financing large capital projects in the energy industry that meet market need and set new standards for environmental performance.

SCS Energy's most recent development project, Astoria Energy, is a 1,000 MW combined cycle natural gas-fired, air-cooled facility located in the Astoria section of Queens, New York. SCS Energy initiated the project in 1999 and was the lead developer and manager of the project through development, financing, construction, and initial operations. With Credit Suisse First Boston, SCS brought in $285 million in private equity participation and approximately $800 million in debt financing. SCS negotiated a Power Purchase Agreement (PPA) with Consolidated Edison Company of New York, Inc. to support the Phase I financing. SCS Energy negotiated an engineering, procurement and construction contract with Stone & Webster to construct Phase I consistent with the demands of the Con Ed PPA and the New York independent system operator (ISO). SCS Energy completed construction of Phase I on budget and on schedule, a highly unusual event for any kind of construction in New York City. Astoria Energy was a recipient of the 2006 New York Industrial Project of the Year Award and the 2007 Pacesetter Plant Award.

From a business perspective, Astoria Energy was significant because it was the first independently developed electric generating station to be built start to finish following the collapse of the project finance markets for power plant projects as a result of the Enron failure. From a construction perspective, Astoria Energy was significant because SCS completed the project and put it into service on time and on budget, despite the challenges of building a new plant in one of the most densely populated urban communities in the world.

From an energy perspective, Astoria Energy was significant because it delivered 1,000 MW of electricity in a load pocket where new generation was desperately needed to address the ISO's reliability and congestion concerns, and to reduce attendant price volatility.

And from an environmental perspective, Astoria Energy was significant because it was the first plant of its type to be built using air cooling of the power block rather than water cooling from a raw water intake from the East River or another sensitive or scarce water source. This made it impossible for power plant developers to continue to fight environmental regulators seeking to protect fisheries and other water resources from the impacts of raw water cooling.

Prior to Astoria Energy, SCS Energy had built Marcus Hook, a 750 MW combined cycle natural gas-fired power plant located in Marcus Hook, Pennsylvania. The plant, which began operation in 2005, is currently owned by FPL Energy. SCS Energy also was the initial developer and an initial owner of Newington Energy, a 500 MW combined cycle natural gas-fired power plant located in Newington New Hampshire.

By industry standards, SCS is a small development company. SCS is especially able to take on blockbuster projects with success because we boast a project team that brings more than 175 years of industry experience to every challenge, and because our small size gives us the nimbleness to move and adapt quickly to rapidly changing conditions in the relevant markets and to the evolution of public policy as it affects energy project development.

II. PurGen One and the Promise of IGCC with CCS

After completing Astoria Energy, SCS recognized the inevitability of carbon regulation, and saw that the first firms to develop a fossil fuel plant with CCS could capture significant market value. Accordingly, SCS began a survey of both the technological options and the preferred location for a plant incorporating CCS into a fossil fuel electric generating platform.

A. Siting and Technology

The northern New Jersey electricity market presents many of the attributes needed for such a project to succeed: a significant deficit of generation (the region imports more than a third of its electricity, most of which comes from inadequately controlled coal-fired plants out-of-state and upwind that contribute to the area's noncompliance with public health standards for soot and smog); high electricity prices and price volatility; reliability and congestion concerns by the independent system operator, PJM; and a policy and regulatory context that includes carbon regulation through the Regional Greenhouse Gas Initiative (RGGI).

The region presented one further attribute that was critical to the feasibility of CCS for PurGen One: proximity to a thoroughly characterized geologic formation in federal waters seventy miles off the New Jersey coast that is perfectly suited to perpetual and safe storage of carbon dioxide, with capacity to store all of the carbon from PurGen One as well as every other fossil fuel plant in the northeast for thousands of years. SCS Energy came to appreciate this attribute through the work of Dr. Daniel Schrag, a geochemist and CCS expert who is the director of Harvard University's Center for the Environment and is who one of President Barack Obama's appointees to the President's Council of Advisors on Science and Technology (PCAST). Dr. Schrag serves as PurGen One's consulting scientist.

Reviewing technology options, SCS settled upon an Integrated Gasification Combined Cycle (IGCC) process. In PurGen One's IGCC plant, coal is used as a feedstock and is chemically converted to a synthetic gas (syngas) rather than burned. Pollutants, including nearly all of the sulfur and mercury that make coal combustion problematic using any other process, are then removed from the syngas prior to combustion, leaving mostly hydrogen and CO_2. A two-phased shift reaction removes more than ninety percent of CO_2 from the syngas, so that by the end of the process the syngas is nearly pure hydrogen. Then, as in a typical IGCC plant, the hydrogen can be used in a highly efficient combined cycle gas-fired power block, nearly identical to that in a combined cycle natural gas plant with the exception that hydrogen requires turbines designed for higher temperature combustion. The carbon dioxide stream is then dried and compressed at ambient temperature, and transported in a 24-inch carbon steel pipeline to a rock formation seventy miles off the coast and nearly one and a half miles below the ocean floor.

PurGen One has identified and secured an ideal site for this plant. PurGen One has entered a purchase and sale agreement for a 108-acre industrial property in Linden, New Jersey that is the former site of an E.I. Dupont de Nemours chemical manufacturing facility. In terms of electricity, the site is at a critical point in the regional grid where high demand and high price volatility result from the area's generation deficit. In terms of infrastructure, the site presents nearby electric and natural gas transmission lines, service by two rail lines, a wharf for ocean transport, and a local wastewater treatment plant whose effluent can be recycled for use in the PurGen One plant. In terms of local land use, this brownfield site previously has been permitted for use as an electric generating station, and the local mayor has welcomed the proposed PurGen One Plant. In terms of sequestration sites, a 100 mile pipeline will take PurGen's CO_2. stream to one of the best sequestration sites in the world, seventy miles off New Jersey's coast.

The offshore geology from Long Island to the Maryland coast has been subject to extensive characterization over the years by the Minerals Management Service (MMS) of the Department of the Interior as well as by private companies and independent scientists looking primarily for oil and gas deposits. That work has been essential to Dr. Schrag and to PurGen One's team in identifying two cretaceous sandstone formations that do not have oil and gas deposits, but that do present the requisite porosity, capacity, and reliability for long-term geologic storage of CO_2. These formations contain ancient seawater rather than oil or gas or the heavy brines and metals present in some onshore saline aquifers. They are overlain by a thick cap rock that ensures containment of the

CO_2, a cap rock that is sufficiently plastic to reseal and contain the carbon dioxide reservoir even in the highly unlikely event of a major seismic event.

These characteristics are important because they allow PurGen One to benefit from the longest continuing and largest successful demonstration of carbon sequestration at commercial scale in the world: the Sleipner field in the North Sea off of Norway. Sleipner has successfully sequestered over 1 million tons of CO_2 per year for over 12 years. The only substantial difference between the Sleipner field and the PurGen One field is that, with Dr. Schrag's help, we have identified formations – well-explored formations – that are approximately twice as deep and under a cap rock structure that is substantially thicker than those at Sleipner. Combined, these features make the PurGen One field more dependable than the most proven sequestration field in the world for long-term storage of carbon dioxide. And the capacity of the field is vast, presenting even with highly conservative assumptions permanent storage capacity for no less than a trillion tons of carbon dioxide.

B. Changing the Business Model for CCS

Having found the perfect site and suitable technology, SCS Energy had the further challenge of developing a business model that would allow an IGCC plant with CCS profitably to cover the higher capital costs associated with gasification, carbon capture, and the pipeline.

In a sense, this challenge pervades the electric generating industry in one form or another because traditional, single purpose power plants operate for large periods of time at breakeven or worse, generating profits only at times of peak electricity demand. This prevailing industry model uses capital inefficiently, because with the exception of those peak periods most of the industry's very expensive capital stock is unutilized or underutilized most of the time. This means that for every two dollars of capital paid for by ratepayers, only about a dollar being used at any given time.

PurGen One solves this problem through a co-production model, in which the hydrogen produced by the plant for the power block is alternately used in a plant that produces urea fertilizer and other commodities. The coal gasifier operates at full capacity to produce hydrogen twenty-four hours a day, seven days a week, but the use of the hydrogen is shifted between production of electricity and production of other hydrogen based commodities – primarily urea fertilizer – as market prices and consumer demand dictate. This both optimizes the revenues and uses the plant's capital stock more efficiently. With the hydrogen plant this is relatively easy to do.

Thus, the capital stock of the PurGen One plant will generate revenue-producing commodities around the clock using full-time production of hydrogen, even though electricity generation from the facility is likely to be at peak only thirty percent of the time. In developing this model, we benefited from the work on co-production undertaken by Robert H. Williams, Senior Research Scientist and head of the Carbon Capture Group of the Carbon Mitigation Initiative of Princeton University's Environmental Institute.[1]

The second change that PurGen One brings to the business model for IGCC with CCS is to make the sequestration pipeline a business rather than a mere cost of production. By over sizing the pipeline so that it can transport 5.3 million tons of carbon dioxide per year from other industrial sources in addition to the 4.7 million tons per year

[1] *See, e.g.*, Robert H. Williams, *What is to be Done with Coal Power?*, Invited Testimony before the New Jersey Clean Air Council (April 1, 2009).

that the PurGen One facility will generate as the pipeline's anchor tenant, PurGen One transforms sequestration into a marketable product rather than just a cost of producing electricity.

This aspect of PurGen's model is made possible by two major policy developments. The $20 per ton carbon sequestration tax credit in the Emergency Economic Stabilization Act of 2008, Pub. L. 110-343 (Oct. 3, 2008)(EESA), and the anticipated development of a market for carbon dioxide sequestration under H.R. 2454, the "American Clean Energy and Security Act" (ACES). As discussed below, more needs to be done and we need to see final passage of the ACES legislation, but the PurGen One presents appealing returns as long as the EESA tax credit remains in place and reliable.

Coupled with PurGen One's technology choices, this changed business model allows us to disprove the persistent and axiomatic claims this Committee has heard that carbon constraints will destroy rather than create jobs, and that CCS is technologically and economically risky, unproven, and twenty years from being ready for commercial deployment. PurGen One will create 1500 skilled union construction jobs, and every component of this plant has been proven at commercial scale.

There are further economic benefits to the PurGen One model that warrant discussion. Most importantly, PurGen One will be a price taker in electricity and other commodity markets, thereby stabilizing prices for consumers by bringing additional supply where it is most needed.

That price stabilization is relevant not just to energy security, but also to food security. As Ranking Member F. James Sensenbrenner, Jr. has stated before this Select

Committee, for our farmers currently "there is no substitute for natural gas in nitrogen production."[2] PurGen One will be a domestic manufacturer of virtually carbon-free nitrogen fertilizer that will be tied to the highly stable price of our domestic coal feedstock, rather than the highly volatile natural gas price, thereby helping America's farmers to avoid devastating price swings in the global nitrogen fertilizer market.

III. PurGen One and "Around the Corner" Technologies.

The Select Committee has convened this hearing largely to look at "around the corner" technologies. I find myself in the odd position of testifying that as far as technology is concerned, PurGen One will achieve virtually carbon-free power from domestic coal using a platform in which every facet of the plant uses off-the-shelf technology that has been proven for years at commercial scale.

The new technology in PurGen One is truly in the business model. We set out to solve the challenges of sequestration, and along the way we solved a fundamental problem in our domestic electricity production system. But while our plant itself uses currently existing and proven technology, the innovation in the PurGen One business model will have significant benefits for the next generation of technologies that will address global warming while enhancing America's energy security.

Our PurGen One site lies in a heavily industrial corridor along New York and New Jersey's Arthur Kill, with a conventional gas-fired power plant as a neighbor on one

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[2] Statement of Ranking Member F. James Sensenbrenner, Jr., Hearing Before the Select Committee on Energy Independence and Global Warming, United States House of Representatives, 110th Cong. (June 18, 2009)(discussing testimony of Ford West, President of the Fertilizer Institute).

end and a major refinery as a neighbor at the other. We anticipate that over the next several years there will be breakthrough advances in post-combustion CCS technologies, making it both technically possible and economically practicable to retrofit existing fossil fuel electric generating stations and other industrial facilities, including PurGen One's immediate neighbors, to capture their carbon for storage. By building a pipeline that can handle twice as much CO_2 as the PurGen One plant itself will produce, our plant will facilitate and bring down the cost of post-combustion CCS as the technology matures.

In addition, we note that one of the significant barriers to the use of fuel cells and the development of liquid fuels using a hydrogen feedstock has been the limited supply and high price of hydrogen. By creating a manufacturing platform that can produce hydrogen in vast quantities and at a very low price, the PurGen One model can be replicated to accelerate our transition to energy sources and even liquid fuel derived from hydrogen without significant adverse effects on prices. To give the Committee an encouraging glimpse of those possibilities, I would note that the energy content and price components of the hydrogen produced by our PurGen One plant compare favorably, when converted to liquid fuel equivalents, to two dollar per gallon gasoline.

IV. Support Needed from the Congress

In PurGen One, SCS Energy is developing a plant that produces virtually carbon free electricity and other commodities at market prices using well-proven technology. This plant produces appealing returns for investors, but Congress still needs to act if PurGen One and other first movers in CCS are to succeed.

