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GREEN JOBS FROM ACTION ON GLOBAL WARMING

FIELD HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

AUGUST 14, 2007–SAN JOSE, CA

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ONE HUNDRED TENTH CONGRESS
FIRST SESSION

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[1]Note: During the 110th Congress, Senator Craig Thomas, of Wyoming, passed away on June 4, 2007. Senator John Barrasso, of Wyoming, joined the committee on July 10, 2007.

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GREEN JOBS FROM ACTION ON GLOBAL WARMING

TUESDAY, AUGUST 14, 2007

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
San Jose, CA.

The committee met, pursuant to notice, at 11 a.m. Santa Clara County Building, 70 West Hedding Street, San Jose, CA, Hon. Barbara Boxer (chairman of the committee) presiding.

Present: Senator Boxer.

OPENING STATEMENT OF SENATOR BARBARA BOXER, U.S. SENATOR FROM THE STATE OF CALIFORNIA

Senator BOXER. The hearing will come to order. I want to welcome the panel here. I am very pleased to have you all here. I'm very excited about what you're going to tell me and I guarantee you that that information will be given to my colleagues as we move forward with important legislation.

Global warming is the greatest environmental threat faced by mankind—is this working yet? Yes? No? How about that? Better?

Global warming is the greatest environmental threat that we face. We have now arrived at a time in our history when human activities related to green house gas emissions could bring dangerous consequences. In July I traveled to Greenland with nine other colleagues to view the rapid melting of the enormous Greenland ice sheet.

If the Greenland ice sheet were to melt, the sea level would rise 23 feet. This would have disastrous consequences, particularly for California and the California bay delta. Do we have a map here, Michael?

This map—and, Michael, why don't you point out—this map shows what a 23 foot sea level rise would mean to this area of California. It would inundate Highway 880 which runs from here to Oakland.

It would flood the bay delta nearly all the way to Sacramento. Places like the San Francisco Airport and entire neighborhoods would go under water. The costs of these kinds of impact are enormous and greatly exceed the cost of controlling emissions. As Sir Nicholas Stern, the internationally renowned former chief World Bank economist had said, the dollars to fight global warming now will save us $5 later.

In fact, most cost projections show that while fighting global warming would cost funds to support it, gross domestic product will continue to increase just a little bit more slowly. For instance, EPA

has determined that if the legislation offered by Senators Lieberman and McCain were to be enacted, U.S. GDP would increase by 112 percent by 2030 instead of by 113 percent, a net decrease of 1 percent estimated growth.

In fact, I believe even these projections may be too pessimistic. I believe that we cap carbon emissions and fight global warming we would be better off for it in every way including economic growth.

You know, I've been around for a while, started my career in local government, sat on the air pollution board in San Francisco, and everyone said oh, my God, if we get clean cars and we have to clean up our cars, economic growth will halt. The fact is none of that ever proved to be true. The fact is if you can't breathe you can't work. The fact is we ignore the environment at our peril if we truly want economic growth and that's why this has been so far ahead of the government because they get this point.

I believe the fight against global warming is a win win. Why? We increase our energy efficiency. We increase our energy independence. We increase our global competitiveness, by creating clean energy technology which we can export to the rest of the world.

The International Energy Agency estimates that the world will spend over $20 trillion on new energy technology by 2030. Let me reiterate that. The world will spend over $20 billion on new energy technology by 2030. I just visited Gloom Energy. If any of you have ever seen this place it just changes the way we think about the future.

It gives you tremendous hope because it's a brilliant idea of how we're going to face our future. It really is in many ways a leapfrog technology. It's a technology that's going to help us till we get to the final solution of our energy needs.

These technologies can either be clean technologies that we create or dirty technologies. They can either be developed or made in the United States or elsewhere. Well, the world doesn't want to buy dirty technology. The word has already decided that. If it would be nice if our administration decided that as well. I certainly hope that we're all moving in this direction, not in the way that I had hoped in terms of the speed with which people come to grips with it, but I think there's an inevitability that we can see right here in Silicon Valley.

We can see where venture capital is going. It's going into these energies these clean energies. By capping carbon emissions we have done here in California we will stimulate investment in these clean technologies. If we just say technology is the situation which our president says, I agree with him, but we have to add something to it, and that is we're going to incentivize these technologies by making sure there are caps in place.

Otherwise, the capital on it is just not going to flow in a steady stream to indicating them. If you look at California we see Cleantech investments. Again, we're in the Silicon Valley making such investment, more than a billion dollars spent on such investment, and that's just the beginning.

According to University of California Berkeley professor Michael Hanemann, who's here with us today, carbon reduction can be a net boon to the economy. According to Professor Hanemann, if Cali-

fornia takes eight specific steps to fight global warming, the result would be a net increase of gross State product of $60 billion and create 20,000 in the new jobs. Companies that are here today, companies I'm very proud of, can help create good new green jobs for Americans.

That is why I approach global warming with hope, not fear, actually excitement because I believe if we get started, this is going to have a life of its own, and again, it's a total win win situation.

You know, if somebody said to me, "Senator, what if you're wrong?" What if I'm wrong? It's not about me. It's about the scientists. They have totally agreed on this. This isn't, you know, something that I'm doing because it's an easy task. It's a hard task. People don't like to think 20, 30, 40, 50, 60 years ahead. We have enough problems just finding a babysitter.

This isn't something that politicians embrace because it's tough to get people excited about an issue that's hitting us years down the road. But the fact is if we start doing this it will take on a life of its own. Even if the scientists are wrong, which I do not believe they are wrong, but even if they are wrong what have we done? We've created a cleaner economy. People save money. You can read breathe the air, all of the wonderful salutary effects that will come from fighting global warming.

So that's the great news. This isn't like a situation where you have the disease and the cure is worse than the disease. People say you take this medicine, the good news is, you know, you'll are be cured of cancer but you'll die of a heart attack.

This isn't the case with global warming. To fight global warming you have all these benefits that go along with it, and if we act soon, we have a chance to avoid the worst effects of global warming, and in doing so we'll strengthen our economy, create new jobs for millions of Americans.

At 60 California Congress have said, and this is important, folks, the most expensive thing we can do is nothing, is nothing. So anyone who advocates turning away from this issue because it's complex or you can't get people interested in it, anyone, any political leader that does that just doesn't deserve to stay in office.

It's as simple as that. It's just simple because this is the change of our generation and we have to step up to the plate. I just became a grandma again, so I had my first 12 years ago, my second grandson about a month ago, and I'm looking at this little child, outside of the fact that he's a genius and you can also see it in his eye, I realize that when he's a 40-year-old guy he's going to really start thinking about what I did and my moment of truth. You know, I just want to thank all of you who are on this panel today because you are really in the trenches and you get this and your testimony that you give today—this is quite an official hearing, and your testimony is going to be printed and distributed and read, and I will be sure it gets to everyone on my committee, but more than that, to the leadership, to the Administration, and to everyone else.

So I am very, very pleased to now turn it over to the panel but I'm going to give a quick, very brief introduction, not even talk about all the merits you bring, just your title, and give people an idea who's on the panel. Barry Cinnamon, chief executive officer of Akeena Solar, Michael Hanemann, who I spoke about, and those

are the people who don't believe in global warming. They visit me as moments like this.

Michael Hanemann you've heard about, Department of Agriculture and resource economist at University of California Berkeley; Elon Musk, chairman of Tesla Motors; Bill Unger, partner emeritus at Mayfield Fund; Bruce Klafter, senior director, Environment, Health and Safety, Applied Materials; Pat Zimmerman, director and chief of Atmospheric Science School of Mines and Technology; Kevin Collins, president and CEO of Evergreen Energy.

So we're going to hear the testimony. I may have a question or two. Then we'll go to the news conference where I'll answer questions from the media and hope that my friends here will follow me just in case they follow the questions.

We may or may not need that. So maybe, Jen, if you could let me know that we're going ahead on each topic, and we'll just leave it at this. So Mr. Cinnamon, chief executive officer of Akeena Solar, please go ahead.

STATEMENT OF BARRY CINNAMON, CEO, AKEENA SOLAR PRESIDENT, CALIFORNIA SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. CINNAMON. Very good. Thank you, Senator Boxer, for the opportunity to testify before this committee. I share your passion for solving these problems.

I founded one of the leading solar installation companies in the United States, Akeena Solar, and I'm also president of the California Solar Energy Industry Association representing the solar industry in California. So I look forward to giving you a hands-on perspective of the job creation benefits of renewable technologies. Clean energy is indeed a win win win.

Senator BOXER. Is his microphone on? Could you hear it on the back? They cannot hear it in the back.

Mr. CINNAMON. Is indeed a win win win. We win for the economy, we win for the environment, and we win by solving our energy problem.

I've divided my remarks into three categories, jobs created by Akeena Solar, jobs created by our industry in California, and jobs created on a national basis. The jobs created by companies like Akeena Solar are tangible and not subject to speculation. At the end of July, Akeena Solar employed 159 full-time and 11 part-time people.

Of these 170 people, 9 are in New Jersey, which is the second best solar State in the country behind California, and the remaining 161 people are spread out over seven offices we currently have in California, and we're doubling and tripling on an annual basis, so that trend will continue.

The nature of this job is not what many people would expect when we look into solar power. Only 63 percent are on the operational side. Of these 62 jobs only 36 percent are of our work force are actually rooftop installers. The rest of the jobs are operational jobs or highly paid engineers, technicians, documentation specialists, as project managers, and we have another 59 employees in sales, marketing, finance, and administration.

The peril's vague, and many of these are good, solid, white collar jobs. Although I do not have a any specific data on the indirect jobs that we create, I do think that it is certainly consistent with the job multiplier that was calculated in the UC Berkeley study cited below.

As we do our work, our employees are substantial consumers of construction materials, solar panels, vehicles, parts, supplies, and subcontractors coexist, so keeping a lot of other companies in business, and our employees are local members of the community and spend their salaries around town. Anecdotally, the hot dog vendor has certainly seen a very big jump in business from our lunchtime crowd.

This job multiplier effect continues for California. In 2005 Akeena Solar in conjunction with the California Solar Energy Industries Association authored a white paper entitled "The Economics of Solar Power For California." The lesson that we learned from that certainly extends throughout the country.

One of the key findings of this white paper was that the renewable energy industry is a powerful job creation engine. California investments in solar since 2001 have helped stimulate the development of a huge new high technology industry.

Several studies have attempted to quantify the economic benefits of solar energy resources. Among these studies it was concluded that have dollar invested in new solar generation would result in an additional 50 cents of economic activity compared to producing the same power through conventional means.

Included within this increased technology activity are more jobs for Californians. Each megawatt of solar generation would produce an additional 40 person years of employment. Professor Dan Kammen of UC Berkeley also studied the incremental economic benefits associated with renewables.

His study estimated that 1.6 to 2.2 additional jobs, just call it two jobs, is created per megawatt of solar installed over the life of a facility, compared to jobs created by conventional electrical generation. Assuming a 20- to 25-year facility life, this results in very similar numbers to the California association results when additional 40 person years of employment per megawatt installed.

Why does the solar industry produce more jobs and more economic benefits than comparable spending on conventional electrical supplies? Simply because the majority of the costs for national gas, fire, and power production are fuel. California obtains only 15 to 17 percent of its gas supplies with in-State sources.

So we're buying that fuel from out of state sources. In contrast, installing solar generation requires skilled local labor and many components are made and manufactured locally.

To put this in perspective——

Senator BOXER. Mr. Cinnamon, I'm going to ask you to wind up because each person has 5 minutes. We need to—if you could sort of summarize.

Mr. CINNAMON. I'll summarize it very quickly.

Senator BOXER. We gave everyone 5 minutes.

Mr. CINNAMON. Great. You may have heard that solar power is cost effective. Well, in fact, it is cost effective. It costs us less than 19 cents a kilowatt hour to generate the power.

When we add the extra economic benefits of the strong domestic job creation, instead of increasing pain as a forum of fossil fuel, it becomes an economic imperative to move as quickly as we can for these new energy sources. Thank you.

[The prepared statement of Mr. Cinnamon follows:]

STATEMENT OF BARRY CINNAMON, CEO, AKEENA SOLAR, PRESIDENT, CALIFORNIA SOLAR ENERGY INDUSTRIES ASSOCIATION

INTRODUCTION

Thank you for the opportunity to testify before this committee. As a result of my work in the solar industry since the 70s, founder of one of the leading solar installation companies in the U.S., and president of the California Solar Energy Industries Association, I look forward to providing the Committee with a real hands-on perspective of the job creation benefits of renewable technologies. I have divided my remarks into three categories—jobs created by Akeena Solar, jobs created by our industry in California, and jobs created on a national basis.