First, as discussed above, PurGen One is profitable without any direct government grants or other incentives, but our pro forma does assume and the project does rely on the $20 per ton carbon sequestration tax credit as enacted in the EESA.

The EESA sequestration tax credit is currently capped at 75 million tons, whereas the PurGen One project alone has the potential to sequester 200 million tons annually over the course of its 20-year financing. Attracting private equity to PurGen One in the face of the current financial crisis will require certainty for investors that they can rely on the availability of the tax credit. Congress needs to raise the cap, and to ensure that the tax credit is available for the life of the project – at least for the first movers in this sector. The need to make the EESA tax credit permanent and reliable for first movers has been made more important, in some sense, by this Committee's decision in the ACES legislation to adopt an allocation scheme for carbon allowances that will dampen the initial price-per-ton of carbon.

Second, the current state of the financial markets and the resulting chill in commercial lending requires Congress to address debt financing of PurGen One and other IGCC projects with CCS that are first movers. Debt financing of a new electric generating facility is tough even in the best of times and for the most conventional projects. For first movers in the current debt markets, IGCC with CCS confronts many of the same headwinds that new nuclear power projects face: huge capital costs, lack of an established track record, policy risk, and lender risk aversion. Just as Congress has recognized the need for loan guarantees and direct loans to "kick start" a new generation of nuclear plants, Congress will need to expand the Department of Energy's authority to provide loan guarantees or direct loans to first movers of IGCC projects with CCS that are otherwise sound from a business and risk perspective.

Third, Congress needs to make sure that use of sub-seabed geologic formations offshore and in federal waters for CO_2 sequestration is not merely permitted, but is a national priority. In discussing energy policy, we often refer to the importance of using domestic resources such as coal and natural gas but rarely acknowledge that the formations suitable for sequestration are as much a resource for our energy future as the formations that may contain oil or gas deposits. We are especially concerned about proposals that would limit the leasing of certain offshore lands exclusively to renewable energy projects. In our initial pre-application meetings with MMS and other federal agencies under President Obama's Administration, we have been encouraged that there appear to be no current statutory or regulatory impediments to sub-seabed sequestration. We need Congress to ensure that this remains the case, particularly as broader policies to "zone' the ocean for specific uses are developed.

Finally, Congress must achieve final passage of the ACES legislation and ensure a long-term market price for carbon that is reasonably commensurate on a per-ton basis with the costs associated with CCS. Once PurGen is built, we will have put in place the infrastructure for broader deployment of CCS technologies, but that broader deployment – and the jobs and other economic benefits it will generate – depend over the long term on enforceable limits and progressive reductions in this Nation's emissions of carbon dioxide and other greenhouse gases.

V. Conclusion

PurGen One, which has begun the permit application process for a 2011 construction start, illustrates that private initiative and an innovative business model make it possible to develop a virtually carbon free facility to produce electricity and other hydrogen based products using off-the-shelf technology and a model for sub-seabed sequestration that has been proven at commercial scale for more than a decade.

PurGen One and other first movers in IGCC will create the infrastructure – carbon pipelines and vastly expanded hydrogen production capacity -- that will support the next generation of energy technologies to solve the climate crisis, create jobs, and stabilize energy prices domestically. For that to happen, Congress must ensure that the incentives needed for first movers in the current financial climate are expanded and made permanent.

Respectfully submitted,

Attachments

Frank Smith
SCS Energy, LLC
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85 Main Street
Concord, Massachusetts 01742
(978) 287-9529

Frank W. Smith

Frank Smith is a founder and principal of SCS Energy LLC where he has worked for the past ten years. In that time, SCS has successfully developed three major electrical generating facilities. The most recent facility was the Astoria Energy facility located at the end of Steinway Street in Queens, NY. Astoria is a 500 MW facility. It is the newest and one of the cleanest facilities in the system, providing much needed generating capacity to the largest load pocket in the system.

Prior to starting SCS, Frank was with Yankee Energy Services Co (Yankee Energy) where he was Vice President of Sales responsible for co-generation project development for "inside the fence" transactions.

Before that, Frank was the Marketing Director at Commonwealth Sprague Capacitor, Inc. and reported to the President of the company. In this role, Frank was responsible for the development of a new line of low-voltage harmonic filters for the power quality marketplace. This line of products has important application in developing countries where power quality problems are more severe than in the U.S.

Frank spent his first ten years in the business world in a variety of marketing and general management jobs at Norton Company, primarily in the coated abrasives division. Before leaving Norton, Frank became General Manager of a $12 million non-woven abrasives business with manufacturing locations in Troy, NY and Reynosa, Mexico.

Frank received a BA degree from Princeton University and holds an MBA from Harvard Business School.

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

Our next witness is Mr. Gary Spitznogle, who is manager of Integrated Gasification Combined Cycle and carbon capture and storage engineering at American Electric Power. He represents AEP in the Midwest Regional Carbon Sequestration Partnership, a regional partnership of research and industry entities arranged by the United States Department of Energy to study carbon sequestration.

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

STATEMENT OF GARY O. SPITZNOGLE

Mr. SPITZNOGLE. Mr. Chairman and distinguished members of the Select Committee, thank you for having me here, and I appreciate you offering me this opportunity to share the views of AEP on power generation and technologies for the reduction of CO_2 emissions. We applaud your efforts to explore new technologies that can help achieve energy independence while reducing or eliminating emissions of greenhouse gases.

In my testimony, I have described AEP's leadership on technology development over the past 100 years, including new generation. Arguably even more urgent than new generation technologies, substantial effort must be placed on retrofit technologies for the reduction of CO_2 from existing power plants. The U.S. currently obtains about half of its electricity from a large fleet of baseload coal generation plants. And most of these will be in operation for decades to come. In recognition of this fact, the Secretary of Energy, Dr. Steven Chu, has recently directed the DOE to invest significantly in the area of post-combustion CO_2 capture.

The recent changes made to the Clean Coal Power Initiative Program and the DOE-funded National Carbon Capture Center reflect the support needed to commercialize CCS technologies. AEP has teamed up with Alstom to demonstrate its chilled ammonia CO_2 capture technology at the 20-megawatt scale at our Mountaineer power plant in West Virginia. With start-up planned for just a few weeks away in early September, we will begin to inject 100,000 tons per year of captured CO_2 into deep saline reservoirs approximately 8,000 feet below the surface. This project represents the Nation's first integrated CO_2 capture and storage project at a coal-fired power plant. After successful validation, our plan is to move the technology to commercial scale, demonstrating the entire process at a rate of 1.5-million tons of CO_2 per year.

Now, if currently available CO_2 capture technologies were to be deployed, the resulting energy consumption of these systems would lead to the loss of one-third of the power plant's output. That means a typical 600-megawatt power plant would be reduced to 400-megawatts, and the cost of electricity would be increased by roughly 60 to 70-percent.

New technologies, such as the chilled ammonia process, offer the promise of reducing this parasitic power loss. However, these technologies are not yet ready for commercial deployment. They must be advanced in a systematic and step-wise manner. AEP's current CCS project represents this next step in the evolutionary progress of technology development. Commercial scale demonstrations of technologies like chilled ammonia will not be in service before

2015. And even when it is, it must be understood that these first projects will not be installed with commercial guarantees from vendors, and they run the risk of not continuously meeting high CO_2 capture levels. This is why we believe that 2020 is approximately the earliest date when commercially reliable carbon-capture systems will be deployable across the industry.

A few other technical hurdles must be also be considered. At CO_2 capture levels exceeding 50 percent, the steam consumption required by conventional capture technologies may jeopardize the unit's ability to continue to produce electricity. In addition to energy demand, CO_2 systems require vast amounts of land. And as a rule of thumb, a full-scale system would double the footprint of a typical power plant. Some plants can accommodate this requirement, but many cannot. Consequently, companies may be forced to deploy CO_2 capture systems on only a portion of the plant's output.

One more significant challenge is the permanent storage of CO_2 after it is captured. The extent of available saline reservoirs, injection pressure limitations, and ultimate capacity are all factors that currently are the subject of intense study. AEP's CCS program demonstrates the prudence of taking technology in a safe and stepwise fashion to commercialization. The timeline for this work again points towards 2020 as a reasonable date for wide-scale availability of the technology.

In summary, continued research, development, and demonstration must be supported, and is essential to make CCS technologies a reality. We must do more than just simply call for it. Our Nation must prepare, inspire, guide, and support our citizens and the very best and 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 part of this important process and to help achieve the best outcome at the most reasonable cost and timelines possible. Thank you again for this opportunity to share our views. I will be happy to answer questions.

[The statement of Mr. Spitznogle follows:]

Testimony of

Gary O. Spitznogle

Manager, IGCC and CCS Engineering

American Electric Power

Before the Select Committee on

Energy Independence and Global Warming

July 28, 2009

Good morning Mr. Chairman and distinguished members of the 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) on electricity generation and technologies for the reduction of greenhouse gas emissions.

My name is Gary Spitznogle, and I am the Manager of IGCC and CO_2 Capture and Storage Engineering for American Electric Power. Headquartered in Columbus, Ohio, we are one of the nation's largest electricity generators -- with more than 36,000 megawatts (MW) 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 fuel sources – including coal, nuclear, hydroelectric, natural gas, 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 and our company is an industry leader in developing advanced electrical generation and emission reduction technologies, including carbon capture and storage (CCS).

AEP's Commitment to Renewable Energy

We applaud your efforts to explore new energy technologies that can help achieve energy independence while reducing or eliminating emissions of greenhouse gases. AEP believes that renewable energy technologies, including those being developed by the other members of this panel, are an important part of that effort. Our company has increased its renewable portfolio significantly in recent years. Our wind energy portfolio currently includes 1,783 MW of installed capacity and long-term power purchase agreements. We also recently signed our first long-term power purchase agreement for all of the electrical output from a 10 megawatt solar energy facility being developed in Wyandotte County, Ohio. AEP plans to add another 1,100 MW of renewable energy resources by the end of 2011. While we strongly believe renewable energy will play an important and increasing role in our nation's energy future, renewable generation is just part of the answer. We must maintain a fleet of baseload power plants, including coal-fueled plants, which can be relied on 24/7 to generate the electricity that our economy requires.

AEP's Leadership in Technology Development

AEP has a long and proud history as a leader in our industry for the development and deployment of new technologies. The first high- and extra-high voltage transmission lines at 345 kilovolt (kV) and 765 kV were developed for and serve as the framework for our interstate transmission system. AEP was among the first to develop large central station power plants and to deploy more efficient supercritical generating technologies. AEP recently celebrated its centennial by reflecting on its century of firsts.

Most recently, we have built upon this history of innovation by focusing our efforts on new clean coal technologies. These technologies will enable AEP and our industry to meet the challenge of reducing GHG emissions while optimizing the use of our nation's plentiful indigenous coal resources. Construction currently is underway in southwest Arkansas on the 600-megawatt Turk Plant that will employ new "ultra-supercritical" coal-fired generating technology. "Ultra-supercritical" technology uses high steam pressure and temperature to increase operational efficiency. The Turk Plant represents a new generation of power plant design that uses less fuel to produce each MWh of electricity. This means that all emissions, including SOx, NOx, and CO_2, will be lower than conventional coal-combustion processes per unit of electricity produced. Once we have obtained all necessary regulatory approvals, finished construction, and begun operation, the Turk Plant will be one of the first commercial-scale "ultra-supercritical" plants to operate in the United States.

AEP also has pursued the development of Integrated Gasification Combined Cycle (IGCC) technology. IGCC represents a major breakthrough in our work to improve the environmental performance of coal-based electric power generation. IGCC technology integrates two proven processes - coal gasification and combined cycle power generation - to convert coal into electricity more efficiently and cleanly than any existing uncontrolled power plant. IGCC also has the potential to be equipped with carbon capture technology at a lower capital cost and with less of an energy penalty than traditional power plant designs, but only after the carbon capture technology has been proven at a commercial scale. Although the Virginia state commission declined to approve rate recovery for the IGCC plant that we proposed to serve our West Virginia and Virginia customers, but we still strongly endorse the technology and hope to move forward with an IGCC plant at an appropriate time as part of our future capacity plans.

AEP's Commitment to the Development of GHG Reduction Technologies

AEP has also been an industry leader in furthering the development of GHG reduction technologies. Anticipated future mandates for reducing greenhouse gas emissions necessitates the demonstration of CO_2 capture and storage technologies that can be retrofit on the existing fleet of coal-fired power plants in the U.S. and around the world. The technologies for effective carbon capture and storage from coal-fueled facilities are developing, and AEP is on forefront of this effort. One notable AEP project, that will begin startup operations in September of this year, will demonstrate Alstom's ammonia-based CO_2 capture technology, known as the Chilled Ammonia Process, at a 20 MW scale on our 1300 MW Mountaineer Power Plant in New Haven, West Virginia. This demonstration project will capture 100,000 tons per year of CO_2, compress it to a supercritical liquid state, and inject it into deep saline aquifers more than 8000 feet beneath the Mountaineer Plant site. This project is the nation's first integrated CO_2 capture, compression, pipeline, and storage project at an existing coal-fired power plant. After successful operation at the 20 MW scale for a period of five years, our plan is to invest in a commercial-scale 230 MW unit at the same site. The commercial scale unit will be capable of removing and injecting CO_2 at a rate of 1.5 million tons per year.