AKEENA SOLAR JOBS

First, the direct jobs created at Akeena Solar are tangible and not subject to speculation. As of the end of July, Akeena Solar employs159 full time and 11 part time people. Of this 170, 9 are based in New Jersey (the second best solar state in the country), and the remaining 161 are spread out over the seven offices we currently have in California.

101 of these jobs, or 63 percent, are on the operation side of the business. However, only 62 of these jobs, or just over 36 percent of our workforce are actual rooftop installers. The balance of our operational jobs are for highly paid engineers, technicians, documentation specialist and project managers. The balance of the 59 employees at Akeena Solar are in sales, marketing, finance and administration.

Although I do not have any specific data on the indirect jobs that we create, I do think that it is certainly consistent with the job multiplier that was calculated in the UC. Berkeley study noted below. As we do our work our employees are substantial consumers of construction materials, solar panels, vehicles, parts, supplies and subcontractor services. Additionally, our employees are members of the community and spend much of their salaries locally. Anecdotally, the hot dog vendor down the street from our office has certainly seen a jump in business from our lunchtime crowd.

CALIFORNIA SOLAR JOBS

In 2005 Akeena Solar, in conjunction with the California Solar Energy Industries Association, authored a White Paper entitled 'The Economics of Solar Power for California.' One of the key findings of this White Paper was that the renewable energy industry is a powerful job creation engine.

California's investments in solar generation since 2001 have helped stimulate the development of a significant new high technology industry. Continued state support for the solar industry is cruc al if the industry is to grow to the point that it is self-supporting. Importantly, investments by consumers and the state in solar generation will produce greater benefits for the California economy than will investments in the gas-fired CCGT and CT plants that they replace.

Several studies have attempted to quantify the economic benefits of the accelerated development of solar resources. The California Solar Energy Industries Associat on has used an input-output model (E3AS) developed by The Goodman Group (TGG). The E3AS software estimates the regional economic impacts of a new technology by tracing the industries involved through successive rounds of supply linkages. At each step, the program traces the portion of the inputs required from each industry that are supplied within the regional economy being modeled. The study concluded that each $1 invested in new solar generation would result in an additional $0.50 of economic activity in California, compared to producing the same power through conventional means. Included within this increased economic activity are more jobs for Californians: each megawatt of solar generation would produce an additional 40 person-years of employment.

Professor Dan Kammen of U.C. Berkeley has also studied the incremental economic benefit associated with renewable energy. In an April 2004 review of the available studies on the jobs created by photovoltaic generation, Dr. Kammen cites estimates of 1.6 to 2.2 additional jobs created per MW of PV installed, over the life

of a facility, compared to the jobs created by conventional electric generation. Assuming a 20- to 25-year facility life, this results in very similar numbers to Cal SEIA's result of an additional 40 person-years of employment per megawatt installed.

Why will the solar industry produce more jobs and more economic benefits than comparable spending on conventional electricity supplies? The majority of the costs of natural gas-fired power production are fuel costs. California obtains only 15 percent to 17 percent of its gas supplies from in-state sources, so most of the spending for fuel does not benefit the California economy. In contrast, installing solar generation requires skilled local labor, and many solar components are manufactured in the state. If the state provides long-term support for the solar industry, suppliers will be encouraged to locate plants in the state, close to a. major long-term market.

RENEWABLE ENERGY JOBS

In 2008 Renewable Energy (RE) contributed to 6 percent of the U.S. energy market. Of this 6 percent solar PV held a 1 percent market share. There were 194,000 RE jobs in 2006 which powered a $39.2 B industry while creating an additional 446,000 jobs directly and indirectly. Most of these jobs that were created were scientific, technical, professional and skilled positions. Additionally, 95 percent of the jobs were in the Private Sector.

In 2006 Solar PV accounted for 6,800 jobs, $1 B in revenue and helped create an additional 15,700 jobs directly and indirectly. The following diagrams outline the growth of renewable energy jobs and revenue between 2006 and 2030.

U.S. Estimated Revenue in 2030

	Renewable Energy	Photovoltaics
Base Case	$95 Billion	$14 Billion
Moderate Case	$227 Billion	$30 Billion
Advanced Scenario	$1,305 Billion	$48 Billion

Management Information Services & American Solar Energy Society

U.S. Estimated Jobs in 2030

	Renewable Energy	Photovoltaics
Base Case	1.305 Million	200,000
Moderate Case	3.138 Million	450,000
Advanced Scenario	7.935 Million	750,000

Management Information Services 8 American Solar Energy Society

In an aggressive scenario RE Jobs would increase 1,700 percent from 2006 to 2030 and at the same time the revenue would increase by 1,400 percent. The increase in jobs and revenues would have a significant positive impact for each state as displayed below:

Benefits to States

(1) New Investments
(2) Total Industry Sales
(3) Industry Profits
(4) Creation of Direct/Indirect Jobs
(5) Specific jobs created by occupational skill
(6) Stimulation of the manufacturing Sector
(7) State & Fed Tax Revenues
(8) Technology development and spinoffs
(9) Revitalization of depressed regions

One of the greatest benefits of RE and PV is the potential to revitalize depressed regions of employment. Nowhere has this been more effective than in Eastern Germany. Through state assistance, federal aid and EU funding for regional development Eastern Germany has utilized the manufacturing of solar power technology to become a model for economic rehabilitation. For example, the Eastern German state of Thuringia has more than 15 companies that cover the entire PV Value Chain. One company, Solon, has 150 employees producing 60 MW of panels each year on

6 production lines that run off 3 shifts a day/24 hours a day. The boom of RE in Germany has spurred the employment level to increase 36 percent in 2 years.

While Germany has been very successful in RE in the past, the U.S. has even greater potential due to higher demand, more opportunity and better resources, for example better solar radiation. One state very similar to Eastern Germany is Ohio. In the last 10 years Ohio manufacturing jobs have decreased by 23 percent. In fact, the total share of U.S. jobs decreased in Ohio from 4.6 percent to 4.0 percent. Through the wide scale deployment of RE and specifically Solar PV states like Ohio would be able to secure well paying, highly skilled employment that would not be subject to foreign outsourcing.

CONCLUSION

Generating electricity from clean, renewable sources is the future. Our early investments in this future are already paying off in the form of cleaner and less expensive energy.

You may have heard that solar power is not cost effective. That statement is certainly not true for rooftop solar power. The typical small residential solar power system costs $24,000 and will generate 4,300 kwh of electricity per year, virtually maintenance free for 30 years. These energy costs work out to about 19 cents per kwh. I am confident that most of the California residents in here today pay much more than that for electricity—probably closer to 34 cents! Wth current incentives for solar power, these costs work out to about 11 cents per kwh—less than a third of the top marginal electricity costs in California.

When we add the extra economic benefits of strong domestic job creation—instead of increasing payments to foreign countries for fossil fuels—it becomes an economic imperative to move as quickly as we can to these new energy sources.

SOURCES

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Management Information Services, Inc., "Economic and Jobs Impacts of the Renewable Energy and Energy Efficiency Industries: U.S. and Ohio," July 2007.

Senator BOXER. Thank you so much. Now W. Michael Hanemann, Chancellor's Professor, Department of Agriculture and Resource Economics, University of California at Berkeley. Welcome, sir.

STATEMENT OF W. MICHAEL HANEMANN, CHANCELLOR'S PROFESSOR, DEPARTMENT OF AGRICULTURE AND RESOURCE ECONOMICS, AND GOLDMAN SCHOOL OF PUBLIC POLICY DIRECTOR, CALIFORNIA CLIMATE CHANGE CENTER AT UC BERKELEY, UNIVERSITY OF CALIFORNIA, BERKELEY

Dr. HANEMANN. Senator Boxer and other members of the committee, I greatly appreciate the opportunity to appear before you today. I'm a professor of environmental economics and policy at the Goldman School of Public Policy at UC Berkeley. The first point I want to make is that government action needs to be taken. Voluntary measures, while helpful, are not going to solve the problem. From an economic perspective greenhouse gas emissions are an example of an externality, like other forms of pollution, and voluntary measures by those who emit the pollutant will be insufficient.

The second point is that global warming is more complex than other problems of pollution which is Congress has dealt with in the past, and will require a broader set of policy measures.

Many economists have tended to view global warming through the prism of the Nation's highly successful experience in dealing with sulfur dioxide in the 1990 Clean Air Act. Through the cap and trade system introduced under Title IV we achieved a 50 percent reduction in emissions that cost substantially less than we anticipated.

Because of its success, this has been seen by some economists as a precise template for dealing with the greenhouse gas emissions. I disagree. While I believe that emission trading needs to be part of the policy mix, trade by itself it won't solve the problem of greenhouse gases. A broader approach is required with a more specific purpose on technology innovation and adoption.

How did title 4, emission trading, solve the problem of SO_2? Owners of power plants responded by changing operations, by modifying combustion, for example, by end of pipe treatment, installing scrubbers to remove emissions.

What should be noted is the strategies not used. Energy conservation and demand management played essentially no role in the reduction of SO_2. Renewal managing played no role. New combustion technologies played no role. What was done involved known and mature technologies.

With greenhouse gases this is a different situation. There's no low CO_2. There's no post combustion scrubber that can be applied to existing demands. This is not a mature technology. Renewable sources of energy will have to play an important role.

Maybe nuclear will play a role. The point is that we're the electricity generation—the focus of greenhouse reduction has to be on new technology and its cost effective incorporation in design.

Moreover, with greenhouse gases we can't solve the problem by focusing just on electricity generation. Electricity generation accounts for about two-thirds of the SO_2 emissions in the United States. But only about one-third of the greenhouse gas emissions, and in California only one-fifth of greenhouse gas emissions is due to other sources, among which transportation looms large.

So these other sources, too, technology innovation, will play a major role, for example, through innovations such as hybrid vehicles and ethanol fuel. Greenhouse gases differ from SO_2 also in the timeframe. As you know, Governor Schwarzenegger set two policy goals for California, by 2020 to reduce our emissions back to what they were in 1990, and by 2050 to reduce our emissions 80 percent below their level in 1990.

We have those two policy objectives as we understand. The short-term objective is to deploy existing near-term technologies to roll back emissions to their level in 1990. The long-term objective is to stimulate innovation and investment in new technologies for a major decarbonization of the future economy.

As the greenhouse gases that are on—unlike SO_2, innovation will play a central role. Another important difference is energy conservation in behavioral change. I'd like to mention quickly one statistic, that in the United States electricity use per capita since 1975 has grown by about 50 percent. In the western states it has grown by about two-thirds. In California it has not grown at all.

We believe that an important factor here is the regulation of energy efficiency in appliances by the California Energy Commission.

So this brings me in concluding to focus on the economics that we now sense, reduction. You mentioned the report that he published in January 2006 showing that meeting—that programs would lead to a net growth in gross State product and in jobs.

In August 2006 he issued a supplementary report which shows how to meet the full 19—the full goal of reducing emissions back by 2020 to their level in 1990, and he included in addition to those regulatory programs the concept of emission trading to achieve the rest of the target and assist in whereby some of the profits from some issuance of the permits will cloud back to—he showed an even larger economic gain, an increase of $74 billion in gross State product, and 89,000 new jobs.

To summarize, first I should point out his analysis was restricted to California, which is certainly different in certain respects from the national economy.

But I want to emphasize in closing the key features of this analysis in California are certain to carry over nationally. In fact, the finding that greenhouse gas emission reduction contributes to economic growth in three important ways.

First, energy efficiency puts money in consumers' pockets, and that leads to economic growth and creation of jobs. Second, policies that enable firms to invest in new technologies that stimulate innovation and benefit—innovation is the most important long-term source of growth of income and employment in the United States.

Third, as you know, policies that promote energy efficiency reduce our dependence on imported fuels, which itself has a cost in terms of economic security.

Just with three areas where I think California has a distinct advantage. One is information technology and particularly a distributed sensing and collection of information such as smog dust. The second is energy and efficiency which California has pioneered. The third is the Cleantech exemplified by Mr. Cinnamon and Mr. Musk, who's now about to testify. Thank you for your consideration.