AEP believes that this dual commitment is essential to meet the challenges of generating electricity in a carbon-constrained future. Clearly, we must develop a new generation of coal-fueled plants that generate electricity with maximum efficiency, to minimize their carbon footprint and other impacts to the environment. However, the challenge does not stop there. Substantial effort also must be placed on the development and demonstration of **retrofit** technologies for the reduction of CO_2 from existing coal-fired generating units. The United States currently obtains approximately half its electricity from a large fleet of baseload coal-fired power generation facilities and the majority of these facilities will be in operation for decades to come. Only with a portfolio that includes effective CO_2 retrofit technologies will the United States be able to achieve the substantial GHG reductions called for in recent legislative proposals and maintain a strong and vibrant economy.

Recent Supportive Measures Must be Supplemented to Assure the Technology is Ready When Needed

United States Secretary of Energy, Dr. Steven Chu, recently has directed the DOE to invest significantly in the area of post-combustion CO_2 capture. The changes made to the Clean Coal Power Initiative (CCPI) Round III Funding Opportunity Announcement (FOA) reflect the kind of support necessary to make commercial scale GHG reduction technologies available when needed. The FOA has removed its previous requirement of directing a minimum 70% of its funds toward IGCC projects, in favor of post-combustion technologies that are amenable to retrofit applications. Additionally, the DOE-funded Power Systems Development Facility (PSDF) in Wilsonville, Alabama, has recently focused more on post-combustion applications (which can be retrofitted on existing generating units) and is now renamed the National Carbon Capture Center.

These measures, together with the Regional Carbon Sequestration Partnerships and private efforts like those being undertaken by AEP, must be supplemented and continued if the extraordinarily-high costs currently associated with CCS technologies are to be mitigated and promising demonstration technologies like the Alstom process are to be commercialized. Without adequate federal support, we will not be able to overcome the significant technical challenges necessary to achieve dramatic reductions in GHG emissions.

Challenges to Commercialization

CO_2 capture and storage using current inhibited monoethanolamine (MEA) technology is expected to increase the cost of electricity from a new coal-fired power plant, at a minimum, by about 60-70 percent. Even the newer Chilled Ammonia CO_2 capture technology being tested by AEP will require significant amounts of energy and therefore result in higher costs for coal-fueled electricity. It is only through the steady and judicious development of commercial scale applications during the course of the next decade that we can start to bring these costs down, and avoid substantial electricity rate shocks and undue harm to the U.S. economy as the result of cutting greenhouse gas emissions.

If technology research and development remained stagnant over the next decade, there would be no choice but to retrofit the existing fleet with commercially-available MEA technology for CO_2 capture. The energy consumed by this conventional technology, at high capture levels, would result in the loss of approximately one third of a generating unit's power output. That means a typical 600 MW generating station would be able to deliver only 400 MW of electricity to the grid after being retrofit with current CCS technology

New technologies, such as Alstom's Chilled Ammonia process, offer the promise of reducing this parasitic power loss to far lower levels. However, these technologies are not yet ready for commercial deployment; rather they must be advanced in a systematic and step-wise manner. AEP's 20 MW project at Mountaineer Plant represents the next step in the evolutionary progress of the technology. However, even with the start-up of the demonstration project this year, commercial-scale applications of the Chilled Ammonia process in a first-of-a-kind unit will not be in service before 2015. These first projects, including the planned 230 MW commercial scale unit at Mountaineer, will not be installed with commercial guarantees from vendors and they run the risk of not continuously or reliably meeting high CO_2 capture levels. Our expectation is that 2020 is the earliest date when a reliable commercial-scale carbon capture system will be available to be deployed across the industry.

Other technical hurdles present challenges to the wide-spread deployment of CCS technology. Most notably, the scale of capture technology installations and the ultimate disposition of CO_2 remain topics of intense evaluation.

In addition to energy demand, physical placement of the capture process equipment will be a constraint at many existing power plants. As a rule of thumb, the capture system, on a per-megawatt basis, will require a real estate footprint equivalent to the existing generating plant. In other words, it is likely that the installation of a system to treat the entire plant flue gas output would double the land space occupied. Some plants can accommodate this requirement, but many plants cannot. Consequently, companies may be able to deploy CO_2 capture systems on only a portion of a plant's output due to siting constraints.

Another significant challenge is the permanent storage of CO_2 after it is captured from a power plant. While the oil and gas industry may be able to utilize a portion of the captured CO_2 for use in Enhanced Oil Recovery (EOR) activities, the supply of CO_2 from the power generation industry will quickly overwhelm the demand from EOR operations. In short order, CO_2 will have to be permanently sequestered or stored in saline formations located many thousands of feet below the surface. The extent of available saline formations, injection pressure limitations, and ultimate capacity are all factors that are currently the subject of intense study. While help from the oil exploration industry is certainly beneficial, there is no substitute for the electric power industry undertaking numerous large-scale demonstration projects involving CO_2 injection into saline or other non-EOR formations. AEP's CCS demonstration program again is an example of the systematic nature of these projects, taking the technology in step-wise fashion from small-scale to commercial-scale deployment. The timeline for this work again points toward 2020 as a reasonable date for wide-scale application of the technology.

In summary, the current state of CCS technology is not yet ready for wide-scale and large CO_2 capture mandates. Continued research, development, and demonstration must be supported and is essential to make CCS technologies a reality. Simply put, our nation cannot wait a decade or longer to begin the development and commercialization of advanced coal generation and carbon capture and sequestration technologies. The need for new electric generating capacity is upon us now and will grow as high energy-consuming CO_2 capture technologies are deployed. The need is real and it is pressing.

Unfortunately, the deployment of advanced coal electric generation technology, such as CCS, ultra-supercritical pulverized coal, and IGCC generation, is expensive now and will only become more so if development is postponed.

Technology is A Critical Component to Meeting Our Climate Challenge

Changing consumer behavior by buying efficient appliances and cars, by driving less, and by similar steps, is helping to reduce the growth of greenhouse gas emissions. But, however important these steps are to reducing our carbon footprint, they are not sufficient to achieving substantial greenhouse gas reduction levels that are now called for under the Waxman-Markey bill. 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 stringent CO_2 emissions caps on our economy. Without the proper federal support for the demonstrating CCS technologies, the result will not be a positive response by the market, but rather a severe impact on the economy.

CCS technologies must play an important role in attaining our nation's future greenhouse gas reduction goals. Achieving such stringent reduction goals may not be realistic until and unless CCS technologies have been demonstrated to be effective and the costs have significantly dropped so that it becomes commercially engineered and available on a widespread basis. Until that threshold is met, it would be technologically unrealistic and economically unacceptable to impose stringent greenhouse gas emissions caps that require the widespread installation of carbon capture equipment.

The electric power industry faces many difficult technical and regulatory challenges for achieving widespread commercial deployment of CCS technologies. 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; and the standards for long-term stewardship are uncertain. While industrial insurance companies may be willing to write insurance policies for operational and post-closure periods of CO_2 storage, such insurance coverage is not readily available following active site management. In response to this potential insurance gap, AEP has been actively working to solve these and other potential barriers to CCS deployment and applauds the recent legislative efforts of many within Congress, including the members of this committee in the House and Senator Bingaman, just to name a few.

Conclusion

AEP has made a commitment to demonstrate and deploy new generating and emission reduction technologies. The goal of our Mountaineer project is to demonstrate the effectiveness of the CCS technology in an incremental set of first-of-a-kind commercial projects. However, AEP and its partners in the utility industry cannot do this on our own. We need the financial and policy support of Congress and the nation. Widespread deployment also requires that a host of other important issues be resolved. Only when these technologies have been commercially demonstrated, will commercial orders be placed on a widespread basis to implement CCS at coal-fueled power plants. With your support and our commitment, we believe this can be accomplished so that large scale retrofit applications can begin in 2020.

In the end, the only sure path to stabilizing GHG concentrations over the long term is through the development and utilization of advanced generation and CCS 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 achieve the best outcome at the most reasonable cost and timelines possible. Thank you again for this opportunity to share these views with you.

I will be happy to answer any questions that you may have.

The CHAIRMAN. All right. Thank you very much.

And our next witness is Mr. Sean Gallagher. He is the vice president of marketing and regulatory affairs for Tessera Solar, the solar development company of Stirling Energy Systems.

We welcome you, sir.

STATEMENT OF SEAN GALLAGHER

Mr. GALLAGHER. Well, thank you very much, Chairman Markey, Ranking Member Sensenbrenner, and members of the committee.

I am Sean Gallagher, vice president of market strategy and regulatory affairs for both Tessera Solar and Stirling Energy Systems. Tessera Solar is based in Houston, Texas, and Stirling based in Scottsdale, Arizona. We very much appreciate the leadership that you and your colleagues have shone on renewable energy this year. And we will work with you to see that that continues.

It is a great pleasure to have an opportunity to address you today about solar power and our concentrating solar power technology in particular.

My companies, Tessera Solar and Stirling Energy Systems, are within the NTR family of companies. NTR is an Irish renewable energy development company which owns a portfolio of primarily U.S.-based businesses, including an ethanol company based in Omaha, Nebraska, called Great Plains Renewable Energy; the wind energy company mentioned earlier, called Wind Capital Group, that is based in St. Louis, Missouri; and a recycling business with operations in Ireland, the U.K., and the U.S.

In May 2008, NTR invested $100 million in solar power manufacturer Stirling Energies Systems and created Tessera Solar as the project development arm of the business. So the two companies that I represent, Tessera Solar and Stirling Energy, are sister companies. Stirling Energy manufactures the sun-power solar-powered generated—SunCatcher solar power generating system that I will describe in a moment, and Tessera Solar will build, own, and operate the solar farms that are powered by the SunCatcher.

Solar power comes in two basic flavors. Many people are familiar with photovoltaic panels, which use an electrochemical process to convert sunlight into electricity. And that is not what we do.

Concentrating solar power, which is sometimes called solar thermal electric, uses the heat from the sun to create mechanical energy that is then converted into electrical energy or electricity. And there are a number of CSP technologies which are coming onto the U.S. market now. The SunCatcher, which is our product, is one of those, and it is a form of concentrating solar power.

The system, which you can see both on the screens on the sides of the room and on the board over here is essentially a large parabolic mirrored dish. It is about 38 feet across. The sun's rays are reflected off the dish and focused onto the heat engine that sits out at the end of the boom that you see there. That collected heat from the sun gets up to about 1,300 degrees when it the enters the front of that heat engine. And that is called a Stirling engine.

A Stirling engine is essentially an external heat engine. Any form of external heat can be used to operate the engine. In this case, it is the heat from the sun that is collected by the parabolic mirror dish that heats a hydrogen gas and pushes a four cylinder engine about the size of a motorcycle engine that is housed on the top of that boom. That four cylinder engine turns a crank shaft which turns a generator which generates 25 kilowatts of electricity right on top of each dish. So, in California, that is about 15 to 20 average homes on a peak summer afternoon that can be run from the power that is generated by each of these dishes.

There are a number of advantages to this technology. It has the highest solar-to-grid electric efficiency, which means that fewer raw materials are used. Its modular design allows greater flexibility in project size, less land disturbance, and higher on-sun availability because there is no single point of failure. Third, this technology uses far less water than any other concentrating solar power system. Up to a thousand times less than some comparable systems. And of course, it does not emit any greenhouse gas emissions or other hazardous byproducts. And because we are building at utility scales of hundreds of thousands of megawatts, many tons of greenhouse gases are avoided.

The supply chain for this technology is automotive. Our supply chain partners are primarily based in the upper Midwest. And they will be converting existing automotive capacity to produce solar power components at a commercial scale, putting auto workers back to work. When we get into commercial volume production, we will be creating up to 4,000 jobs across the supply chain.

Beginning next year, in 2010, Tessera Solar plans to break ground on two of the world's largest solar farms in southern California. These projects will produce up to 1,750 megawatts of clean power. They will create 300 to 700 construction jobs as they are being built, and on the order of a hundred permanent jobs, operations and maintenance jobs. We will also be building the first concentrating solar power plant in Texas. And we are developing a supply chain—I am sorry, a project pipeline both domestically and internationally. So we will be creating jobs in the U.S. for export.

There are a few things that the Congress can do to help bring this technology to fruition. First of all, the Department of Energy has got to get the loan guarantee rules out. It has been 6 months already since the stimulus package was passed, and we still don't have the loan guarantee materials. Congress should consider extending the commenced construction deadline for receiving the grant in lieu of ITC by a year in recognition of the fact that the loan guarantee has been delayed thus far. The two programs really work together. If you can't get the loan guarantee, you can't get into construction to get the grant.

We will also need transmission to bring this power that is produced primarily in the U.S. Southwest to the rest of the western United States and across the country.

It is a great pleasure to have an opportunity to address you here today, and I will be happy to answer any questions. Thank you.

[The statement of Mr. Gallagher follows:]

Testimony of Sean Gallagher

Vice President of Marketing and Regulatory Affairs, Tessera Solar

Before the House Select Committee on Energy Independence and Global Warming

July 28, 2009

Introduction:

Thank you, Chairman Markey, Ranking Member Sensenbrenner, Members of the Committee. I am Sean Gallagher, Vice President of Marketing and Regulatory Affairs for Tessera Solar. It is a pleasure to share some insights with the Committee about our technology and our quest to bring that technology to utility-scale commercial development.

Tessera Solar, headquartered in Houston, Texas, was formed to be the exclusive developer and operator of the SunCatcher™ Power System developed by our sister company, Stirling Energy Systems, headquartered in Scottsdale, Arizona. In May 2008, the NTR, an Irish renewable energy development company, invested $100 million into Stirling Energy Systems, and created Tessera Solar as the project development arm of the business.

Technology:

Concentrating Solar Power (CSP) is emerging as one of the most promising sources of zero greenhouse gas emission renewable energy for the 21st Century. Enough solar energy falls on the earth's surface in one hour to meet the world's energy needs for one year. However, the technological challenge is to harness that energy and deliver it to customers in a cost-effective manner.

Solar electric technologies come in two basic flavors: photovoltaic and solar thermal electric or CSP. Photovoltaic systems like those you find on residential and commercial rooftops use an electrochemical process to convert sunlight directly into electricity. CSP systems use heat from the sun to create mechanical energy, which is converted into electricity. Our system is a species of CSP.

Stirling Energy Systems developed the SunCatcher™ Power System in cooperation with the Sandia National Laboratories. The SunCatcher™ system is a 25-kilowatt-electric (kWe) solar dish Stirling system that automatically tracks the sun in order to collect and focus solar energy on the power conversion unit, which generates grid quality electricity. The system consists of a parabolic dish structure that supports an array of curved glass mirrors, which concentrates the solar energy on to the power conversion unit. A power conversion unit is mounted on a boom at the focal point of the dish, where the sun's rays are concentrated. Power is generated by a closed-loop, high-efficiency four-cylinder reciprocating Solar Stirling Engine. Heat from the sun is concentrated onto the front end of the engine, which reaches temperatures of 1300 degrees Fahrenheit. The heat causes the internal working fluid to expand and power the pistons in the four-cylinder Stirling Engine. The pistons are attached to a crankshaft, which turns a generator. Each dish-engine system produces 25 kW of power, enough to power approximately 15-20 average California households on a hot summer afternoon. No water is used for cooling.

Technology Benefits & Advantages

The system's design has some significant advantages and benefits that will help to make solar thermal technology a reliable, cost effective and environmentally sustainable option for utilities.

- First, the SunCatcher™ Power System has the highest solar-to-grid electric efficiency, 31.25%. This efficiency means that the SunCatcher system has lower raw material use than other solar power technologies
- Second, the modular design allows for minimal land disturbance, higher terrain flexibility, and highest on-sun availability since there is no single point of failure. The modular system can also be built to the scale required by a particular community.
- Third, the technology uses far less water than peer technologies. Water-cooled parabolic trough plants producing 500 megawatts of electricity require over 3,000 acre-feet of water per year, and even air-cooled solar tower systems require 125 acre-feet per year. The SunCatcher™ system requires only 22 acre-feet of water per year—and only uses water to wash the mirrors. For the arid Southwest, where solar resources are most abundant, this is a significant advantage.
- And finally, it is an environmentally friendly technology that produces no greenhouse gas emissions, or other combustion byproducts. The system also contains no hazardous heat transfer fluids.

These advantages enable Tessera Solar to offer peak power output at very competitive prices. The SunCatcher is among the lowest cost solar power options available.

The SunCatcher™ system is a result of over a decade of innovative engineering and validation testing with hundreds of thousands of hours of on-sun testing on each major subsystem, and over 50,000 hours of on-sun testing for the complete system.

Over the years, companies like Ford Motor Company, McDonnell-Douglas, Boeing, and Southern California Edison have all worked to improve the design of the Stirling Dish Engine. In 1996, Stirling Energy Systems bought the earlier designs and worked in collaboration with the Sandia National Laboratories to create a system that is now ready to be manufactured and deployed in world-scale power plants.

Job Creation

Our technology's past is in America and we believe its future should be here too. Because this technology uses steel, glass, and engines, the supply chain is automotive. We are partnering with Tier 1 automotive suppliers to manufacture SunCatcher™ components. The company that will make the engines manufactures engines for the U.S. carmakers. The company that will make the mirror facets makes windshields, doors, and car hoods. The American automotive industry has the skills and expertise to build this. The industry has existing manufacturing capacity that will be converted for manufacturing of solar power components. Deploying this technology on a commercial scale in the United States and across the world will create jobs in precisely those sectors and regions of the country in which America has been falling behind. As we get into volume production in 2010 we will be putting autoworkers back to work, eventually creating up to 4,000 jobs across the supply chain.

Development:

The next challenge for our company, and the United States is to begin developing breakthrough technologies like the SunCatcher™ on a commercial scale. Beginning in 2010, Tessera Solar plans to break ground on two of the world's largest solar farms in California with our partners San Diego Gas & Electric and Southern California Edison. Our Calico and the Imperial Valley projects in Southern California will create 300-700 construction and assembly jobs each. These projects will produce a combined 1,750MW of clean, renewable electricity using 64,000 SunCatcher™ units in all. We have also signed a power purchase agreement with CPS Energy to build another 27MW plant in West Texas to supply San Antonio with peak power. The Western Ranch project will be the first concentrating solar power plant in Texas.

Our California projects are in the BLM permitting process. The Imperial Valley project should have its permitting complete by next spring and will go into construction next year. The Calico project in the Southern California and the Western Ranch project on private land in Texas are also slated to begin construction next year pending the completion of all permit approvals.

Tessera Solar has two of the three projects that are farthest along in the BLM permitting process. We've established good working relationships with the BLM and appreciate their efforts to conduct a full, open, public process in a timely manner. We also recognize that BLM has been overwhelmed with renewable energy applications over the past two years. We support Congress' providing additional resources and additional direction to BLM to process these applications. We have suggested process reforms to the BLM process. For instance, increased application fees and milestone requirements on developers would address the potential for land speculation. We do not support proposals that would apply the oil & gas competitive leasing model to renewable energy applications – among other things, competitive leasing would tend to skew the playing field to companies with large balance sheets rather than companies with good projects.

Financing Challenges

The changes that have wracked the financial sector in the past year have created significant challenges for financing renewable power plants. Congress responded to these challenges by creating the Department of Energy's loan guarantee programs, and the Treasury grant in lieu of investment tax credits. These programs will be critical in the next two years for projects like ours – and others in the solar industry to obtain the financing necessary to construct projects. In order to take advantage of these incentives the Administration will need to take the following steps to allow companies like ours to move these projects forward, create jobs and generate carbon free electricity:

- Issue effective regulations for the Department of Energy section 1703 and 1705 loan guarantee programs that are consistent with commercial banking practices and successful loan guarantee programs like the Export-Import Bank of the United States and the Overseas Private Investment Corporation (OPIC), which have both been successful from a risk management perspective. Absent loan guarantees, our projects and others like them face an impossible task finding financing due to the battered credit markets, and the unwillingness of private lenders to take risks on new technologies.

- Accelerate the National Environmental Policy Act (NEPA) review process that is triggered by the Loan Guarantee application. Based on previous reviews, we estimate that the NEPA review process will take 12-18 months. The length of this process delays the length of time it takes to commence construction, and may cause us to miss important start dates to take advantage of financial incentives provided by the Recovery Act. For projects that do not otherwise trigger NEPA, a more efficient process should be applied.
- In order to qualify for grants in lieu of the investment tax credit provided in the Recovery Act our projects must commence construction by December 31, 2010. The Treasury Department has issued initial guidance for these grants. The delay of the Department of Energy's Loan Guarantee Program for renewable energy projects makes it more difficult to meet the "commence construction" date. A one-year extension of the grant program to December 31, 2011 is clearly needed.

Transmission

Transmission lines will also have to be sited and constructed to get this zero-carbon electricity to customers in Southern California's population centers, and to maximize the ability of the solar power resource in the Southwest to be delivered to customers across the west and the US. We support the transmission title in the American Clean Energy Leadership Act, which was passed out of the Senate Energy and Natural Resources Committee, and we are working through our trade association to strengthen it.

One obstacle to both renewable development and transmission development is current policy and practices that requires a renewable power developer to pay for the cost of any transmission network upgrades necessary to deliver the renewable energy to customers. In the case of our Calico project in the Southern California, the network transmission costs that would be allocated to the project are close to $400 million. Although the transmission owner pays such funds back to the developer over a five-year period, the obligation to fund the transmission upgrades in the first place puts an unreasonable burden on a renewable energy developer. The solution would require transmission owners to fund such network upgrades.

Closing

Generations of entrepreneurs and engineers have been working towards the moment when this technology can be deployed, now we need to seize the opportunity and see that it is done. Thank you Mr. Chairman.

Attachment 1

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

And our final witness is Dr. Emanuel Sachs. He is the chief technical officer and co-founder of 1366 Technologies. Dr. Sachs is a professor of mechanical engineering at the Massachusetts Institute of Technology and holds over 40 patents as inventor or co-inventor of technologies for manufacturing processes and solar cells.

We welcome you, Dr. Sachs.

STATEMENT OF EMANUEL SACHS

Mr. SACHS. Thank you, Mr. Chairman.

The challenges of global warming and energy security present extraordinary opportunities to grow new industries and to remake our industrial society in a sustainable form. Not since JFK marshaled us to go to the moon have we had such a clarion call to our young people to do well while doing good. And they have heard this call on their own.

The opportunity to energize generations of engineers, scientists, business leaders, builders, and policymakers is precious. As an engineering graduate in 1976, I was motivated to work in solar energy by the oil embargoes of the early 1970s. Fortunately, the opportunity was there. I was hired onto a DOE-funded program at a photovoltaics company, and within 2 years, I knew what I wanted to do with my career.

The term photovoltaics refers to the direct conversion of sunlight to electricity using semiconductor devices. That is with no moving parts. I will use the acronym PV for short. I returned to MIT for a Ph.D. in engineering and invented a new technology for making PV wafers called String Ribbon. String Ribbon is now the core technology of two companies. Evergreen Solar, a Nasdaq-listed U.S. company that employs approximately 1,000 people at its R&D facilities and manufacturing plant in Massachusetts, is one of them. But along the way, from lab to public company, much time was lost due to a lack of resources. In fact, String Ribbon lay fallow for 8 years, beginning in 1986, when oil prices dropped precipitously and PV funding essentially dried up.

On September 12th, 2001, I turned my MIT research program fully to renewable energy. This was my personal response to the events of 9/11. My students, staff, and I created three new technologies in PV. In 2007, I co-founded 1366 Technologies to take these inventions from the lab at MIT into industry. We are now 25 people working to change the energy landscape, and we are one of 150 solar startups in the U.S.

This chart captures some of the history of PV and the rationale behind our company. It is centered on wafer-based silicon PV, which accounts for approximately 90 percent of products sold. The chart shows the cost of electricity from PV graphed against the cumulative production of PV modules. It covers the period from 1978, when solar cells were used in space, through today, and then projects forward to 2020. What we see is a steady decline in manufacturing costs with production. This is a classic learning curve of the type that characterizes most manufacturing enterprises. The cost reductions are achieved in part by economy of scale. But in PV, the major contribution is a succession of technological advances which act cumulatively to reduce costs dramatically. This situation is similar to the sequence of developments that has kept silicon the dominant material in microelectronics for over 30 years.

While PV is already economical in some markets without subsidy, in a few years unsubsidized costs will drop sufficiently below the price of electricity from natural gas so that we will enter the region of grid parity, while still allowing for sufficient profit to sustain growth. Continuation of the current 35 percent annual growth rate through 2020 will get us to parity with coal. At that time, PV will satisfy 7 percent of the global demand for electricity. Storage technology to compensate for intermittency will become necessary by 2025. Once this storage problem is solved, PV will become the largest manufacturing industry in history.

PV modules are simple, attractive products with proven field reliability, and they are made mostly from sand. The challenge is to bring the costs down. Our aim at 1366 is to contribute key innovations in the march of PV to grid parity. For example, today the highest cost step is manufacturing the silicon wafers that solar cells are built on. Cast blocks of silicon 6 inches wide and 12 inches long are sawn into the wafers that cells are made of. The sawing is a slow and expensive process. The worst part is that only half the brick ends up as usable wafers, and the other half of the brick is turned into dust by the sawing process. And it is unreclaimable dust because it is thoroughly contaminated.

At 1366, we have a new process for directly producing high-quality silicon wafers with no sawing and no surface treatment required. This single step can save 30 percent of making the costs of a PV module.

From my experience, the biggest issue facing the rise of PV as a global energy source is consistency in funding and in the economic landscape. For example, after a few strong years, the venture capital community has drastically cut back on funding for PV. The current credit crunch makes it difficult to finance the multimegawatt installations that are central to the future of PV. Federal funding for R&D has been up one decade, down for two, and is now beginning to recover. If you will pardon me, what I can say is that the up-and-down Federal funding cycle has enjoyed strong bipartisan support.

Finally, Mr. Chairman, you asked for thoughts on policy. I am not a policy expert or even amateur, but I note that changes in energy infrastructure take decades, and I can suppose that a primary goal of effective policy should be to smooth out the wild fluctuations which have plagued the development of PV. It would be helpful to provide more support when fossil fuel prices are relatively low and allow the private sector to carry more of the weight when they are high. This proposal is the exact opposite of the natural tendency. Thank you for your attention.