[The prepared statement of Dr. Hanemann follows:]

STATEMENT OF W. MICHAEL HANEMANN, CHANCELLOR'S PROFESSOR, DEPARTMENT OF AGRICULTURAL & RESOURCE ECONOMICS, AND GOLDMAN SCHOOL OF PUBLIC POLICY, DIRECTOR, CALIFORNIA CLIMATE CHANGE CENTER AT UC BERKELEY, UNIVERSITY OF CALIFORNIA, BERKELEY

Senator Boxer and other members of the Senate Committee Environment and Public Works Committee, I greatly appreciate the invitation to appear before you today.

I am a professor of environmental economics and policy and Director of the California Climate Change Center in the Goldman School of Public Policy. Since the Center was established four years ago, my colleagues and I have been working on various aspects of climate change and its implications for California, including the potential adverse impacts to California's economy, society and ecology, and also the policies that California needs to adopt to reduce our greenhouse gas emissions in an effective manner and at a tolerable cost.

Climate change and global warming are the greatest environmental policy challenges that we face today not only because of the scale and magnitude of the problem but also because of its complexity and novelty. However, climate change is also a great opportunity because it inevitably will force a substantial change in how we generate and use energy throughout our economy, and this will require major technological innovations. If this is done right, with the right policies in place, and also with a degree of good fortune, it can become a source of economic growth for California and for the United States.

Thc first point to be made is that governmental action needs to be taken. Voluntary measures, while helpful, are not going to solve the problem. From an eco-

nomic perspective, greenhouse gas emissions are an example of an externality, like other forms of pollution, and voluntary measures by those who emit the pollutant will be insufficient to yield the required reduction in pollution.

The second point is that is that, as noted above, global warming is more complex than other problems of pollution which Congress has dealt with in the past, and it will require a broader set of policy measures.

In my observation, many economists have tended to view global warming through the prism of the nation's highly successful experience in dealing with sulfur dioxide ($S0_2$) under 'Title IV of the Clean Air Act Amendments of 1990. Through the cap and trade system introduced under Title IV, we achieved a 50 percent reduction in emissions at a cost substantially less than had been anticipated. Because of its success, this has been seen by some economists as a precise template for dealing with greenhouse gas emissions. I disagree. While I believe that emission trading needs to be part of the policy mix in dealing with greenhouse gases, by itself it will not solve the problem of greenhouse gases: a broader approach, with a more explicit focus on technology innovation and adoption, is required.

How did Title IV emission trading solve the problem of $S0_2$? The emissions cap was applied to individual generating units, and they responded in several ways. Owners of power plants responded by changing operations—by modifying combustion, switching from high- to low-sulfur coal, and by changing the order of dispatch across different facilities—and by end of pipe treatment, installing scrubbers to remove emissions post-combustion. What should be noted is the strategies not used. Energy conservation and demand management played essentially no role in the reduction of SO_2. Renewable energy sources played no role. New combustion technologies played no role. What was done involved known and mature technologies. There was some experimentation and innovation in plant operation, but technological innovation in the sense we normally think of played no role in the events post 1990.

With greenhouse gases there is a very different situation. There is no low CO_2 coal; fuel switching with biomass is a possibility but this can only be done on a limited scale and this is not a mature technology. There is no post-combustion scrubber that can readily be applied to an existing coal-fired generating unit. There is the potential of carbon capture and sequestration, but this is not a mature technology in electricity generation. Renewable sources of electricity will play an important role. Maybe nuclear will ultimately play an important role, especially if the disposal problem can be solved effectively. With electricity generation per se, the focus for greenhouse gases is clearly on new technology and its cost-effective incorporation in the design of new power plants.

Moreover, with greenhouse gases, unlike SO_2, we cannot expect to solve the problem by focusing on electricity generation alone. Electricity generation accounts for about ⅔ of all SO_2 emissions in the United States. With greenhouse gases, by contrast, electricity generation accounts for only about ⅔ of emissions and in California it accounts for only ⅔ of emissions. The majority of emissions are due to other sources, among which transportation looms very large. For these other sources, too, technological innovation will play a major role, for example through innovations such as hybrid vehicles or cellulosic ethanol for vehicles.

Greenhouse gases differ from SO_2, also in the time frame of the problem. As you know, Governor Schwarzenegger has set two policy goals for California: by 2020 to reduce our greenhouse gas emissions back to their level in 1990, and by 2050 to reduce our emissions 80 percent below their level in 1990. The second goal—at least, a reduction roughly of that order of magnitude and on that timeframe—needs to be met by all of the developed countries if a severe and dangerous increase in the global atmospheric concentration of CO_2 is to be avoided. This will require profound innovation to permit as substantial restructuring of energy use in the modem economy.

There are thus, two policy objectives for greenhouse gases, short-term and long-term. The short-term objective is to deploy existing and near-term technologies to roll back emissions to their level of 1990. The long-term objective is to stimulate innovation and investment in new technologies for a major decarbonization of the future economy.

In short, for greenhouse gases, unlike SO_2, innovation will play a central role if we are to meet the short- and long-run policy objectives.

Another important difference for the short-term policy objective is energy conservation and behavioral change. As noted earlier, these played essentially no role in the reduction of SO_2 but they will be crucial for meeting California's 2020 goal for greenhouse gas reduction.

In this context I would like to draw your attention to California's remarkable success in promoting energy conservation through the regulatory programs of the Cali-

fornia Energy Commission (CEC), which was established 30 years ago. Over that period of time, electricity use per capita in the United Stales has increased by about 50 percent; in the Western states, it has increased by about ⅔. In California, however, it has not increased at all. My colleague Professor Max Auffhammer in the Department of Agricultural & Resource Economics at Berkeley and I are currently conducting a study to pinpoint the reasons for this striking divergence; it seems clear that at least part is attributable to California's unique history in regulating appliance efficiency through the CEC: it is an example of regulation-induced innovation.

This brings me to the economics of greenhouse gas reduction. As pan of a larger study on Managing Greenhouse Gas Emissions in California, co-directed with my colleague Professor Alex Farrell and issued in January 2006, my colleague Professor David Roland-Holst conducted a study of the economic cost to the California economy of reducing greenhouse gas emissions in California. The January 2006 analysis focused on a set of emission reduction regulations which together accounted for about half of the 2020 reduction target. In August 2006, he released an updated analysis accounting for all of the 2020 emission reduction target; it combines the regulatory strategies in his earlier report with an emission trading system covering the remainder of the economy and bringing about attainment of the full 2020 target. His analysis uses the BEAR model, currently the most disaggregated and sophisticated computable general equilibrium model of the California economy. His August 2006 report finds that that meeting the 2020 cap can stimulate the state's economy. He projects the cap to boost annual Gross State Product (GSP) in 2020 by $60 billion and create 17,000 new jobs. if the emissions trading system is implemented so as to create direct incentives for innovation, by using revenues from the sale of emission permits to finance innovation, he estimates the gains to be even larger: $74 billion in GSP and 89,000 new jobs.

His analysis is restricted to California, which is different in certain respects from the national economy. But, some key features of his analysis for California are certain to carry over to the national economy, in particular his finding that greenhouse gas emission reduction contributes to economic growth in that important ways:

(1) Energy efficiency increases consumer purchasing power and puts money into the economy, stimulating job growth and incomes.

(2) Policies that enable firms to invest in new technologies stimulate innovation, which is the most important long term source of growth in income and employment.

(3) Policies that promote energy efficiency also reduce our dependence on imported fuels that are an important threat to our economic security.

Thank you for your consideration.

Senator BOXER. Thank you so much—really appreciate—you covered a lot of ground in five minutes. Thank you.

Mr. Elon Musk, chairman of Tesla Motors. I've had the pleasure of riding along in your cars and I'm looking forward to hearing from you.

STATEMENT OF ELON MUSK, CHAIRMAN OF TESLA MOTORS

Mr. MUSK. Thank you. In addition to being the chairman and principal owner of Tesla Motors, I'm also chairman of Solar City, which is a complementary endeavor, energy generation to the energy consumption of Tesla Motors car. So I'll talk in terms of those two companies because I think those are very appropriate, which is that by pursuing green technologies we not only save the environment but we actually support and grow the economy.

If we fail to go in that direction our economy will be harmed and. Tesla Motors' initial product is a sports car. It's an expensive sport car, but it allows us to enter the market at the high end where we can do low unit volume and a high price just as new—whether it's a software or a laptop at higher price and lower unit volume because as we ensure the technology we're able to bring out the technology and make it available to a larger and larger segment of the population.

It also helps refute some of the misapprehensions about electric vehicles. This is a first-class car. It goes 0 to 60 in under 4 seconds. It has a range, in fact, just driving around the Bay Area we've got the range as high as 267 miles on a single charge.

It's fully guaranteed. In fact, it's been crash tested. The Roadster is the only production electric car that has done that. We're moving quite quickly beyond the Roadster to more mass market vehicles.

Model number 2, where anyone for a price of around $50,000 for a four-door five-passenger sedan and the model 3 will go even beyond that lower price and higher quality. We're also working on providing electric drive train technology to the conventional car business to the marriage suppliers which we think will further accelerate the adoption of electric vehicles.

In terms of jobs we've grown from two employees in 2003 to almost 300 today in 4 years. We expect to add another 400 employees with our New Mexico plant and we expect to really just double and triple the employee volume year over year beyond that time.

We expect eventually to have several direct jobs and with some appropriate multiplier on indirect jobs in the future.

Getting to Solar City, you have to address both the consumption and the production of power. I think my prediction is that by the middle of the century a majority of our power will be solar. A combination of photovoltaic as well as thermal.

So if in the case of Solar City it's growing extremely quickly. It's creating a tremendous number of jobs, a range of jobs; engineering, but also green color jobs. These are jobs that people can obtain who don't necessarily have a college degree, and it's the—Solar City will pay between 15 and $22 an hour for somebody who doesn't even have a college degree, two to three times the minimum wage, opportunities for advance employment that can be applied in other areas.

So in less than a year in operation Solar City has created a 160 new jobs and plans on hiring 1,200 new jobs over the next 2 years. Those are direct jobs. As I said, there's an opportunity to go from installer to team lead to regional supervisor, and this is just in California.

We continue to expand to other states. So as your committee and the Congress as a whole consider legislation to address energy policy, I urge you and Congress to adopt policies that will continue to offer new technologies like Tesla Motors and the other companies that are represented here today. It's very important that we have these incentives. I'm a huge proponent of subsidies or special advantages or anything, that sort of thing. I'm a believer in the free management under ordinary circumstances. We have consumption of the common good. That's the fundamental issue. The common good is the environment as over see to the atmosphere—you see similar problems in fisheries where the consumption for the common good, willing to let go and fish out of the sea, it's destructive to everyone.

So if we properly recognize the cost of to the economy and the atmosphere and at the gas pump and at the power plant then it—there would be no issue.

There would be no—but we don't——

[The prepared statement of Mr. Musk follows:]

STATEMENT OF ELON MUSK, CHAIRMAN OF TESLA MOTORS

Madame Chairman (and Members of the Committee), welcome to Silicon Valley and thank you for the opportunity to testify before the Committee today on the Subject the creation of so-called "green jobs" in the high tech and industry. As the Chairman of two clean tech companies that are focused on combating global warming, I enjoy a front row seat from which to view the rapid creation of new jobs and in one case—a wholly new industry.

While the number of jobs created by Tesla Motors, Solar City and other players in the Clean Tech arena is impressive, and the rate of job growth is even more so, perhaps the most striking aspect of the jobs we are creating is embodied in their diversity. As has often been the case in Silicon Valley, we have created a wealth of new jobs for holders of advanced technical and management degrees. However, the truly notable aspect of the Clean Tech revolution is its ability to create high quality "green collar" jobs in addition to those high end technical positions. Tesla Motors and Solar City are both exemplars of this phenomenon.

As I believe you are aware, Tesla Motors' initial product is a high-performance electric sports car called the Roadster. However, the intent is to build electric cars of all kinds, including low-cost family vehicles. As our unveiling of the Tesla Roadster has demonstrated, reports of the death of the electric car have been greatly exaggerated. The Roadster defies all conventions associated with environmentally friendly cars, particularly those of a purely electric nature.

My apologies for the brief commercial, but to understand what is possible, I must present the key facts of the vehicle:

- 0 to 60 mph in 3.9 seconds
- 135 MPG equivalent
- Over 200 mile driving range on a single charge
- Fully DOT-compliant crash tested, with airbags, crash structures, etc.