[The statement of Mr. Sachs follows:]

Testimony to Select Committee on Energy Independence and Global Warming
U.S. House of Representatives
July 28, 2009

Prof. Emanuel Sachs
Chief Technology Officer
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Lexington, MA
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The challenges of global warming and energy security present extraordinary opportunities to grow new industries and to remake our industrial society in a sustainable form. Not since JFK marshaled us go to the moon have we had such a clarion call to our young people to do well while doing good and they have heard this call on their own. The opportunity to energize generations of engineers, scientists, business leaders, builders, and policy makers is precious.

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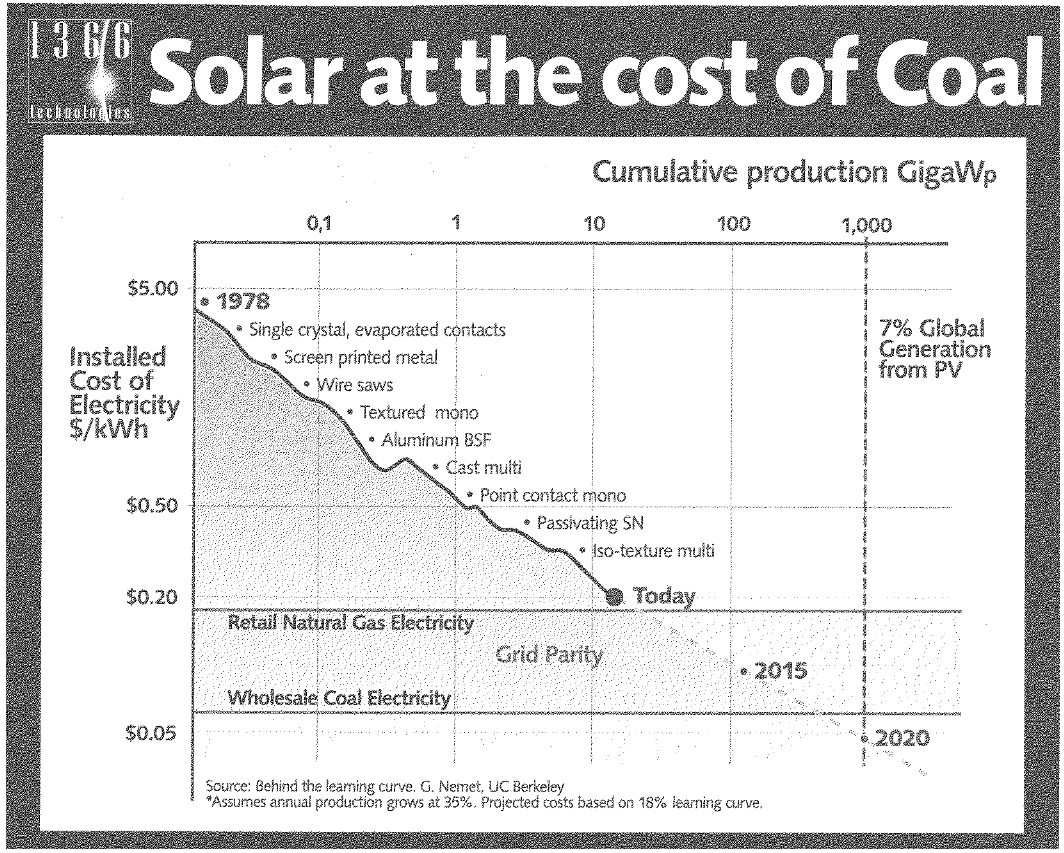
Thank you for your attention.


1366 technologies
Solar at the cost of Coal
Cumulative production GigaWp
0,1
1
10
100
1,000
Installed Cost of Electricity $/kWh
$5.00
$0.50
$0.20
$0.05
1978
Single crystal, evaporated contacts
Screen printed metal
Wire saws
Textured mono
Aluminum BSF
Cast multi
Point contact mono
Passivating SN
Iso-texture multi
Today
Retail Natural Gas Electricity
Grid Parity
2015
Wholesale Coal Electricity
2020
7% Global Generation from PV
Source: Behind the learning curve. G. Nemet, UC Berkeley
*Assumes annual production grows at 35%. Projected costs based on 18% learning curve.

The CHAIRMAN. Thank you, Dr. Sachs, very much.

Now we will turn to our questions from the Select Committee members.

And the Chair will recognize himself.

Mr. Spitznogle, you said I think that you did not believe that there would be a commercially viable carbon capture and sequestration technology until at least 2020. Is that correct?

Mr. SPITZNOGLE. Mr. Chairman, I believe that is the case when we will be able to have wide deployment of these technologies with commercial guarantees. In my opening statement, I mentioned that 2015 would be the first time we start to see deployment at commercial scale with technologies that do not necessarily come with guarantees. So from that time period to 2020 is the time we see that those first installations are proven and process changes are made to make them reliable and they can be deployed widely.

The CHAIRMAN. Thank you.

Mr. Smith, do you agree with that, that we will have to wait until 2020 to have a truly commercially viable technology?

Mr. SMITH. Well, our plant is scheduled to go into production in 2014, 2015. The technologies are known and proven. They are not—it is not a retrofit. And perhaps my colleague to the right is talking about retrofit technologies. So maybe those have some different problems. But our plant is scheduled to go into production in 2014, 2015. It is commercially viable. It is ready to go.

The CHAIRMAN. Do you agree with that, Dr. Kunkel? Where are you in the Spitznogle-Smith spectrum?

Mr. KUNKEL. Well, I think there is—we, obviously, have a couple of projects that are commercial scale that we are advancing. And those are among, you know, a small group of pioneering projects. And those projects, we will learn a lot from those. I think that is the first step, is to get that group of projects on the ground. And then there will be significant improvements.

So, after 2015, there will be significant improvements all the way down the value chain, from engineering to the equipment manufacturers and so on. So we do need—I think that the pioneering plants, the pioneering efforts are the object in front of us now. But we can build commercial-scale facilities now, both gasification and post-combustion.

The CHAIRMAN. Now, let me come back to you, Dr. Sachs. You I think said that the manufacture of solar technologies will become the largest single manufacturing sector, I think you said, in the history of the world.

Mr. SACHS. Yes.

The CHAIRMAN. Can you expand upon that?

Mr. SACHS. Sure.

So what the production level that we will reach in 2020 is roughly a terawatt a year. And we will have to get to quite a larger production level of several terawatts a year in order to satisfy global demand. The price of photovoltaics at that point fully installed will be on the order roughly of $1.50 a watt. So we are talking about trillions of dollars in total revenue.

The CHAIRMAN. And the year that you picked for the point at which solar reaches equivalency with coal in the cost to generate electricity is 2020 on your chart?

Mr. SACHS. Yes, and that is a continuation of the 18 percent learning curve that photovoltaics has been on since the mid-1970s. So the part of the curve that you saw from 1978 to today is real data. And then the dotted line is a projection with the same slope, the same learning curve.

The CHAIRMAN. So you are saying that the same rule that exists, Moore's law that exists in terms of the power of computer processing, exists over here as well?

Mr. SACHS. It is not exactly Moore's law, but it is somewhat, somewhat analogous. So technologically that powers Moore's law is the accumulation of innovations in a processing of microelectronics. So no one company has to invent the entire processing sequence, but rather they build on the shoulders of people who came before them. And that is exactly what is happening in photovoltaics.

The CHAIRMAN. Do you agree with that, Mr. Gallagher?

Mr. GALLAGHER. Mr. Markey, in principle, I do. In the concentrating solar power industry, we think we have a similar cost-down curve that will enable us—actually, for the concentrating solar power technologies, the efficiency of solar radiation to good quality electricity is quite a bit higher than PV. And so we think that we are pretty close to the point where we are competitive with, for example, retail power prices in California already; and we think that as we get into volume production, we will see costs continue to come down through economies of scale, through exercising the supply chain to find the right supply chain partners, and through improvements in the technology as we go forward.

The CHAIRMAN. Thank you, Mr. Gallagher.

The Chair recognizes the gentlelady from West Virginia, Mrs. Capito.

Mrs. CAPITO. Thank you. I thank the witnesses as well.

Let me just make sure. I am little—not confused; I am looking for clarity here. Because I see some of the stumbling blocks to CCS cost, but some witnesses have testified, I think that—well, somebody said we need to have the loan guarantees, that is absolutely critical. We need to have the DOE come in with specialized project money. I am assuming that all the technologies still need this kind of financial impetus to get us to the—let's say, 2020 or 2015 where it will be commercially viable.

Across the witnesses who talked about the coal, would that be pretty accurate in your—is there going to be a point where you don't need loan guarantees and other financial impetus to move this technology and make it, I don't know, revenue neutral to the government?

Mr. SMITH. From my point of view, if it weren't for the financial crisis, I think that would get less emphasis. Essentially, when you do a large power plant, you know, you are talking about billions of dollars. And the problem is that you are going to—when you talk about a first mover, you run into the problem of bankers and their sense of risk and things like that.

If—in a more robust economy, prior to the problems we had last fall, their fear of loss is compensated by their greed, and you can get these things done. But fear is more a dominant emotionality in the financial communities, and so it becomes more difficult. It is particularly true with first movers. Even if all the technologies are proven and you are bolting pieces together, if they haven't seen it before, there is a concern.

So in terms of funding this long term, absolutely. The U.S. economy will fund this. We are talking about how-to-get-started problems from my point of view.

Mrs. CAPITO. Anybody else?

Mr. KUNKEL. I would just say that removing carbon dioxide from power plants costs money, and we know that. You know, using the oil industry, we can get paid for the carbon dioxide so that helps, obviously, and that is pretty much undeniable.

The initial projects are probably going to be more expensive than later projects because we will learn a lot. And so we hope to bring down the costs. But, still, if society doesn't value emissions reductions, then this probably doesn't make sense.

If society does value remission reductions, then it does make sense.

Mrs. CAPITO. Thank you.

Mr. SPITZNOGLE. I guess what I can add to the comments on the concern about risk is, put in perspective the fact that AEP has obligations to its rate payers and its shareholders to make good decisions and mitigate that risk as much as possible.

So when you look at these technologies, the first movers are truly the ones stepping forward and taking that initial risk. That is the case even with what we are doing down at our Mountaineer plant at 20 megawatts. We have asked the rate payers and shareholders to understand the need to do this, and they do. But there, again, it is a fairly small-scale step-out.

Mrs. CAPITO. Well, understanding that a lot of times the rate changes go through the State, in our case, public service commission, those are tough things to get through. I know you have been through a couple here most recently.

Let me ask—another question that is kind of a thread I heard through the CCS is the amount of energy it costs to reduce the carbon emission, like, I think one of them was 25 percent of the power used in the separation from—I guess separating the carbon. I guess, as we are looking at we are going to have more energy appetite as we move towards this—I mean, I am thinking to myself, how are we going to do this? We are going to increase our solar, which is going to help fill in some of the gaps because we are going to lose energy as we try to cut down our emissions from the coal power plant.

Do you think this is something that is scientifically or technologically that we can keep squeezing down how much energy it takes to capture and sequester the carbon?

Mr. SPITZNOGLE. That would be AEP's engineering judgment, that we are starting at fairly high levels, like you said, 25, 30 percent at the parasitic—25, 30 percent of the output of the plant to run these technologies. And we believe, just like the evolution of what FGDs, through the 1970s, 1980s, and 1990s, and SGRs maybe a little bit more compressed, but there is going to be a little bit of a growth period there where we will be under tight constraints for energy, and that developers with these types incentives will come up with technologies that are more efficient.

So we are optimistic that that can happen, and that chilled ammonia is one of those examples that we see a step-wise improvement.

Mrs. CAPITO. Thank you. My time is up. Thank you.

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

Mr. HALL. Thank you, Mr. Chairman. And thank you to our witnesses.

Mr. Gallagher, I was struck by your testimony about your supply chain specifically, and I would quote, "Because this technology uses steel, glass, and engines, the supply chain is automotive. We are partnering with Tier 1 automotive suppliers to manufacture SunCatcher components, the company that will make the engine manufacturers engines for the U.S. car makers. The company that will make the mirror facets makes windshields, doors, and car hoods. The American automobile industry has the skills and expertise to build this. The industry has existing manufacturing capacity that will be converted for manufacturing of solar power components. "Deploying this technology on a commercial scale in the United States and across the world will create jobs in precisely those sectors and regions of the country in which America has been falling behind. As we get into volume production in 2010, we will be putting auto workers back to work, eventually creating up to 4,000 jobs across the supply chain."

Very exciting news, particularly given the current state of the auto industry. Can you elaborate on this, more details about it?

Mr. GALLAGHER. Certainly. Thank you, Mr. Hall.

This technology—this technology essentially is—it is engines, and the U.S. automotive industry certainly knows how to make engines.

In fact, in 2007, the U.S. auto industry manufactured about 17 million cars; this year, it is going to manufacture about 9 million cars. There is a lot of slack capacity in the U.S. auto industry at this time, and so it is a good time for a company like ours to be going to the auto industry and bringing them new business.

Our supply chain partners are very excited to diversify their businesses away from auto parts and into energy. The auto industry knows how to make products at high volumes with high reliability, and to drive down costs with continuous improvements in the manufacturing process. So we are excited about using that industry and that supply chain to produce solar power at a continuously decreasing cost.

Mr. HALL. Thank you.

You also noticed that your technology was developed in collaboration with Sandia National Laboratories. Some critics of Federal policy have said that investments in R&D do not create jobs. I assume you would disagree with that?

Mr. GALLAGHER. We think we are a pretty good model of the public-private partnership. We have had a long relationship with Sandia. We have received some funding from the Department of Energy to commercialize this technology. In fact, the pictures that you saw earlier of new SunCatcher systems are at Sandia National Labs. That is where the technology has been refined and much of the commercialization process has taken place.

So we are very appreciative of the support we have gotten from the government, and will be bringing that into commercial production next year.

Mr. HALL. Thank you. And I assume that we are talking about CCS, for instance, we are talking about pilot projects on various scales in various locations with your different companies.

But all of you on this panel have stressed the need for loan guarantees for stable requirements for carbon emissions levels, and for Federal investment to continue.

I would assume that none disagree that there are jobs created by those investments?

Mr. GALLAGHER. We certainly think so.

Mr. HALL. If there is somebody that disagrees, please raise your hand or speak up. It may not be on the scale that you will be at once you get into pilot stage and into building a full-scale sequestration project that can match a 1,000 megawatt or greater power plant. I am sure that is obvious; but nonetheless, there are jobs created.

Mr. Smith, I am curious, if you are generating hydrogen, why not burn it and spin the turbine and put power back into the grid and have water be the effluent?

Mr. SMITH. We do, actually. The trick is—the question is this; and it goes to this earlier question of what is the cost of carbon capture:

When you make hydrogen, there are some costs of making it. You have to use electricity to create in the chemical process. And that is sometimes referred to as the parasitic.

Mr. HALL. Unless the energy comes from a removal that is free.

Mr. SMITH. Well, yes. But from someplace it comes, wherever it is.

The issue is this: If you try to assign all of those costs of making this hydrogen to the electricity generation, you end up with parasitics that look like 25 or 30 percent. If you say, no, no, I have to spend some of that energy to make hydrogen, then what you can do is say, oh, I can do these other things with hydrogen.

What our plant does is make electricity when electricity demand is high, and it makes—and prices are good. And it makes urea when prices are low. As it turns out, that is a good thing from a carbon footprint point of view and from a national policy point of view. The urea comes from—presently is largely manufactured from natural gas. In this case, it will be manufactured from coal.

Mr. HALL. And you get paid for it?

Mr. SMITH. And we get paid—I get paid for it, yes. And you are talking prices which are better than the prices for electricity at 2 in the morning. We have more capacity for generating electricity at 2 in the morning than we need, so you turn my plant to making urea. And in that case, if you looked at the parasitic, we think that the amount of energy required to capture and compress the CO_2 is 10 percent, not 30.

Mr. HALL. Thank you, Mr. Chairman.

The CHAIRMAN. The gentleman's time has expired.

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

Mrs. BLACKBURN. Thank you, Mr. Chairman. And, again, thank you to our witnesses.

Mr. Smith, I appreciated your statement in your testimony where you said the new technology was the business model and the way you all approached your situation, and that that is why we shouldn't choose winners and losers. And I agree. I think that that is something that is important for us, to allow you all to be innovators, and for us not to sit here and try to choose winners and losers and decide what is and is not going to—to have the opportunity to see if something actually works.

Dr. Sachs' chart about how long he has worked on the cell is a great example of this. I guess what we have to do is figure out what we are going to do with all that dust that you have left over in those bottles.

Mr. Smith, a couple of questions for you about PurGen and your technology.

Do you have any long-term liability concerns about sequestering the CO_2 under water? And the reason I ask this is because, part of my district is Memphis, and we have the New Madrid Falls in the Mississippi River. And we have read some studies that sequestering the CO_2 underground may lead to some tremors. And that is something we are very sensitive to in our region of the country, so I would just like to know if you had any long-term liability concerns on sequestration.

Mr. SMITH. Well, as it turns out, if you tried to describe a perfect geology for storing carbon dioxide, you would describe the site that we are proposing. It is—and I have to be a little careful because I am on the edge of starting to speak geological speak, and I am not that good on it.

But it is on a passive margin. It is tectonically inactive.

Mrs. BLACKBURN. So you feel that is something manageable?

Mr. SMITH. I think it is something that has proven to be manageable.

Mrs. BLACKBURN. All right. I appreciate that. Let me move on with a reminder of the time that I have.

Dr. Kunkel, who owns the patents for the CCS technology that you are currently using? Do you all own them? Or individuals?

Mr. KUNKEL. No. Actually—well, there is a whole variety of companies involved in this space. As the developer of projects, we are really open to a whole variety of technologies, and in fact, we have looked at most of the technologies being discussed here today for different projects.

And we have solar going in on rooftops in development. So we are developers. We will use any technology that is out there. We do have a small investment in a company called Powerspan that has new technology for carbon capture that we think is very favorable in terms of reducing the energy requirement, but generally we look at a wide variety.

Mrs. BLACKBURN. Thank you for that.

And I have got a couple of questions on rate payer bills, but I am so close on time, I will probably submit those to you. Because, as Mrs. Capito said, I think we are all sensitive to what would happen with the rates and how this would affect the rate payer. So I will submit those to you.

Mrs. BLACKBURN. Mr. Gallagher, I do have a question for you. Your SunCatcher project you said is in California and Texas, and I wanted to know if you had any plans for solar plants in the Southeast, and if you see this as a technology that would be viable for our area of the country.

It sounds like you work off of heat units, not off of rays. And of course, this year, I was reading an article when you were talking about that, and it looks like our west Tennessee cotton, it needs 28 heat units a day to germinate properly, but it only got 16 to 17 units per day this month.

So is SunCatcher looking at anything in the Southeast?

Mr. GALLAGHER. Well, the form of solar energy that concentrating solar power uses is called direct normal insulation, and that form of insulation is the best in the U.S. Southwest. So I think in the next several years what you will see are projects built by our company, and others like ours, in the U.S. Southwest.

The sun, or the insulation, in the Southeast is significantly less than in the Southwest, or the form of radiation that this technology needs. I think there is some potential if we move down the cost curve the way we think that we can to think about doing projects in the Southeast.

But I think the other way to bring solar power to the Southeast is to expand our transmission system, our national transmission system.

Mrs. BLACKBURN. So, basically what you have works for one region of the country, but not the whole country?

Mr. GALLAGHER. At this time, that is accurate.

Mrs. BLACKBURN. That is a fair statement. Thank you, sir.

I yield back.

The CHAIRMAN. The gentlelady's time has expired.

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

Mr. CLEAVER. Thank you, Mr. Chairman.

The algae-based biofuels are getting a lot of attention from some of the major companies like Exxon. And in Kansas City, Missouri, in the district that I serve, Midwest Research Institute has a pilot scale algae production facility.

And I am just wondering whether or not any of you see a commercial potential for algae biofuels. And, if so, what are the obstacles that are in the way? What can we do to make it more possible?

Anyone?

Mr. SACHS. I am not an expert on algae biofuels, but I will observe that that is another way to collect solar energy. So that is essentially what that is doing. Algae is attracted because it is 3 to 5 percent efficient in photosynthesis versus a 0.5 percent efficient for green plants.

And the point I want to make is that there are a number of ways of collecting solar energy that are under investigation, that are at different points in their development. You have heard about two: concentrating solar power and flat panels, flat-panel photovoltaics.

There is also solar thermal electric, where solar energy is turned into heat, which is then turned into electricity, or the heat is stored to turn into electricity a few hours later. And algae is in that class.

So as someone who works in renewable energy, I foresee a portfolio of solutions, even though I am here to represent photovoltaics.

Mr. CLEAVER. Mr. Gallagher.

Mr. GALLAGHER. Well, I would say only that my company, as I mentioned, is owned by the Irish infrastructure company, NTR. They also own an ethanol company in Omaha called Great Plains Renewable Energy.

Great Plains has recently made an investment in algae. So there is a lot of interest in algae as a form of renewable energy production; most of it is in the R&D stage at this point. And, frankly, I can't speak intelligently as to the time frame for bringing it into commercial production.

Mr. CLEAVER. Anyone.

Dr. Kunkel.

Mr. KUNKEL. It is not something we are invested in, although we have been approached from CO_2. We are going to be a carbon dioxide producer and capture that for people, and the algae people are interested in that. So there could be an interesting synergy between these capture technologies and the algae industry.

Of course, the brilliant thing that algae do is, they make a liquid that could be used as a liquid fuel, which is what we are short on.

Mr. CLEAVER. So it is too new to even have a good picture of what it might become. Is that kind of where everybody's coming from?

Mr. SACHS. Well, just to make the comparison between capturing solar energy through algae and photovoltaics; photovoltaics has a long history of deployment in the field and algae does not.

Mr. CLEAVER. Well, since you are at the microphone, Professor, you mentioned in your testimony that some of the hurdles to large-scale use of solar technology are storage and transmission lines to get the newly generated power to the grid.

What are the possibilities that are currently being explored to do this?

Mr. SACHS. Well, first of all, I think the most important thing is to point out that those issues don't come into play for almost two decades, because what happens now is, for example, photovoltaics—the power from photovoltaics overlaps very well with air conditioning loads, and so it displaces the natural gas peakers, the plants that are fired up to deal with that peak; and those are very high-cost plants. And so that is one of the reasons that photovoltaics is so close to entering that zone of grid parity. So that can accommodate up to about 15 percent, by most estimates, of electricity demand in the U.S. without storing. And that—we are nowhere near that. So there is a lot of growth potential, but we need to start work on storage technologies because it is a difficult proposition.

One of the attractive ones solves a few problems at the same time, and that is plug-in hybrid vehicles which are charged during the day when photovoltaics are working. And so it is a kind of distributed storage, and it also obviously displaces some part of our consumption of oil.

The other point is that photovoltaics has the merit of being very well distributed. So it can be done in large power plants, but it can also be done in amounts as small as home rooftops. And it can be deployed anywhere in the country. Of course, the yield will be less in the Northeast than in the Southwest, but you don't need the collimated light. You can have cloud scatter and still get response from flat panels.

Mr. CLEAVER. Thank you.

My time has concluded. Thank you, Mr. Chairman.

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

Mr. INSLEE. Thank you. First I thank you for being here; you are the angels descended from heaven just at the right moment. So thanks for you and your whole team's work on this.

Dr. Sachs, I missed something you said about the relative efficiency of photovoltaics or concentrated solar and photosynthetic processes. And I think there is an interesting competition between in our transportation policy having electricity run our cars or a photosynthetic process through biofuels.

Is there any sort of master way to look at these two approaches? Does one have any intrinsic ultimate greater efficiency?

Mr. SACHS. Well, the thermodynamic limit of efficiency for photovoltaics is actually over 80 percent; that is, conversion of sunlight to electricity. The type of multijunction cells that are used on—up to now up, to recently, primarily on satellites but also now on concentrated ground-based applications have demonstrated 40 percent efficiencies. Those are quite expensive, and the majority of product is in the 15 to 20 percent range.

So whether there is a thermodynamic limit to the efficiency of a biological process, I am sure there is, but I don't know what it is. I know that the most efficient green plants are about a half percent efficient. And, as I mentioned, algae is three to five. So photovoltaics is, even at 15 percent, very considerably ahead.

And the other aspect is that photovoltaics actually works as well or better in the winter. So cold weather, the efficiency of the cells actually goes up slightly. Of course, you have less sunlight. But it would be hard to grow green plants during that same season.

Mr. INSLEE. Thank you. One of you made reference to the need to extend the construction deadline, and I missed what that reference was to. Was that Mr. Gallagher? Can you tell me what you were referring to?

Mr. GALLAGHER. Certainly. In the Recovery Act that was passed this year, in order to obtain the grant in lieu of the investment tax credit for renewable energy, the project must get into construction by the end of 2010. Right now, as some of the witnesses have mentioned, the financing environment is quite challenging for projects, generally for renewable projects in particular, and for technologies that are first being commercialized even more so.

So when our finance guys are talking to the banks right now, they are finding that the banks are not prepared to loan us money for the period of time that we need or at the interest rates that we need.

So I think you will see over the next year or two the renewable energy in general and the solar industry in particular placing quite a lot of reliance on the Department of Energy's loan guarantee program. But that loan guarantee program takes some time to work through, and we are now almost six months into the Recovery Act period and the Department of Energy hasn't managed to get out the solicitations for the next round of loan guarantees.

So we can't get into construction by the end of next year and, thus, be eligible for the grant unless we can get through the Department of Energy's loan guarantee process, which we haven't been able to start yet. So that was my point.

Mr. INSLEE. By the way, is your technology different? Or how is it different from the Infinia approach using sterling engines?

Mr. GALLAGHER. It is very similar to Infinia's, uses a somewhat different sterling engine. They use what is called a free piston engine; we use what is called a reciprocating sterling engine. But the principles are quite similar. Our dish is larger; it is a 25 kilowatt dish versus a 3 kilowatt dish. But it is, in principle, a very similar system.

Mr. INSLEE. Do any of you have any suggestions about how to accelerate our loan guarantee program? We will be talking to DOE. We do that. And I think they are making strides and I know they are focused, but do you have any suggestions on how any of us can help, how you would suggest the Department should go about this? I am looking for free input here.