The Tesla Roadster is designed to beat a gasoline sports car like a Porsche or a Ferrari in a head-to-head showdown, but it has more than twice the energy efficiency of a Prius. In other words, it is a great sports car without significant compromises. Now, some may question whether this really does any good for the world. Are we really in need of another high-performance sports car? Will it actually make a difference to global carbon emissions and our oil dependence?

Well, the answers are no and not much. However, that misses the point. Almost any new technology initially has high unit cost before it can be optimized. This is no less true for electric cars. Tesla's strategy is to enter at the high end of the market, where customers are prepared to pay a premium, and then drive down market as fast as possible to higher unit volume and lower prices with each successive model.

Tesla's second model will be a large four door family car starting at $50,000 and the third model will be a smaller, more affordable four door. In keeping with a fast-growing technology company, all free cash flow is plowed back into R&D to drive down the costs and bring the follow-on products to market as quickly as possible. When someone buys the Roadster sports car, they are actually helping to pay for the development of the low cost family car.

Since the Tesla Motors' birth in 2003, the company has grown from 2 employees to over 300, with a headquarters and R&D center here in Silicon Valley, a vehicle development center outside of Detroit and plans to break ground on a vehicle assembly plant (in New Mexico) that will employ an additional 400 employees later this year. While the early employees of the company were, not surprisingly, engineers and technical experts, as we have move into a manufacturing phase, we will be aggressively adding high quality high paying hourly jobs. It is worth noting that every one of our employees enjoys a full benefits package, is an equity shareholder in the company and will share in the success of the enterprise.

Vehicle manufacturing is a supplier intensive business and so while the aforementioned direct employment numbers are impressive enough, it is safe to say that the indirect job creation that Tesla is and will continue to catalyze, while difficult to quantify can safely be assumed to be a Significant multiple of the direct labor pool.

Our second company, SolarCity, is focused on bringing solar power to every home and business and in so doing it is measurably reducing the carbon footprint of the growing number of communities where SolarCity operates. By creating a trusted brand and bringing cost-reducing innovations to the market, SolarCity has become the largest residential solar installer in California.

In contrast to Tesla Motors Solar City is neither a manufacturing company nor a developer of high technology. Rather, it is a service company focused on the installation of residential solar systems. Since solar installation is a labor intensive enterprise and because the number of systems installed drives the success of the enter-

prise as a whole, Solar City's success to date and as future prospects are fundamentally dependent on the creation of a high quality "green collar" labor pool. In other words, the more jobs that SolarCity can create, the more the company will succeed.

In less than a year of operation, SolarCity has created 160 new jobs and has plans to hire an additional 1200 well-paid "green collar" workers by We end of 2009. These "green collar" jobs are high-quality jobs that enable individuals with limited experience and limited advanced education and training to learn a skilled trade and develop valuable skills and experience. These jobs pay well ($15-22/hour), include benefits and stock options and offer the opportunity for career advancement: from installer to senior installer to team lead to regional supervisor. As SolarCity extends its business from California across the country, the company and the industry will prosper in direct relation to the number of jobs that the company can create.

As your committee and the Congress as a whole consider legislation to address Climate Change and Global Warming in the fall, I am hopeful that you will to drive for policies and legislation that will support the continued development of promising new technologies like Tesla Motors' performance electric cars and to encourage companies that are applying new business models to expand renewable energy generation like Solar City. You can do so by encouraging incentives for consumers to adopt these technologies—in particular by creating tax policies that pull larger unit volumes into the market and help to accelerate our ability to get to economies of scale and effort on the supply side. You can also encourage job training programs that will increase the available labor pool for the green work force that our continued success will demand.

In conclusion, I believe that we are just now beginning to understand the promise of job and wealth creation that is embodied in the drive to develop the alternative technologies and business models that will address the tern crises of petroleum dependence and global warming. But I am certain beyond a shadow of a doubt that if we as a nation commit to supporting these industries we will be laying the groundwork for America's economic prosperity and competitive advantage for decades to come.

Thank you for your time. I will be happy to address your questions.

Senator BOXER. Thank you so much.

Mr. Unger, Bill Unger, partner emeritus at Mayfield Fund.

STATEMENT OF BILL UNGER, PARTNER EMERITUS AT MAYFIELD FUND ENVIRONMENTAL ENTREPRENEURS

Mr. UNGER. I'm also a member of Environmental Entrepreneurs, which is an 800 member organization of CEOs and investment professionals that believe that a good economy is also a good environmental policy. One of the things that venture capital industry is most proud of is job creation and the role we play in it. In 2006 venture back companies since 1970 provided 10.4 million jobs and these job companies had revenues of $2.3 trillion. 17.6 percent of total GP in this country.

Since 1970 for every $28,000 invested we created one job. I say we. I shouldn't say—we provided counsel to help them do it. But how does this really happen? First I think it's the wealth of technology generated in our national laboratories and our universities. These with other public and private institutions are national resources.

Really, they're treasures. I'm on the advisory board at Berkeley, college of engineering, also at Illinois. There's clearly more work going on than we can take advantage of today.

DARPA and NIH have played a crucial role in nurturing technology development with microventure capitalists. We help on the front end in nurturing technology. Then we can bring them to the marketplace.

The United States is no longer the world leader in two important clean energy fields. We're third in installing behind Denmark and

Spain. We're third in photovoltaic power installed behind Germany and Japan.

These are technologies that were developed in our national laboratories. Taxpayer dollars paid for this and we need to need to be first again. There's many other examples of that in the country.

Since the energy crisis of the 1970's total Federal spending on energy research is down. Some of this is made up by the venture capital industry and by other funded research. But by and large, we're still operating with quite a handicap.

We can regain this market share. In 1998 the semiconductor industry was doomed because the Japanese were going to eat our lunch and the game was over. Some groups helped turn that around. We can do that again.

The second reason is the public and private investments in biotechnology and software have been very strong and there's a spillover effect of this in the Cleantech. So we're able to benefit from that Cleantech even though energy source is down.

We can also measure the people who were entrepreneurs in the 1980s and 1990s and are now going into Cleantech. So we have a wonderful pool of experienced entrepreneurs and experienced technologists who want to apply themselves to this next industry.

There isn't anyplace in the world, much less in the United States—certainly the United States has more of these capabilities than anyplace else in the world, and we should be taking advantage of it.

So it's a great story. Last year there was $2.9 billion invested in Cleantech, which is up 75 percent from 2005. It's now the third largest venture sector, bigger than some—I cannote this, bigger than medical devices. The analysis from UC Berkeley that we all read from the professors who do this concluded that if renewable energy sector generated more jobs per megawatt of power installed per unit of energy produced and dollar of investment than the fossil fuel-based energy sector.

Our analysis shows that for every $100 million invested generates 2,700 new jobs. If we invest the $14 to $19 billion we expect to be invested over the next 4 years that will create 400 to 500,000 new jobs. The National Venture Capital Association actually—their numbers would say it would create over 600,000 new jobs during that time.

There are still barriers which have been said by other folks and I don't need to repeat them, we have to head off a climate crisis, though, and we can't treat that lightly. We need consistent policy. We need to have some even playing field so that the long-term subsidies in traditional energy generating industries and the trade barriers do not unfairly impact us. We like a level playing field.

So as with and the other strategies mentioned before, we know you hear a lot about that, and I would only gather we would like to see the states not prohibited from being more aggressive, whatever the national energy policy turns out to be.

There are people who say move slowly and incrementally on this turn it or the action is unnecessary. Those who say the market forces are enough without government mandate we believe are incorrect. The problems are much too big and much too urgent. We

need to have both. We should not be the people our parents warned us about who pass the buck.

You can have this kind of economy and address global warming. We have all the capital and entrepreneurial skills to do this. We need the government to work together with private sectors. We need government leadership today to stand up to do this.

We are the country that showed what could be accomplished in World War I and World War II, the Manhattan project, the Marshall Plan, and the space program are all examples when others would have held back.

We succeed when we do this. We need to be the people we've been waiting for. If we do this, we will be the people that our children will say give a better world to their children.

[The prepared statement of Mr. Unger follows:]

STATEMENT OF BILL UNGER, PARTNER EMERITUS AT MAYFIELD FUND, ENVIRONMENTAL ENTREPRENEURS (E2)

Good morning Committee Chair Boxer, Ranking Member Inhofe and Members of the Committee, I am Bill Unger, a Partner Emeritus at Mayfield Fund, a venture partnership investing in technology companies since 1970, and a member of Environmental Entrepreneurs (E2), a volunteer organization of business and investment professionals who believe that good environmental policy is good economic policy. I now spend only a part of my time investing in for profit companies, and more of my time as a board member of several non-profit organizations, such as CARE USA, YouthNoise, The Anita Borg Institute for Women and Technology, as an Advisor to and member of E2. I also serve on the advisory boards of the Colleges of Engineering at The University of California at Berkeley and The University of Illinois at Chicago. I appreciate the opportunity to be here today to share my views as a venture capitalist, and as a member of E2, on the creation of new jobs created in "Cleantech" related industries, including jobs created by measures taken in response to threat of Global Warming. In particular, I would like to show how the economic and employment growth of the Cleantech sector is related to a national carbon policy.

Some history of the Venture Capital industry's impact on our economy will set the stage. One of the achievements the venture capital industry is most proud of is our role in job creation. For example, the U.S. semiconductor industry, as of the year 2000, employs 210,000 people in high-wage manufacturing jobs, and had sales totaling $102 billion in the global market in 2000 (50 percent of total worldwide sales). In 1999, this sector was the largest value-added industry in manufacturing in the U.S.—larger than the iron, steel and motor vehicle industries combined.

The 2005 employment data show a heavy concentration of venture capital supported jobs in the software industry as well, with nearly 860,000 jobs—almost 90 percent of the total jobs in the sector. Venture-backed companies recorded $210 billion in sales in 2005, which represents more than 36 percent of the industry's total revenues generated that year.

In 2006, venture backed companies provided 10.43 million U.S. jobs and these companies had revenues of $2.3 Trillion. The revenue represents 17.6% of US GDP. Data from the National Venture Capital Association, (this entire study is at *http://www.nvca.org/pdf/NVCA*_VentureCapital07_2nd.pdf.) shows that at the end of 2006, one ongoing job existed in venture backed companies for every $28,463 invested in venture capital since 1970, or about 3,500 jobs for every $100M invested by the Venture Capital industry. (Investment in the 5 years preceding the jobs and revenue measurement date is not included because its effect on 2006 statistics would be minimal.) Furthermore in 2006, these companies generated $7.87 in revenue for every dollar invested. This is very impressive for an industry that typically invests less than 0.2% of GDP each year.

Looking just at the biotech world, for every dollar of venture capital invested, $4.43 in revenue was being produced in 2006 ($83 Billion total). As with VC in general, most of these investee companies failed. For every $76k of investment, one ongoing job existed in 2006 (and these are typically high-paying jobs). This refers only to the investment economic effect of biotech investment.

Publicly funded research, especially through such entities as DARPA and the NIH have played a crucial role in manning technology development to the point where the Venture industry, which likes to invest in product development, can fund companies to bring valuable new products and solutions to the market place. At

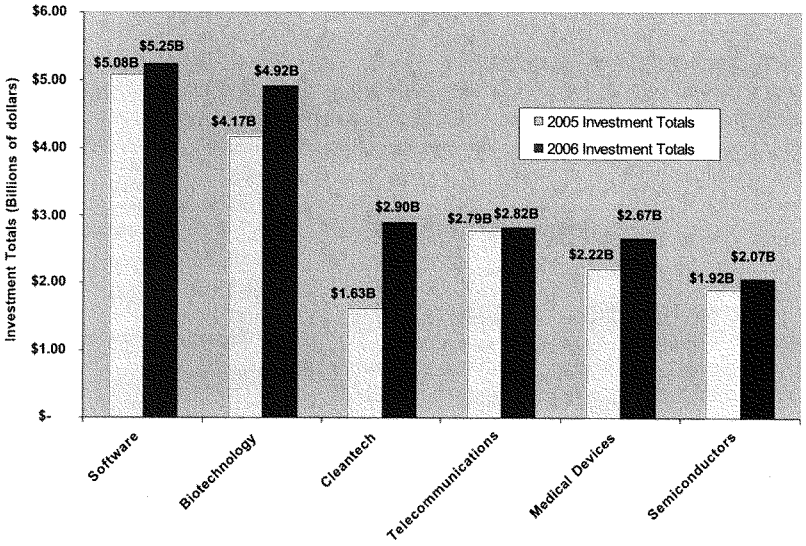
Mayfield Fund, we funded companies such as Atari, Silicon Graphics, Compaq, 3Com, Genentech, Amgen and over 100 hundred other public companies that are examples of this kind of success. In 1990 Mayfield led the second round investment in Sandisk. There were few cell phones by today's standards, no digital cameras, no MP3 players, no Blackberries; a slower, simpler time. All these markets and more were enabled by Flash Memory technology created by the founding team. I suspect there are few of us here who haven't purchased a device with the Sandisk name on it, or a device with Sandisk memory in it. Mayfield was the founding investor in Millennium Pharmaceuticals, which was the pioneering company in genetic design of pharmaceuticals based on an individual's reaction to disease at the molecular level. In the early 1990's, Mayfield funded Heartstream, the manufacturer of the defibrillator machines found now in virtually even-public building and every airport. When this company was started, it took a special truck, a suitcase sized $10,000+ machine, and specially trained technicians to save a life. Today you can buy one on Amazon.com for $1100.

Mayfield Fund and the Venture industry have seen the unfolding of the semiconductor, software, medical device biotechnology, computer, networking and communications industries, creating millions of jobs and trillions of dollars in revenue.

Cleantech has some important similarities to these success stories, and some differences. Cumulative venture investment in the Cleantech sector of venture investing from 1999 through 2006 totaled $11.1 billion[1] So though it is early times in Cleantech investing, by historical standards we think there are encouraging signs for economic growth and job creation.

2006 was a banner year for the cleantech industry—with total venture investments surpassing those of the medical devices, telecommunications, and semiconductor sectors—all of which it had trailed in 2005. Venture investments in cleantech firms in North America totaled $2.9 billion, a 78 percent increase over the same total in 2005, and a 243 percent increase since 2001. This total also represented 11 percent of all North American venture capital investments for the year ($27.0 billion),[2] making cleantech the third largest venture capital category—after only software and biotechnology.

Top 6 North American Venture Capital Industries, 2005 to 2006 (Billions of dollars)



[1] According to the Cleantech Capital Group, $7.4B was invested from 1999 through Q2 2005. Q3 2005 was $.425B. Q4 2005 was $.502B and 2006 was $2.9B for a total of $11.1B.

[2] Cleantech Venture Network; PricewaterhouseCoopers/National Venture Capital Association Money Tree™ Report (CVN; MoneyTree). (2007). http://www.pwcmoneytree.com/exhibits/MoneyTree_4Q2006_Final.pdf.

In fact, since the economic downturn of 2000-2001, cleantech is one of the few U.S. industries to experience real growth in venture investments. While U.S. venture capital investments as a whole were off by 33 percent in 2006 compared to 2001, investments in American cleantech companies were up 243 percent in that time—more than two and a half times the growth rate of the next strongest industry (electronics/instrumentation) over that period.[3]

So let's define Cleantech. The cleantech industry encompasses a broad range of products and services, from alternative energy generation to wastewater treatment to more resource-efficient industrial processes. Although some of these industries are very different, all share a common thread: they use new, innovative technology to create products and services that compete favorably on price and performance while reducing humankind's impact on the environment. To be considered "cleantech," products and services must:

- Optimize use of natural resources, offering a cleaner or less wasteful alternative to traditional products and services;
- Have their genesis in an innovative or novel technology or application;
- Add economic value compared to traditional alternatives.

The eleven cleantech categories, as defined by the Cleantech Venture Network, are[4]:

- Energy Generation
- Energy Storage
- Energy Infrastructure
- Energy Efficiency
- Transportation
- Water & Wastewater
- Air & Environment
- Materials
- Manufacturing/Industrial
- Agriculture
- Recycling & Waste

Some findings from the E2 Cleantech Report of 2007[5] show real progress:

FINDING 1: GROWTH IN CLEANTECH ACCELERATED IN 2006, WITH SIGNIFICANT ACTIVITY IN THE PUBLIC MARKETS

In 2006, cleantech became the third-largest North American venture capital investment category (11 percent of all venture investments), behind software and biotechnology. Total North American venture capital invested in cleantech companies reached $2.9 billion in 2006, an increase of 78 percent over the $1.6 billion invested in 2005.

A significant increase in investments during the second and third quarters of 2006 was driven by capital targeted for companies moving into production. Cilion, Altra, Bloom Energy, Renewable Energy Group, and Nanasolar—all of which represent new renewable energy technology or biofuels—collectively accounted for more than $600 million in investment in 2006. But this boom can also pose challenges: Companies with new technologies have difficulty accessing capital for manufacturing build-outs. While established technologies such as corn ethanol can rely on debt financing, the first thin film solar or cellulosic ethanol facilities cannot as readily access debt financing because of the higher risks associated with first production facilities. These companies are forced to either raise additional equity capital and/or look to government assistance. As part of the 2005 Energy Act, the Department of Energy granted six cellulosic facilities special financing of up to $385 million to help build their first production facilities that, in aggregate, should reach 130 million gallons per year.[6]

Cleantech is now an established investment category in the public markets. There are multiple stock indices including the Cleantech Capital Indices (CTIUS), WilderHill's ECO, Ardour Capital's Alternative Energy Indexes (e.g. AGINA, AGIGL), and Clean Edge's CELS and CLEN indexes. The 45 public companies that make up the Cleantech Index (CTIUS) have an aggregate market capitalization of over $300 billion. The performance of CTIUS over the past two years has been strong. In the two years through April 23, 2007, CTIUS has risen 38.9 percent, from

[3] Ibid CVN; MoneyTree.

[4] Environmental Information Technology (IT) and Enabling Technologies had also been considered cleantech categories by the Cleantech Venture Network until October 2006.

[5] Cleantech Venture Capital: How Public Policy Has Stimulated Private Investment, May 30, 2007 *http://www.e2.org/jsp/controller?docId=12959*

[6] "DOE Selects Six Cellulosic Ethanol Plants for up to $385 Million in Federal Funding" *http://www.energy.gov/news/4827.htm*

850 to 1180.6. This growth outpaced that of the S&P 500 Index (+28.6%), the NASDAQ Index (+29.9%), and the Dow Jones Industrial Average (+26.1%) over that period. After Sunpower and Suntech went public in late 2005, no fewer than seven photovoltaics companies (Canadian Solar, First Solar, PowerFilm, Akeena Solar, ReneSola, Trim Solar Limited, and Solarfun Power Holdings) went public in 2006. Recent IPOs in the biofuels sector have included Aventine Renewable Energy, Pacific Ethanol, Verasun, and U.S. BioEnergy. Perhaps because of this robust IPO market and the increase in publicly traded companies, the past two years in cleantech investing has moved from a specialty area of investment to one with broad participation from all major venture capital firms.

FINDING 2: ENERGY PRICES, ENTREPRENEURIAL TALENT, AND ADVANCES IN TECHNOLOGY ARE INDUSTRY FACTORS ACCELERATING GROWTH

Several important factors accelerated cleantech's growth in 2006:

• Sustained high oil prices have driven investor interest in alternative fuels. Most alternative fuel business plans are designed to compete with oil prices above $40 to $45 per barrel.

• As the cleantech market matures, it is attracting entrepreneurial management talent from other venture sectors—especially from information technology and biotechnology. These experienced entrepreneurs make it both easier to attract investments and more likely the company will develop into a viable business.

• Advances in technologies have been the basis for many new companies, including nano-materials used in thin-film solar and new chemistry in battery technologies.

FINDING 3: PUBLIC POLICIES AT THE NATIONAL AND STATE LEVEL HAVE ACCELERATED CLEANTECH GROWTH

National and State policies have provided early foundations for many cleantech sectors, although investors do not expect those policies to continue in the long term. While the federal government has ramped up its efforts to promote ethanol, the current boom is primarily the result of states rapidly phasing out the MTBE gasoline additive and replacing it with ethanol. Venture activity in corn and cellulosic ethanol was a significant portion of investment growth in 2006, and investment in renewable electricity has been driven primarily by state renewable portfolio standards. Policies that provide long-term certainty are the most successful at driving business investment.

FINDING 4: CLIMATE CHANGE IS BEGINNING TO INFLUENCE GROWTH IN CLEANTECH

Many of the biggest news stories of the past few years have been tied directly to extreme weather phenomena—from disastrous hurricanes to record droughts, wildfires, heat waves, and melting polar icecaps. The public has grown increasingly aware of environmental issues, judging by public opinion polls showing rising public concern about global warming and energy security. Investors, sensing the level of public interest in these stories—and therefore an opportunity in the market—are beginning to invest in industries that reduce human impacts on the ecosystem. Climate change policies will play a key role in the growth of cleantech as it becomes increasingly apparent that products and processes that reduce greenhouse gases will see increased demand.

FINDING 5: CLEANTECH CAN CREATE THOUSANDS OF NEW JOBS

Analysis from the University of California at Berkeley[7] concluded "the renewable energy sector generates more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment than the fossil-fuel-based energy sector." E2's own analysis found that every $100 million in venture investment generates an average of 2,700 new jobs. We estimate additional U.S. cleantech investment between 2007 and 2010 will be between $14 billion and $19 billion, resulting in 400,000 to 500,000 new jobs. If one uses the data from the National Venture Capital Association of 3,500 jobs per $100 million, the job figure could be as much as 665,000 jobs.

Lots of good news for the industry, and much remains to be done. In spite of the many steps that have been taken in support of the cleantech industry, barriers still

[7] Kammen, D., Kapadia, K., & Fripp, M. "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?" Energy and Resources Group/Goldman School of Public Policy at University of California, Berkeley. (2004). *http://rael.berkeley.edu/files/2004/Kammen-Renewable-Jobs-2004.pdf.*

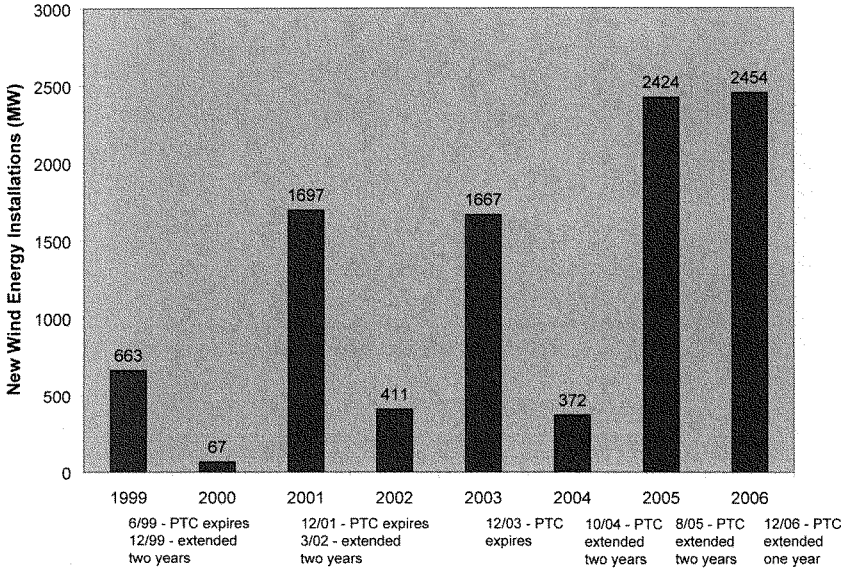
remain, keeping it from growing fast enough to head off the climate crisis. The most common barriers are inconsistent policy, long term subsidies for conventional industries, and trade barriers.

Although government agencies play key regulatory roles in some venture backed industries, they have generally been even handed (in the case of the FDA and Biopharmaceutical approvals) or an agent of change for the future (in the case of the breakup of ATT in the 1970s), creating competition to the benefit of the economy, consumers and employees. The energy industry is different as the existing infrastructure protects the existing companies and the status quo. For example, customers do not directly choose the source of their electricity. Their electric utility company makes that choice for them.

We did a survey of investors in Cleantech, and among the investors we surveyed, the most often cited complaint about the current regulatory environment surrounding cleantech was the inconsistency and unpredictability of policies affecting the industry. In an open-ended question about industry barriers, 37 percent of our survey respondents volunteered their strong desire for a long-term, predictable approach to policymaking in this arena. As one investor noted, "If the federal policy is unclear or inconsistent, it introduces an element of risk that detracts from the attractiveness of a potential investment. If a federal policy is supportive and appears stable, it makes the investment more attractive." It appeared to be the group consensus that a less than perfect—but predictable—policy would be preferred over a better policy that comes and goes and can't be relied on.