Mr. GALLAGHER. Well, I can say that—we think we have been hearing all the right things from the Department of Energy, also. What we haven't seen is the regulations being issued. They have to come out with the rules that are consistent with commercial banking practices so that we can use them.

There were some problems with the 1703 program passed in the 2005 Energy Policy Act that has hard conditions that have made it hard for companies to use. We think that DOE is going in the right direction, and probably it would be useful without a conversation with OMB, which we understand has to approve the DOE's rules before they can be issued.

Mr. INSLEE. Thank you.

Dr. Constantz, could you tell us about what you consider your major challenges? This is an amazingly exciting field to those of us on the outside of it. What do you consider your biggest challenges? Are they technological or are they financial?

Mr. CONSTANTZ. At this point, they are mainly just financial. You know, as I said, we have already financed our demonstration plant at Moss Landing where we have had a pilot plant operating for about 8 months now. But there we will be capturing, I believe, about 100,000 tons of CO_2 a year. That makes about 200,000 tons of building material. So you can almost get profitable, you know, the SCM sells for $100 a ton. We are finding a lot of venues.

You know, we really need to build, say, a 50-megawatt demonstration plant, is about $120 million. And to go from—we are a venture capital-backed startup, and there is just no way we can sell equity to raise that kind of money. So we really need a significant amount. Following the first larger-scale plant, though, it has become apparent that we will be able to receive financing fairly readily.

The problem in this chasm now is, venues not only in the United States but around the world are looking back to the last 8 years and the concept—are very fixated on geologic sequestration, rather than a profitable use for the CO_2.

Mr. INSLEE. A quick question: I know the building industry can be conservative about adopting new technologies. They want to make sure things last 100 years. What are the best things you can do to achieve that confidence?

Mr. CONSTANTZ. We are in pretty good shape. We gave an AEA-accredited course at the World of Concrete, which is the largest—you know, 80,000-person meeting. My Vice President of Materials Development is the Past President of the American Concrete Institute. We have a 40,000-square-foot lab in Los Gatos doing all the tests. We are in discussions with all the major cement companies. We are doing very well on that front.

I personally hold over 70 issued patents on cement, and we are very confident about the technology. We are very confident about the carbon capture. We are achieving over 90-percent carbon capture in Moss Landing.

Mr. INSLEE. It is very exciting. I think I am the only former cement truck driver on this panel, so I really appreciate your expertise on this. Thank you very much.

The CHAIRMAN. The Chair recognizes the gentleman from New York.

Mr. HALL. Thank you, Mr. Chairman. I just had a couple of quick questions. One to——

The CHAIRMAN. I haven't recognized the gentlelady from California yet.

Ms. SPEIER. Thank you, Mr. Chairman. And thank you to the learned witnesses that we have before us today.

A couple of questions to Mr. Gallagher and Dr. Sachs. You mentioned the difficult policy framework solar energy has had to contend with over the years and the fluctuating support for funding.

What, in your mind, would represent a more permanent and longer lasting solution to these fluctuations that Congress has not yet seen fit to provide?

Mr. SACHS. If you look, I think there should be two components to the guidance for such policy. One is the one that I mentioned in my testimony. That is, to take into account what the externalities are—externalities to, say, photovoltaic development. And that is principally the price of fossil fuels.

As I mentioned, in my own experience I have seen it go from a hot field to cold field to a hot field to cold field, and these changes can take place over as little as a 1-month period of time, depending on the price of oil. So somehow policy has to compensate for that.

The other element is already in place, in policy, in some countries. For example, Germany has a feed-in tariff which has helped renewable energy greatly, not just photovoltaics but wind as well. And that feed-in tariff—that is, you get paid for every kilowatt hour of electricity fed into that grid. That feed-in tariff declines in a programmed way over time; and that lets people know—gives some stability for what is likely to happen—of course, it may be subject to change, but is likely to happen; and people can make plans accordingly.

And I think it is important for that rate of decline to take its cue from the learning curve for that industry, not to be motivated by other factors, but to recognize that industries have their own rate of decline of cost, and that learning curve has a different slope for different industries, and the preprogrammed rate of decline should be keyed to that learning curve.

Mr. GALLAGHER. I would say three quick things:

One, Congress took one terrific step last fall with the extension of the investment tax credit for 8 years, which provides some durability;

Second, Congress could enact a meaningful renewable energy standard this year as part of the bill that the House has already passed; and

Third, Congress could create a permanent clean energy bank to provide source of funding going forward.

Ms. SPEIER. Thank you.

Dr. Constantz, I was struck by your statement in which you chastised us, and probably rightfully so, for kind of picking winners and losers, which is a bugaboo of mine, where there have been tax incentives legislated exclusively for geologic sequestration, but not for alternative forms of capture and conversion.

Could you expand upon that for us?

Mr. CONSTANTZ. Yes. Actually, if you read the legislation, it is written prescriptively for a specific method of geologic sequestration. And also, you know, in discussions with DOE and the bodies, it is made very clear that the funds are already directed for geologic projects and geologic sequestration projects which, of course, are going to benefit people that build separation equipment and people that build pipelines and people that drill wells. You know, it has been very crafted, specifically. I have an analyst report that shows a $1 trillion market opportunity for the builders of carbon separation equipment, and the people that, you know, own rights to the reservoirs and are going to be pumping.

The legislation is very, very prescriptive. I can't say it more strongly.

Ms. SPEIER. So it is almost rigged, is what you are saying.

Mr. CONSTANTZ. It absolutely is. You can talk to anybody at DOE. In fact, even in the industrial use program which was recently brought out, after a lot of talking to people on Capitol Hill, they took a $1.4 billion program and said, okay, we will just take $1.3 billion and target it specifically for geologic sequestration; and then we will have this other $100 million that we will put for every other project out there, and we will call that useful.

And part of the inaccuracy is that—for example, my technology, we are making product every day, tons and tons of product. You know, as the gentleman from AEP said, they are going to be the very first people to take a single molecule from CO_2, take it through the whole process and get it into the ground. They are the leaders in that. So they are 5 years behind us, but from DOE's point of view, that is a proven technology. And we are still in the R&D stage, even though we are making product that can be used every day.

It is like the world's gone mad.

Ms. SPEIER. Dr. Constantz, could you provide me with a document that would spell that out specifically? And I would like to share it with the chairman of the committee.

Mr. CONSTANTZ. Absolutely.

Ms. SPEIER. The bill, as you know, is still working its way through the Senate; and we can fix mistakes if, in fact, this would be classified as one. But certainly having the opportunity for more institutions and companies to participate is to all of our interests. And I don't like the idea that this has been so constrained.

So I would appreciate that. Thank you.

I yield back.

Mr. CLEAVER [presiding]. Thank you. The mistake we made is—the Founders did, in creating the Senate.

I recognize the gentleman from New York.

Mr. HALL. Thank you, Mr. Chairman.

And quickly, Dr. Sachs and Mr. Gallagher, you both talked about storage issues having to do with renewables that are not around the clock or weather reliable.

And so what do you see as the leading three or what is your favorite horse in the race in terms of storing electricity from solar, wind?

Mr. GALLAGHER. Well, of course, the best storage technology that is in operation today is pumped hydro, where you have a two-pond system and you store water in the lake below and you pump it uphill at night when there is a lower power demand, and you run it downhill to create energy during the day when you need the power.

A couple of other promising technologies. A number of the concentrating solar power technologies are using molten salt for storage to store heat and generate power later in the day.

There is also a lot of interest in compressed air energy storage. Our parent company is taking a small interest in an R&D company that is working on compressed air energy storage as well.

I think storage is a very promising area. One thing that I would encourage you to think about is that storage can do basically two things for a renewable energy system or for a grid operator. It can either help reduce the costs of producing energy for the developer by allowing it to produce more energy over more hours, or it can essentially help the grid operator by providing some grid integration services, grid stability kinds of services.

Today, storage is too expensive to make it worthwhile for the developer to do it, from an economic perspective. So we should really think about the grid stability and grid integration value of storage, and think about where the storage obligation, if it is to be placed, should be placed.

Mr. HALL. Thank you.

Dr. Sachs.

Mr. SACHS. I think Dr. Gallagher had a very good list of technologies. I would add the very attractive proposition of—as I mentioned earlier, of coupling storage to a reduction in need for oil for transportation that could be by plug-in hybrids run on batteries.

There are also efforts at taking the electricity from renewables and turning them into other forms of chemical storage—batteries being electrochemical, these would be chemical forms—and then running transportation vehicles on that form.

I will also point out that a portfolio of renewables helps greatly to mitigate the swings in the availability. For example, on a seasonal basis, wind complements solar being more available in the winter, solar more available in the summer. Geothermal is particularly interesting because it has the possibility of providing some of the base load and being dispatchable power.

Mr. HALL. Thank you.

I just want to get my second question for the CCS folks on the panel, which is, are any of you now or do you know of anybody who is working on carbon capture and sequestration from gas-fired power plants?

They, too, emit carbon dioxide. They don't have anywhere near the particulate emissions of coal, and I understand that is where most of our work is going right now, because of the need to bring coal from the more polluting source of power into a cleaner realm. But right down the road from my street is a 1,000-megawatt gas-fired power plant that sits on the Iroquois pipeline in Dover Plains, New York, that is most likely going to be built.

And I am curious, what is available? And is there a discussion going on about capturing carbon from gas-fired plants as well?

Mr. KUNKEL. There is an interesting project in Mitsubishi, in Vietnam of all places, where they are looking at a 1,200-megawatt natural-gas-fired power plant and capturing the CO_2 from it and using that CO_2 in enhanced oil recovery offshore, which kind of combines a whole bunch of ideas we are talking about here.

But don't underestimate things going on in Asia.

But people are looking at that. And I think there are various issues. The biggest one, in my mind, is that the capacity factors of gas-fired plants tend to be lower than coal units; and so they are not operating all the time and so your investment is sitting idle. But as we move to a carbon-constrained world, those gas units will run more and those economics will begin to favor capture from gas units.

Mr. SMITH. I would say that the first problem in capture from gas plants is, having captured it, what do you do with it? And in your district, which—one of our plants, we built in Astoria, somewhat close to Westchester. The problem is, having captured it—there aren't any oil wells in Westchester that I know of—what do you do with carbon dioxide?

And that is a significant element in the costs.

Mr. HALL. We are building a lot of roads, though.

Mr. SMITH. That is true.

But the answer, I think, is that as you develop sequestration sites, you can then think about, oh, I have a place to put the carbon dioxide. Our plant will be next to a natural gas plant, Linden. It is Linden Station, and it sends power to Staten Island.

And that is a perfectly reasonable place to employ the same technologies that Gary was talking about in chilled ammonia capture. You capture the CO_2, and now that plant will have a way to get rid of it. Having captured it, you can do something with it. If the value of the carbon emissions is sufficiently high, it will find an economic incentive to do that. And that is the point of a cap-and-trade bill.

Mr. SPITZNOGLE. It is an interesting question you ask. I don't hear it asked very often, and I think it needs to be looked at more closely.

If you look at requiring a 90 percent capture, say, on a coal unit, that translates to about 80 percent capture needed on a combined cycle gas plant. So, yes, if you are going to require at those levels, you need significant controls on gas as well.

One of the technical challenges with capturing CO_2 from gas turbines is the amount of oxygen that flows through the system is much higher in the combustion gas from a gas-fired plant. And oxygen is an enemy of some of the capture technologies for a post-combustion. So I think there are some problems, some challenges, to be overcome in implementing capture technologies with gas. But at deep levels of required reduction on coal, you have to start looking at gas as well.

Mr. HALL. Thank you.

Thank you, Mr. Chairman.

Mr. CLEAVER. Thank you.

As we end this hearing, let me just say—make sure that you all understand that the members leaving and coming in had absolutely nothing with your testimony. The way this place operates is, there are multiple committees going on, and some are doing markups, which means voting to get something out of committee. So people are running between committees.

We appreciate your testimony. And as we consider new technologies and the role that Congress will play, I think you will find that your testimony will be quoted—sometimes out of context, but it will be quoted.

And so we appreciate very much the time that you have taken to provide us with the benefit of your august thinking.

Thank you very much. This hearing has adjourned.

[Whereupon, at 11:28 a.m., the committee was adjourned.]

THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

Dear Mr. Gallagher:
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 3 weeks. Responses may be submitted in electronic form, at aliya.brodsky@mail.house.gov. Please call with any questions or concerns.

Thank you,
Ali Brodsky

Ali Brodsky
Chief Clerk
Select Committee on Energy Independence and Global Warming
(202)225-4012
Aliya.Brodsky@mail.house.gov

1. Where are your SunCatchers manufactured? If the United States wants to enhance our energy independence, does it make sense to move from using Middle Eastern oil to using Chinese solar panels?
   a. Approximately 95% of the SunCatcher components will be manufactured in the US and Canada, largely in the upper Midwest. Sites for manufacturing and assembling some components and subcomponents are still being decided. Final assembly of the SunCatchers from the components and sub-assemblies will take place in the US at project sites in the southwest. This North American supply chain and manufacturing base will support US energy independence. We also expect to utilize our North American supply chain and manufacturing base to export generating equipment overseas to support our international development projects.
2. What is the life cycle of the SunCatcher? Are there environmental considerations that must be examined during the disposal of waste solar panels?
   a. SunCatchers are designed to operate for approximately 30 years. The machines are undergoing accelerated life-cycle testing now to validate those designs. The SunCatcher is a different technology from solar panels, and does not raise the same issues with respect to potential for hazardous waste. For projects that are on BLM land, the BLM requires financial security to be posted to ensure that the project and equipment can be

removed from the land at the end of their useful lives (or end of the lease) and the land can be reclaimed.