Take the wind energy sector as an example. The renewable energy Production Tax Credit (PTC) is equally important to the success of the wind energy industry, which faaces both economic and technical hurdles in competing with traditional fossil power sources. But unlike the VEETC and the ethanol import tariff, which have remained in place for many years, the PTC has suffered a yo-yo like fate, lapsing and being renewed approximately every two years—to the consternation of investors and companies, who find themselves unable to plan ahead in such an uncertain environment. As a result of this policy uncertainty, the wind industry has experienced a dramatic boom-bust cycle, as the figure below demonstrates.

The Production Tax Credit and its Impact on Wind Energy Installations



Source: Union of Concerned Scientists and American Wind Energy Association

Another barrier that investors mentioned regularly in the survey (27 percent of the investors surveyed discussed it) is the fact that cleantech products aren't playing on a level playing field with traditional alternatives. These respondents believe that conventional technologies (e.g. fossil fuels) regularly receive large government sub-

sidies that give them a price advantage, even though these technologies have been mainstream for decades. (According to the U.S. Government Accountability Office, the petroleum industry alone received as much as $150 billion in tax incentives between 1968 and 2000.[8]) One investor suggested "corporate welfare for larger companies provides a hidden subsidy to non-cleansed, companies. Provide equal subsidies for all technologies, or provide none. Let market forces decide the best application of innovation."

While the relatively modest subsidies and incentives that the cleantech industry receives always receive intense scrutiny, the large, long-term subsidies that conventional industries are given are more often taken for granted. Investors were not, however, arguing for large incentives to prop up the industry. As Bill Reichert, Managing Director of Garage Technology Ventures said, "The investment has to make sense independent of the public policy or the subsidy or the environmental fad of the month."

As the investors in our survey noted, cleantech products are frequently at a competitive disadvantage compared to conventional products. In addition to receiving significant subsidies, conventional products generally waste more natural resources and emit more pollution than cleantech products, thus imposing a cost on society that is not reflected in their price tags. In order to help level the playing field the prices of products need to better reflect their true economic costs to society, thereby sending a signal to consumers about the real effects of their choices.

Congress needs to consider an integrated set of policies which will both address climate change and will stimulate private investment to provide the solutions. I will briefly mention three important policies:

1. Mandatory National Carbon Cap

A mandatory, comprehensive national cap on greenhouse gas emissions, coupled with an emissions trading market, would immediately place a value on the release of carbon dioxide and other greenhouse gases, rewarding those companies that already operate in a clean and efficient manner, and forcing those companies that do not to improve their performances. More importantly, any changes that industry would make to reduce its environmental footprint and come into compliance with the cap would be done efficiently. By establishing an economy-wide cap on greenhouse gases—without specifying specific technologies or strategies—the market would naturally find the most cost-effective responses, whether by purchasing emissions credits, becoming more efficient, or altering the materials or processes used. Thus it should come as no surprise that 59 percent of respondents in our survey (17 of 29) said a national mandatory cap-and-trade system would be critical or important in influencing their investment decisions.

When ten major U.S. corporations[9] joined forces with four environmental advocacy groups in January to form the U.S. Climate Action Partnership (USCAP) and called on Congress to quickly pass legislation to tackle global climate change, it became clear that a significant, growing portion of U.S. businesses believe a carbon cap is necessary for U.S. competitiveness. USCAP, whose corporate members have a combined market capitalization of over $850 billion and whose non-profit groups have well over one million members worldwide, specifically called for a mandatory cap-and-trade program, along with an accelerated technology research, development and demonstration program, and diplomatic efforts to convince other countries to follow suit.[10] As of July, USCAP had grown to 29 members organizations.

The unprecedented action of business leaders, including those from the utility industry, proactively and voluntarily seeking government regulation has been repeated several times since the January 2007 press conference. In March 2007, under the leadership of CERES, more than 50 major institutional investors with combined funds under management exceeding $4 trillion signed a statement asking Congress to impose clear, consistent climate change regulations to help them mitigate climate change risks. Because ill addition to making them more competitive globally, a national carbon standard would allow American companies to avoid having to navigate a chaotic maze of state-by-state climate policies. "Without national policies, the competitiveness of American business will be compromised. We don't think we can

[8] "Tax Incentives for Petroleum and Ethanol Fuels." U.S. Government Accountability Office. (September 25, 2000). *http://www.gao.gov/archive/2000/rc0030lr.pdf.*

[9] This group has since been joined by ConocoPhilips, the third largest U.S. oil company and second largest U.S. oil refiner, with a market capitalization of $116 billion.

[10] "Major Businesses and Environmental Leaders Unite to Call for Swift Action on Global Climate Change." (Press Release). United States Climate Action Partnership. (January 22, 2007). *http://www.us-cap.org/media/release.pdf.*

wait," said Fred Buenrostro, Jr., CEO of CalPERS, the country's largest public pension fund.[11]

One week prior to the March 2007 CERES announcement, a bipartisan group of Silicon Valley venture capitalists and entrepreneurs testified in Congress about the need for greater federal tax incentives and research funding in cleantech. With a sense of urgency, they also recommended consolidating all federal energy research into a National Institute of Energy that could support public-private partnerships, in the model of the medical sciences' National Institute of Health. "We are in a crisis, and we have to translate this crisis into opportunity. Missing this moment would be horrible." said Aart de Geus, CEO of Synopsys, an electronic design automation company.[12] These business leaders are also part of a bipartisan group of dozens of technology company CEOs known as TechNet, which also advocates establishing a national 9renewable portfolio standard, a national renewable energy credit marketplace, and a system of long-term, declining incentives for clean technologies.[13]

2. National Renewable Energy Standard

California's experience over the past few decades demonstrates that, far from hurting an economy, well-designed cleantech regulations—such as California's advanced energy efficiency and air quality regulations—can actually stimulate innovation, leading to new economic growth. Knowing that, it becomes clear why 65 percent of the investors we surveyed (19 of 29) said a national renewable energy standard would be a critical or important factor in their investment decisions. In the increasingly carbon-constrained world in which we live, improving the performance of our renewable energy technologies through innovation will be extremely important—not only for our environment but for our economic competitiveness as well. A national renewable energy standard could be a major contributor in driving this innovation in next-generation clean energy technologies.

3. More Public R&D Investment

While growth of the clean technologies would benefit from programs that increase demand (for example a cap-and-trade system or renewable portfolio standard), the industry still needs strong investment in basic R&D. Since the energy crises of the 1970s, federal spending on energy research is down significantly, with private investments making up some, but not all, of the difference. Fortunately for the cleantech industry, public and private investments in complementary industries such as biotechnology, semiconductors, and software have been quite strong in recent years, and there is a high degree of technical knowledge spillover from these industries to cleantech sectors. In fact, some of the same people who were involved in startup companies in those other industries in the 1990s are now getting involved in ethanol and photovoltaics companies, among others.[14]

Still, the success of the cleantech industry should not depend on spillover from its cousin industries, or from private investment alone. Public investment in cleantech research is also crucial, for several reasons:

- In its magnitude alone, it can accelerate the pace of research innovation and development.
- It helps to reassure private investors that this area is important to the public, is worth investing in, and will receive real public support. As one investor in our survey said, public support from individual states "sends a message to entrepreneurs, investors and others that the state intends to create a business environment that is supportive of cleantech."

Public investment in basic R&D is still necessary to growing new industries of the future. The investors participating in our survey noted that a cleantech product must be able to stand on its own merits, and while they would not invest in a company solely on the basis of government support or subsidies, many noted that government investments are important and would encourage a higher level of private investing. For instance, 59 percent of respondents (17 of 29) said that a government program that matched private investment dollars would be critical or important to their investment decisions. One investor even noted that his fund's specific investing

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[11] Herbst, M." Investors Call on Congress to Go Green." Business Week. (March 20, 2007). *http://www.businessweek.com/bwdaily/dnflash/content/mar2007/db20070320*_535194.htm?chan=top+news_top+ness+index_top+story.

[12] Davies, F. "Silicon Valley Leaders: Political Climate Right for 'Green Tech.'" San Jose Mercury News. (March 15, 2007). *http://www.mercurynews.com/search/ci*_5440875.

[13] "Green Technologies: An Innovation Agenda for America." TechNet. (2007). *http://www.technet.org/resources/GreenTechReport.pdf.*

[14] Richtel, M. "Start-up Fervor Shifts to Energy in Silicon Valley." The New York Times. (March 14, 2007). *http://www.nytimes.com/2007/03/14/technology/14valley.html?ex=1176609600&en=678b72b953a2ae32&ei=5070.*

strategy is to "leverage publicly funded research at labs and universities, so greater investment on the federal level in that research would be beneficial, as long as it is focused on commercial outcomes."

THE IMPORTANCE OF IMPLEMENTATION

Aside from the policies themselves, the manner in which they are implemented is crucial to their success. For instance, it's very important that when a carbon cap (or renewable energy standard or other program) is enacted nationwide, that measure should not preempt states from going even further. If particular states or regions want to enact more stringent carbon caps, or more aggressive renewable portfolio (or fuel) standards this will only improve the country's environmental health and competitiveness in the cleantech marketplace—it would cost other regions nothing.

The consistency and reliability of the federal policies that are enacted is another important factor. As mentioned earlier, 37 percent of the investors participating in our survey (11 of 30) responded to an open-ended question about the barriers facing the industry by stating the necessity of having predictable, long-term policies in place. This is a strong concern of many stakeholders in the industry. Given that many cleantech companies must compete against subsidized conventional alternatives, having supportive policies stripped away unexpectedly can wreak havoc on them. This is plainly evident in the wind installations and production tax credit. Entrepreneurs and investors both need to have the ability to plan ahead beyond the end of the current fiscal year.

There are questions often asked when these topics are discussed, I will try to anticipate a few of these.

1. It seems like investment and activity in Cleantech is growing and healthy, so why should the government intervene?

Because we are in a crisis. A dramatic decrease of carbon released into our climate has to happen quickly. Without intervention, our auto industry has made no progress at all in increasing mileage and decreasing emissions in decades, while Japan and the European community already meet or exceed the 35 mpg standards proposed for the United States to meet by 2018 (the most aggressive proposal)! This has helped neither the environment, nor the American auto industry. While California has passed legislation requiring power it buys to be generated through clean technology, there are those in Congress who would like to see this overturned, as it is more aggressive than what other states might demand. California's Greenhouse Gases Emission Performance Standard Act (SB1368) that became law on January 1, directs the California Energy Commission to set greenhouse gas emissions standards for the baseload electricity used by the state (whether generated in-state or imported from out of state).[15] The law effectively prevents the state from signing any long-term procurement contracts for traditional coal-fired power, or any electricity that comes from sources that emit more than a clean, efficient natural gas power plant. (However, the law doesn't explicitly ban any particular form of energy generation—electricity from coal plants with carbon sequestration, for example, would still be able to be sold in the state.)

While almost no electricity from coal is currently generated inside California, the state still imports a fair amount of coal-generated power from outside its borders—and at last count, dozens of new coal power plants were being planned for construction in western states, many with the aim of selling their power in the growing California electricity market. But SB1368 sends a strong signal to western energy markets, aiming to discourage these large, long-term investments in highly polluting technologies. As a result, cleaner production technologies, like geothermal, wind, or small hydro, will receive a significant competitive advantage in the state.

2. Is this just a bubble that will blow away and things will return to normal?

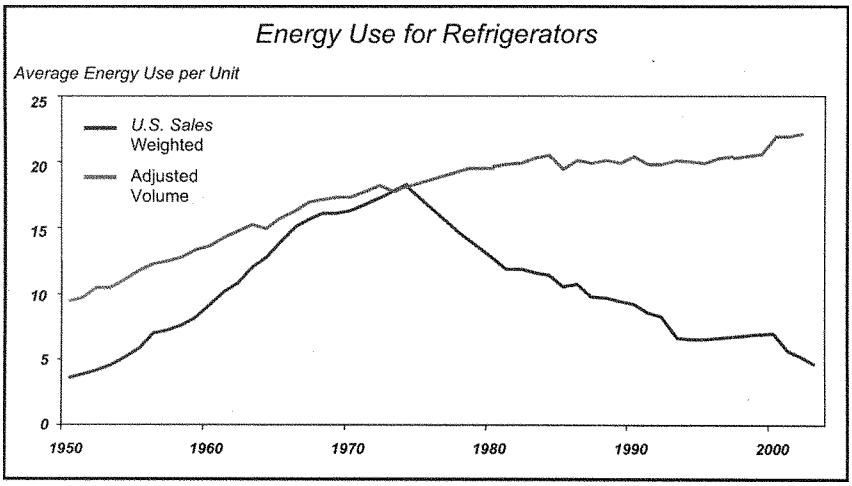
No, the world has changed. In the last 10 years over 400 million people have emerged from poverty in India and China. They want cars, refrigerators. They want to travel and have air conditioning when it is too hot. They want to live like us, and to do that they need to have as much energy as we use. Meanwhile, the industrialized world continues to use as much energy as ever. Competition for resources has irrevocably changed the game.

3. Will this mean that the government picks winners and losers?

No, it does not. The government did not tell automobile manufacturers how to increase mileage when the first CAFE standards were set. Nor did it tell refrigerator

[15] "Senate Bill No. 1368." California Energy Commission. (September 29, 2006). *http://www.energy.ca.gov/ghgstandards/documents/sb*1368_bill_20060929_chaptered.pdf.

manufacturers how to reduce their energy consumption (since those standards were set in the 1970's, energy use in refrigerators has dropped 75%, the equivalent of not building 100 to 300 power plants). But the government did tell them they HAD to meet performance standards, and they did. We recommend a declining carbon cap coupled with federal R&D in a variety of technologies. Let the market have a flatter field for competition.



4. Does this mean that every company wins with a carbon cap strategy?

Not at all. Change has always been a constant, the components of the Dow Jones Index continually have turned over since it's creation over 100 years ago and our economy thrives by creating industries that add jobs and that add value. Some companies will resist change and those that are better at adapting will replace them. The result will be a net increase in economic output and jobs and a more competitive U.S. This has always been so. Industries that expect or need the government to protect them from change cannot compete in the modern world (if in fact they ever could in any era, today there are no Railroad, Steel or Airline stocks in the Dow).

5. Should the U.S. link its carbon policy to decisions by China and India?

Only if we want to slow ourselves down. Our contribution to Global Warming is significant and needs to be reduced. California decided that an early start on climate would make the state more competitive vis-à-vis the rest of the U.S. The U.S. will be in a better position to sell cleantech to China and India if we get our country moving first. As we continue to show that our policies create a more robust economy and a cleaner environment, they will rush to join us. They already have a significant appetite to buy cleantech products and services, and they are now buying some of them from countries other than us. The U.S. is no longer the world leader in two important clean energy fields—it ranks third in installed wind power production behind Denmark and Spain,[16] and third in photovoltaic power installed behind Germany and Japan. We can regain market leadership with a simple policy of a declining carbon cap coupled with federal R&D is a variety of technologies.

6. What else should we be doing?

We need to be the people the world has been waiting for, the people our children will say made the decisions that gave their children a safer and healthier place to live. We should not be the people who pass the buck, the people our parents warned us about.

Senator BOXER. Mr. Unger, thank you so much. I so agree with the view and so far, everyone, I just think that you really put it into the perspective that we need to think about it as, you know,

[16] World Wind Energy Association. (2007). *http://www.wwindea.org/home/index.php?option=com_content&task=view&id=167&Itemid=43*

we all need to make a living and we all need to take care of our families, but we need to also do something that gives back.

Otherwise, it's useless. I think the beauty of this is we're showing that we can do both. We can do well and we can do good for society. You should be proud of that and I think—and you are and I think you need to say that more, and don't be inhibited because you need to challenge others who have the ability to join with you. Then it's just unstoppable.

Bruce Klafter, a senior director, environmental health at Applied Material, welcome.

STATEMENT OF BRUCE S. KLAFTER, SENIOR DIRECTOR, ENVIRONMENT, HEALTH AND SAFETY, APPLIED MATERIALS

Mr. KLAFTER. Thank you, Senator Boxer. I have the corporate responsibility and sustainability for my company. I welcome the opportunity to be here today. I thought it would be instructive for you and the committee to learn a little bit about how an established Silicon Valley company is attacking some of the problems we're discussing today.

It's becoming a very substantial business for us and our contention is that the same economic engine that's been fueling the boom here in Silicon Valley can be extended into tackling problems like global warming and I think it holds tremendous promise.

We've already seen this business take off tremendously for us and wanted to give you a little context about this. Applied Materials is a 40-year-old company. We're celebrating our 40th anniversary this year. We're the global leader in nanomanufacturing technology. We have portfolio of products that are used to fabricate semiconductor devices. We are also now providing equipment that's used to manufacture low E low maintenance glass, thin film photovoltaic panels, and a variety of other products.

As what we call an infrastructure company, a company that produces manufacturing equipment, we can play a vital role in commercializing some of the technologies that you're hearing about because the key to proliferating them is the ability to manufacture them at a reasonable cost.

That's been our value proposition for 40 years and that's what we're trying to do right now. We recently reorganized some of our company and announced the formation of an energy and environmental solutions group which contains some of the working groups that are working in these particular areas.

So just a couple of words about the products we're making. The one that we announced last year in September 2006 was a thin film photovoltaic factory production line. We're providing entire factory product lines to customers around the world to manufacture photovoltaic thin film.

So this is not traditional crystalline silicon that you see on roof tops that Mr. Cinnamon's company installs and so on. This is a different type of product, related technology converting sunlight into electricity. We're going to move into other areas of EV or photovoltaic in the future as well.

We announced, again, this strategy in September of 2006 and just at the time that's passed since that point we've already announced seven contracts worth over $500 million in Spain, Ger-

many, China, Taiwan, and elsewhere, so you mentioned in your introductory remarks the importance of establishing product that we can export around the world providing solutions to global citizens.

That's exactly what we've been able to establish in this short a time. We hope to enter into contracts with U.S. customers as well. We'd like to see manufacturing of this product in the United States but we've already established tremendous tracks around the world and I share Mr. Cinnamon's observations about the fact that Germany and other countries have been leading the way.

We need to establish U.S. presence in this industry as well. Now, the focus of our discussion today is green jobs. Just in that time and also understand we've been laying strategy—the foundation of it for some time.

But approximately 10 percent of our global workforce now, that's about somewhere between 14,000 and 15,000 individuals, 10 percent of that workforce is now employed in the energy environmental solutions area, so well over a thousand people. As the others mentioned, these are all very high paying, very good jobs.

We have engineers who are optimizing the process. We have engineers who are laying out the factory line. We will have engineers and technicians that will travel around the world to install these production lines and help our customers make them work and optimize the output from those lines.

We expect to see from each one of these factories that we set up additional jobs created. Our estimate is that while this is a fairly highly automated type of process, there will be at least 150 or more jobs in each one of these factories that are set up. As these are scaled up from 40 or 50 megawatts of annual production perhaps to a gigawatt, where you put several of these factory production lines together, you'll have hundreds of jobs in each one of these locations.

Our hope is this will become a distributed type of manufacturing process where we are not shifting products around the world to see them where we need to consume them.

The other thing I wanted to point out today in the time I have that we shouldn't overlook the fact that responsible corporations around the world are also customers of these technologies. We are turning on our own 28 kilowatt solar installation in Austin, Texas next week. That has to be the largest commercial installation in Austin at the present time, and later this year we'll begin installing a two megawatt installation in Sunnyvale, California which we believe is the largest corporate installation in the United States.

We hope that we'll be leapfrogged in the future, but we're very happy to make a substantial investment in that type of technology ourselves. So thank you very much.

[The prepared statement of Mr. Klafter follows:]

STATEMENT OF BRUCE S. KLAFTER, ON BEHALF OF APPLIED MATERIALS, INC.

Honorable members of the Committee, Senator Boxer, Senator Inhofe, my name is Bruce Klafter. I am Head of Corporate Responsibility and Sustainability for Applied Materials, Inc., and am based in our Santa Clara, California, headquarters. Applied Materials. is the global leader in nanomanufacturing technology solutions with a broad portfolio of innovative equipment, service and software products for the fabrication of semiconductor chips, flat panel displays, solar photovoltaic cells, flexible electronics and energy efficient glass

Founded in 1967, Applied Materials creates and commercializes the nanomanufacturing technology that helps produce virtually every semiconductor chip and flat panel display in the world. The company recently entered the market for equipment to produce solar arrays and energy efficient glass. To support our customers, Applied Materials employs approximately 14,000 people throughout the world (8,000 in the United States). In fiscal year 2006, Applied Materials recorded net sales of U.S. $9.17 billion. We are pleased to offer this testimony to the Committee and hope that an explication of Applied Materials green business strategy will be instructive to the Committee's understanding of the tremendous opportunities created by taking action on global warming.

GREEN MEANS GROWTH

Applied Materials is making significant investments of capital and other resources into developing and growing substantial new lines of business focused on "green" technology. By "green" technology, we are referring to a variety of equipment, products and services that enable generation of energy from renewable sources, help our customers use energy as efficiently in their operations and that prevent or minimize the greenhouse gases generated in those same operations. Our new Energy and Environmental Solutions Group reflects our view that "going green" creates jobs and economic opportunity.

It is also our view that the United States Congress has an important role to play in crafting legislation that promotes development of innovative, advanced green technologies, that encourages businesses and consumers to employ those technologies and that creates conditions favorable to the domestic manufacture and distribution of green products. As one of the leading high-technology companies in Silicon Valley and the world, we have long worked with Congress and federal agencies to help to fuel the amazing job creation engine that high tech has become. Green jobs are a natural extension of the high-tech job phenomenon with the added benefit of making direct and important contributions to addressing some of the most pressing problems facing the world today. Applied is involved in several green technologies:

Photovoltaics.—Photovoltaics, or more commonly, direct conversion of sunlight to electricity, has long represented a great opportunity for the world to access clean, renewable energy. Solar energy generation produces no pollution and requires little or no maintenance. It can be distributed throughout the grid, and offers the most power during peak demand periods. By alleviating peak power demand, solar energy lowers the number of conventional power plants needed, and reduces strain that causes transmission failures. Despite these advantages, solar currently generates a very small fraction of total energy generation in the United States.

As worldwide energy demand continues to rise, the overall solar equipment market is expected to grow from approximately $1 billion in 2006 to more than $3 billion in 2010, according to industry estimates. Just last week, one analyst predicted the thin-film PV market could grow to $7.2 billion by 2015. Notably, these estimates do not include additional opportunities for service-related growth, so the real economic impact will be a much larger number. Applied Materials intends to capture and accelerate this growth by dramatically lowering the cost to produce solar cells, thereby allowing widespread generation of this clean, renewable energy.

Glass Coatings.—Collectively, buildings in the United States consume 68 percent of all electricity. Direct energy purchases for household and vehicle use constitutes approximately one-third of the energy demand in the United States. Our Glass Coating Products Group aims to make a dent in those demands, window by window.

We design and manufacture equipment that coats architectural glass (the kind seen commonly in homes, offices, as well as commercial and industrial buildings) with "low eminence" (Low-E) materials. Low-E materials are high-quality metal/oxide films on glass that reduce the flow of heat into and out of buildings. Low-E glass improves efficiency of buildings heating and cooling while still allowing light to pass through the windows (solar gain).

Our Low-E glass coating equipment, manufactured in North America and Europe, has contributed to reducing the cost of energy-efficient glass 10-fold over the last decade, bringing new building technology to many consumers for whom costs have previously been prohibitive. These high-quality films on architectural glass have facilitated energy efficiency improvements in buildings worldwide.

Today our installed base of this equipment in glass manufacturing plants has enabled the application of energy efficient films on more than 20 billion square feet of architectural glass. The savings in energy enabled by our films and equipment is roughly equivalent to the oil contained in 57 large oil tankers. Stated another way, the total energy saved through installation of windows coated using Applied

Materials technology equates to the amount of energy it would take to heat 30000 homes for one year.

In developing economies such as China and India, our equipment was the first of its kind installed in architectural glass factories that are making the Low-E glass used in buildings and in areas where extreme temperatures are the norm. More than 100 Applied Materials employees work in Fairfield, California, manufacturing our glass coating equipment. More than 80 percent of these systems are exported to Asia and other markets through the Port of Oakland. These regions represent important markets for exports of American equipment. While these export success stories are good news, it is important to note that these factories are not being built in the United States. We believe this can change if the right mix of public policies is put in place.

Automotive Glass.—In addition to providing technologically advanced solutions for lowering energy demands in buildings, our Glass/Web products increase energy efficiency in hundreds of thousands of automobiles. Known in the automotive world as Solar Infrared Reflective glazing, or SIRR, coated automotive glass reflects more than 60 percent of the sun's thermal heating potential from the car interior. This improves fuel consumption and comfort, by reducing the need for air conditioning without reducing visible light. This translates into a savings in vehicle tailpipe emissions and greater fuel economy.