3. You make some recommendations for improving the permitting process. Can you extrapolate on your proposed reforms? How would increasing application fees and thus driving up the price of a project, be of benefit to solar companies? Do these hurdles primarily exist on federal lands and with BLM or do state and local regulatory bodies also pose significant challenges during the permitting process? How much (what percentage) do you suggest increasing the fees by? Won't this pose a similar burden as the competitive leasing model in that smaller companies with fewer financial resources would have a tougher time meeting these costs?
    a. Increased application fees would tend to deter speculation, thus reducing the workload for BLM and allowing a greater focus on "real" projects that are willing to pay increased application fees and meet stricter milestones for development. Deterrence of speculation through increased fees would also help to address concerns that too much BLM land may be developed for Renewable Energy.
    b. BLM has worked diligently on the permitting and environmental review process for utility scale solar projects, and Tessera Solar/SES have established a good working relationship with BLM. However, BLM has been under-resourced and we support providing greater resources to BLM to handle the workload. As a corollary, we recommend providing tighter milestones that both the BLM and the project applicants must meet in the permitting process. That is, applicants should have to meet milestones in order to keep the project "alive" in the permitting process, and BLM should similarly be required to meet permitting milestones – utilizing the enhanced resources that we recommend they be provided – to move the process toward completion.
    c. State and local permitting varies by state but can add complexity. For instance, in California BLM has entered an MOU for permitting with the California Energy Commission, which has state jurisdiction for environmental review and permitting. The CEC and BLM are working to producing a joint state (CEQA) and federal (NEPA) document. This is a worthy goal and the agencies are working well together, but it certainly adds complexity and sometimes time to work together. Additional BLM resources would be helpful.
    d. In February the solar industry made a proposal to BLM to require payment of a non-refundable $75,000 fee for parcels up to 7,500 acres, with payments of $50,000 per each

additional 0-5,000 acre block. Under the proposal, this non-refundable fee would, by

Congressional authorization, be used solely for staffing BLM solar energy staffing needs. We believe that a reasonable fee increase on this order of magnitude would enable smaller companies that have serious, shovel-ready, projects to continue to participate. A competitive leasing model could drive initial costs much higher.

4. Do you support reducing the NEPA process only for solar loan guarantee projects or would the streamlining of NEPA apply to other clean energy projects as well?
    a. We as a company and the solar industry as a whole are very supportive of NEPA, and are loathe to propose changes to NEPA that some may perceive as weakening it. That being said, there is a serious concern that applying NEPA to the Loan Guarantee process could impact the ability of otherwise shovel-ready projects to commence construction in 2010. That concern has been exacerbated by the slow start-up of the Loan Guarantee program. For instance, a project in Texas that is on private land and does not otherwise trigger NEPA (e.g. no ESA issues) can complete permitting in Texas is a matter of months. If the project seeks a Loan Guarantee, and NEPA is triggered, DOE will not even begin its NEPA process for several months (e.g. until a term sheet is offered), thus permitting and construction may be delayed. It should be possible to work out a mechanism for NEPA streamlining to be applied to clean energy projects that (i) otherwise do not trigger NEPA; and (ii) otherwise could go into construction in time to obtain the ITC grant. For instance, one possibility may be to allow access to the site for initial construction activities after the completion of the state permitting process but before completion of the DOE LG NEPA process.
5. Have you or are you planning on applying for funding provided by the American Recovery and Reinvestment Act? If so, how is that funding going to be used? Is the funding provided by the grants capital that could not be acquired through other means?
    a. We expect to apply for DOE loan guarantees for up to three projects (still under consideration since the recently released DOE solicitation appears to limit to one application per technology per applicant). We intend to commence construction for up to three projects by the end of 2010, plus our small (1.5 MW) reference plant facility which will commence construction in fall 2009, and to seek the ITC Grant for such projects.

The Grant program was intended to make up for the market failure in the tax equity market stemming from the troubles in the financial industry. We understand that the tax equity market continues to be largely closed to projects such as ours.

6. How frequently must the SunCatchers be generating electricity to be cost-competitive? Specifically, would your product be cost-competitive in regions that are not abundant with solar resources, such as Wisconsin?
   a. Initially, we will seek to develop projects in the southwestern United States, where the "direct normal insolation" or DNI is highest. Over time, as costs come down through volume, supplier optimization, and technology roadmap improvements, it may be possible to develop projects in areas with less solar resources, further north and east. Solar power can also be delivered to the north and east through expansion of the transmission grid, which will be necessary to meet renewable energy and climate goals.
7. Regarding transmission costs, you say that this should be borne by the transmission owners – in the case of your Southern California Project, you estimate a cost of $400 million. How do you propose this occurring without the costs being transferred on to consumers?
   a. Consumers pay either way; it is primarily a matter of timing. When new generation comes on line, network upgrades may be required to accommodate the new generation on the grid. In the case of our project with Edison, the costs of the network upgrades are estimated at $400 million, although those upgrade will also serve other new generation projects. Under the current system, transmission customers such as a renewable developers pay the costs of the network upgrades "up-front," and then are reimbursed by the transmission owner (e.g. the utility) over a five year period. Of course, the utility passes the costs on to consumers. This system effectively makes the renewable energy developer a banker to the utility. It is inefficient – the utility has a much lower cost of capital than the developer. And it threatens projects, since developers may be unable to come up with the funding for the transmission on top of the funding for the clean energy project. The system results from the reasonable goal that the utility only build transmission for generation projects that actually get built, to ensure that the transmission upgrades are utilized. The solution is to require the utility to pay "up-front," when certain reasonable criteria are met – such as that the transmission upgrades would serve multiple new generation projects, and/or that there are enough potential generation projects in the area to reasonably conclude that the transmission upgrades will not become stranded assets if they are built.

8. Do you support the development of more nuclear power to satisfy baseload demand as a carbon-free source of electricity?
    a. We do not have a company position on nuclear power at this time.

THE SELECT COMMITTEE ON
ENERGY INDEPENDENCE AND GLOBAL WARMING

1) Do you think that sustaining a 35% annual growth rate is realistic, particularly given the length of time and investment already directed towards PV?

Although PV technology has been around for decades, we stand at the cusp of transforming PV from niche to mainstream. We recently achieved a critical cost milestone where PV is now cheaper than some forms of peaking electric generation (ie. single-cycle gas plants). As shown in Figure 1, the cost of PV has plummeted by a factor of 25 over the last 30 years, from approximately \$5.00/kWh to \$0.20/kWh. This "learning curve" phenomena has occurred in countless industries (notably with Moore's Law in microelectronics), where continuing technological innovations and scale have led to dramatic cost declines. By 2020 PV will be as cheap as coal generated electricity and economically compete with over 60% of existing electric generation (see Figure 2). There is room for PV generation to grow by a factor of 1,000 over the next 20 years.

Figure 1. PV Costs are Projected to Reach \$0.05/kWh by 2020[1]

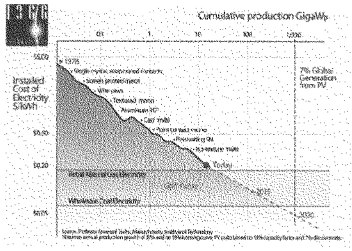
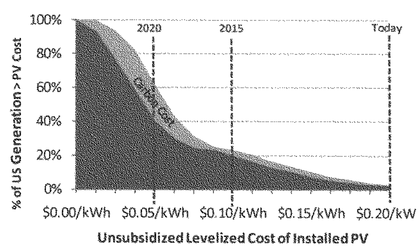


Figure 2. At \$0.05/kWh PV is Cheaper Than 60% of Current Electric Generation[1]



(1) Levelized cost of electricity (LCOE) for PV compared to 2008 data for total plant operating costs. LCOE calculated assuming an 18% capacity factor, 8% discount rate, and 25 year module life. Wholesale electricity costs used for existing generation. Carbon costs of \$20/ton are assumed, with average CO_2 emission of 0.75 tons/MWh. Table on right includes carbon cost.
Source: "Darwin's Theory-Survival of the Fittest," UBS Research, February 2009. Platts Power Database.

The cost trajectory of PV will enable over 35% annual growth as more utilities and end consumers opt for cheaper solar power. Growth rates above 35% would spur a massive domestic PV manufacturing and installation industry, driven by US technology. Much of the original PV technology was developed in the US in the 1970s and 1980s, only to see it commercialized and standardized overseas, except for producing silicon feedstock. The US now has the opportunity to foster the development of the next generation of PV technologies that drive cost reductions and rapid growth of US PV installations. The US PV industry has the potential to create over 1 million jobs in silicon, wafer, and cell manufacturing, as well as over 5 million installation jobs by 2025.

Temporarily sustaining private and public financial support of PV is critical to accelerate the deployment of PV. In the last five years we have witnessed significant government legislation (35% Investment Tax Credit, DOE Solar America Initiative, DOE Loan Program) and billions of dollars of private investment. Although the government support is not required to keep PV viable, it is essential to accelerating the transition to alternative fuels. In the process, such support can fuel the growth of a domestic PV industry and create millions of sustainable jobs.

2) *Will adequate storage technology be commercially available by 2025?*

Some types of storage technology will certainly be available by 2025, including traditional hydro, pumped hydro, and the thermal storage associated with solar-thermal-electric installations. Hopefully, by 2025, plug-in hybrid vehicles will be widely used and therefore serve as a distributed form of storage for electricity generated from solar. Further, the need for storage can be offset somewhat by improved transmission as this will allow for use of electricity from renewable over a wider geographic range, even if local demand is fully satisfied. And finally, a portfolio of renewables also reduces the need for storage as various renewable technologies tend to be complimentary.

However, there is no doubt that full realization of the potential of renewable energy will require innovations in storage technology. This is another great opportunity for the U.S. to bring its scientific and technological resources to bear and to lead in the area of storage technology.

3) *How much landmass will be necessary to generate 7% of global electricity demand?*

a. To satisfy 7% of Global Electric Generation:
   i. Landmass required = 2,725 square miles
b. To Satisfy 100% of Global Electric Generation
   i. Landmass required = 38,932 square miles
c. To satisfy 7% of US Electric Generation
   i. Landmass required = 674 square miles
   ii. % of US land area = 0.02%
d. To satisfy 100% of US Electric Generation
   i. Landmass required = 9,640 square miles
   ii. % of US land area = 0.3%

4) *You note the difficulty of securing adequate financing for the development of PV. Do you believe that reflects the broader concern by investment companies into the commercial viability of your technology? If the open competitive market is not funding PV projects, why is it necessary for the government to prop up a foundering industry?*

Despite PV's recent financing challenges, the industry continues to experience above average growth and attract billions of dollars in investment, both in the US and globally. Like all long-term assets that depend on long-term financing, PV was adversely impacted by the financial collapse at the end of 2008. However, the financing challenges have eased substantially in the last month, allowing large PV projects to be installed and expansion plans to continue.

The fundamentals for PV remain strong and the technology is proven, however the industry is at a critical juncture. PV has tremendous potential to create wealth and jobs but is still nascent. Wild swings in competing energy technologies (coal, natural gas) can have major negative effects on investment activity and optimism. What does not change, however, is the long-term cost potential of PV as an energy source with the capacity to displace a large percentage of fossil-fuel based electric generation. However, energy markets take decades to change and tend to suffer from technological inertia, as witnessed by the slow evolution of our energy supply over the last 100 years. It is at this early stage of a new technology when government can have the greatest impact. All that is required is some consistency in support to allow PV to gain critical scale and accelerate the transition to alternative energy sources.

5) *Are there currently any multi-megawatt PV facilities under construction?*
   a. Southern California Edison (SCE): San Bernadino project – 300MW
   b. SCE: Riverside Project – 250MW
   c. SunEdison: Alamosa Project – 8.2MW
   d. First Solar: Announced 2GW of projects in China

6) *Do you support the development of more nuclear power to satisfy baseload demand as a carbon-free source of electricity?*

I am not an expert on nuclear energy, the safety of nuclear power, or nuclear proliferation. My response is that of a concerned citizen – one with a scientific background.

I note that advocates of expanded nuclear energy give limited voice to the relationship between nuclear energy and the proliferation of nuclear weapons. Typically, I hear advocates say that proliferation can and must be contained, but that nuclear energy and nuclear proliferation are two separate issues. However, I do not believe these issues to be separable. At MIT we teach our students the laws of nature; Newton's laws of motion, electromagnetism, thermodynamics and so on.

I believe that there are also laws of human nature. The limitations inherent in human nature do not allow for us to create perfect systems for the inventory, management, storage, and transport of fissile material.

The news from Iran, Pakistan, Burma and other nations support this view, sad to say. The frightening fact is that it takes only a handful of plutonium to make a bomb. Estimates are that there is more than 20,000 bombs worth of fissile material in storage as a result of the European and Japanese nuclear energy programs.

Who has the right to bet the course of history on the assertion that there will *never* be a blunder or a bribe that puts the fissile material for a bomb in the hands of extremists – of any persuasion?