Our aim is to improve market access to SIRR glass for automobiles and Low-E glass for buildings. As energy conservation becomes more important to society and regulatory initiatives develop, our technology will enable integration of these important technologies in buildings and cars.

ECONOMIC IMPACT

Applied formally announced its solar strategy in September, 2006 and in the space of just 10 months the company has entered into seven contracts worth over $500 million and representing over 200MW of annual thin-film PV production. Within Applied Materials, approximately 10 percent of Applied's global workforce of 14,000 employees is involved in the production or servicing of our green products. Throughout Silicon Valley, hundreds of jobs are already tied to solar and more are added all the time. It is worth noting that the business will generate a wide variety of well-paid jobs requiring different skills and experience: design engineers; engineers optimizing the production process itself; engineers designing the factory layout; installation teams; service technicians; and a wide variety of jobs such as sales and account teams, marketing, etc. Distributed solar energy always involves local distribution and installation and Applied Materials' customers will establish partnerships with many PV integrators and installers, each of whom will employ technicians and many others.

Externally, green products drive economic development and jobs as well For example, a newly announced plan to build a new 40-megawatt facility in Bielefeld, Germany, to become operational by mid-2008, would add 150 long-term jobs (and this does not include the construction jobs). Our own internal analyses for operation of a 60–MW thin-film fab estimate 160 employees per fab. The economics of producing solar power collectors favor manufacture close to the market, which means there could be dozens of these plants in almost every region of the country. If the right set of policies are in place to stimulate demand by commercial and residential customers, solar demand will drive this investment.

Estimates of the job-generating impact of just PV vary, but all are significant. According to the Solar Energy Industry Association, for example, extending the solar tax credit could bring 55,000 new American jobs and more than $45 billion in economic investment. According to a study by Dr. Roger H. Bezdek of Management Information Services, Inc., and the American Solar Energy Society, US private-sector employment in photovoltaics last year was approximately 7,000 direct jobs and 16,000 indirect jobs. Depending on the public policy environment for PV technology, this sector could grow to anywhere from 200,000 to 750,000 employees by 2030. These are significant numbers and involve mostly high-paying jobs.

Similarly, a recent paper from the IC2 Institute at the University of Texas in Austin cites research showing "renewable energy generates more jobs in its construction and manufacturing sectors, per megawatt of installed power capacity, than does fossil fuel generation. Specifically for PV generation, far more jobs are produced constructing PV facilities than are produced by the construction and operation of coal and natural gas-fired plants."

At this point, it is instructive to compare the United States with the world leader in renewable technologies—Germany. Germany has about one-fourth the GDP and

population of the United States, yet renewables employ 20,000 more workers than in all of the United States (approximately 214,000 there vs. 194,000 here).

Applied is intent on leading others to make investments in solar photovoltaic energy. Earlier this year we announced our plan to install a 2.0 megawatt (mW) system on our main R&D campus in Sunnyvale, California. This will be one of the largest PV installations on an existing corporate campus in the United States, if not the largest and involves a multi-million dollar investment. In addition, Applied has already installed a 28 kW system at our manufacturing facility in Austin, Texas. The Austin installation is one of the largest commercial PV systems to date. Our plans are an illustration of how policy can influence decisionmaking—we were able to make the California installation substantially larger because there are financial incentives in California that scale to the output of a system. The incentives in Texas, by contrast, are minimal. With action by Congress, hopefully solar and renewable policy nationwide can be enhanced.

POLICY RECOMMENDATIONS

First and foremost, Applied urges the extension and expansion of a robust solar investment tax credit. Although the Senate's energy bill did not include tax provisions, the House did include tax provisions in its bill and we hope the Senate-House conference report will include a tax title. We would like to see a combination of the best elements from both chambers, which would include an eight-year extension of both the residential and commercial investment credits and a removal of the $2,000 residential cap. Importantly, the solar tax credits should be able to offset fully any AMT (alternative minimum tax) liability.

Although it benefits other renewables far more than solar, we generally favor a national renewable portfolio standard and would like to see inclusion of a solar "set-aside" or triple credit for solar in any RPS scheme. This would be a temporary measure that would disappear as the industry matures and achieves commercial viability.

The creation of ARPA–E in the America COMPETES Act is another welcome step forward. We would hope that at least some portion of the increased funding toward STEM (science, technology, engineering and mathematics) education be directed toward solar energy because we face a serious shortage of talent in this industry.

Moving forward, we would strongly support Senator Menendez's bill S. 1016, the Solar Act. This measure would establish national standards for the interconnection and net metering of solar energy systems, based on the most progressive state standards to date. The legislation would require utilities to credit their customers at retail electric rates for supplying excess solar power to the grid. The bill would also establish that ownership of renewable energy credits (RECs) resides with the solar system owner for purposes of selling or trading to meet a state or federal renewable portfolio standard.

On the international trade front, we strongly encourage the US Trade Representative to continue its efforts to negotiate a sectoral agreement that would reduce or eliminate tariffs on environmentally friendly goods. Such an agreement could do for "green" what the Information Technology Agreement has done for IT products.

CONCLUSION

Applied Materials is convinced that the issues of climate, energy and environmental stewardship are serious challenges, but we are equally convinced of our ability to tackle these challenges successfully. We are confident that our technology, ingenuity and inventiveness will turn these challenges into an economic win for the United States and that Silicon Valley will again lead the way.

Senator BOXER. Thank you, sir. I think it's an important point to walk the walk and to utilize these new amazing technologies. I just—right before I came here I did two stops. The second stop was at Sun Microsystems where they showed me their conservation program.

They took a lot of campuses and they consolidated them. That's the first thing they did, and then this amazing innovation of the way they cool their huge servers onsite as opposed to cooling the room.

So they—as the heat comes out they cool it immediately at the site and they have saved already 50 percent of their energy bill. Imagine the numbers we're talking about here. As we get to the

point where now they're telling us some of their customers are complaining the cost to run the computers is now almost more than the cost of the computer itself.

So the energy factor in all of this, you all know this, this is what you're dealing with. This is the potential that the solar folks are going to go after. What they have done, I just hope you will go visit them because, actually, they want to become the model, and I gave them a little conservation award.

The fact that they have figured out a way to reduce their cost by half, and they've just sort of gotten started and they installed all this new type of equipment. It's pretty remarkable in less than a year so you might want to run over there.

But your point, Mr. Klafter, is right. We need not only to invent these technologies, we need to start using them here, to have your technologies be sold elsewhere and not here doesn't make much sense, does it? OK.

So moving along, Mr. Pat Zimmerman, director of the Institute of Atmospheric Sciences at the School of Mines and Technology, welcome, sir.

STATEMENT OF PATRICK R. ZIMMERMAN, PH.D., CHIEF TECHNOLOGY OFFICER, C–LOCK TECHNOLOGY

Dr. ZIMMERMAN. Thank you, Senator Boxer, for the opportunity to testify today. I have a good example of what even the preregulatory phase of a cap and trade system has done. As of August 1, I resigned my position as director of the Institute of Atmospheric Sciences as a professor of the Department of Atmospheric Sciences to become the chief technology officer for C–Lock Technology.

C–Lock Technology is a wholly owned subsidiary of Evergreen Energy that was created based on patented technology that I developed at the Institute of Atmospheric Sciences. Our technology is focused on creating a framework that will accurately quantify greenhouse gas emissions.

Quickly, it will minimize transaction cost. It's very transparent. It increases the ease of independent third party verification, and it provides offsets that can be mixed from various sources to maximize liquidity. All that is designed to minimize transactional cost so rewards go directly to the people and businesses that create offsets.

So today I'm going to talk a little bit about some of the things that need to be done in order for businesses like this to do well. Of course, these businesses create many jobs, from my own job to the graduate students that I hire at the university to further scientific research to jobs in rural communities.

The focus of C–Lock initially was on agriculture. We calculate that if a cap and trade—when a cap and trade program is fully implemented that roughly a billion dollars a year can be injected into rural economies and create something like $6 to $7 of additional benefits all along the value chain.

These are jobs in places that traditionally have had low paying jobs. Earlier in my career, I was a scientist at the National Center for Atmospheric Research where our work focused on the interactions between biology and radiation balance of the atmosphere,

and it was an exciting job. It was important to lay the groundwork for understanding climate change.

But when I got the opportunity to move to South Dakota and apply cutting edge science and transform it into technology that people can use every day, to move South Dakota from its extractive agrarian past to a technology driven future, I jumped at the chance.

There's a few things we need. The first thing we need is we need credit for early action. What's holding up the market now is that people are waiting. They're waiting for the rules. I think that an incentive to move forward regardless of what the rules will be will be important.

Those incentives can come as a form of, say, a tax incentive, so that if you buy credits that—that meet certain criteria for they're independently verified, they're scientifically sound, and make a real difference in the atmosphere, will you be sure that some of that investment won't be lost regardless of future rules. That would create a real improvement.

Second, we need some sort of uniformity. Right now 38 states have implemented greenhouse gas rules. They're all slightly different. People who buy credits don't know are these credits compatible with your registry or California's registry or—and so Federal legislation is needed to provide that framework.

Third, we need to resolve issues of ownership. In South Dakota, Wyoming, and Montana much of the land is owned by Federal Government and it's leased by independent operators.

Many of those operators have come to me and said can I earn carbon credits for doing reclamation projects that decrease erosion, that plant trees that are going to remove CO_2 from the atmosphere now. I can't give them an answer.

So we need Federal policy on leased lands that dictates that improvements that are made by the land owner or the lessee belong to the lessee or maybe they're shared, but we need something in writing. We've got to apply those offsets if the ownership is not clear.

But the fundamental framework for all of this has to be science-based. It has to be scientifically sound. It has to be credible. There should never be a farmer who's interviewed who says, "Yes I've been doing no till for 30 years and now I get a chance to be paid for doing no till, so I'm going to keep doing it."

Now, that doesn't mean that you can't design a system that will encourage that farmer to stay in a management practice that continues to store CO_2. In fact, the agricultural sector is vital because all of the technology that we've talked about today, the thing that we can do right now to remove CO_2 from the atmosphere that we need to do right now to keep climate from moving to a state of relatively stable equilibrium to another state of another different climate regime, we need to keep CO_2 from accumulating. Agriculture can do that right now. U.S. agriculture can do that better than almost any agricultural system in the world because almost 60 percent of our land mass is managed, whereas the global average is only 7 percent.

So now we have a framework that's based on science. We have regulations that make sense. We have solutions to focus on what we can do now. Then——

Senator BOXER. Sir, I'd like you to wrap it up because we've got to get to Mr. Collins.

Dr. ZIMMERMAN. OK. OK. Finally, carbon credits need to be valuable. There needs to be a value associated with these offsets so that they create incentives for technological solutions and investments.

So I think it's more important to have a carbon floater price than it is to have a carbon escape valve. Thank you.

[The prepared statement of Dr. Zimmerman follows:]

STATEMENT OF PATRICK R. ZIMMERMAN, PH.D., CHIEF TECHNOLOGY OFFICER, C–LOCK TECHNOLOGY

Thank you Chairwoman Boxer, Ranking Member Inhofe, and members of the Committee for the opportunity to testify today. My name is Patrick Zimmerman. I am the Chief Technology Officer at C–Lock Technology.

A well-designed Federal greenhouse gas cap and trade system will link economic incentives and environmental benefits in ways that will stimulate the economy and create thousands of new jobs across all economic sectors. Our new business, C–Lock Technology, provides an excellent example.

C–Lock Technology is a wholly-owned subsidiary of Evergreen Energy—a company with patented technology to refuse low-rank coals to improve heating efficiency and significantly reduce pollutants. The pollutant reductions include the removal of compounds that affect air quality including sulfur dioxide, oxides of nitrogen and mercury, as well as decrease the emissions of carbon dioxide.

C–Lock Technology utilizes a patented process to quantify, certify and aggregate greenhouse gas emission reductions, avoidances and offsets so that they have maximum value to sellers and buyers. The process was developed within the Institute of Atmospheric Sciences at the South Dakota School of Mines and Technology (SDSM&T). All patents are therefore the property of the State of South Dakota. As the inventor of this process, I negotiated an exclusive license to develop commercial applications of this technology and recently left my position as Director of the Institute of Atmospheric Sciences at SDSM&T to focus on the C–Lock Technology start-up. The new company employs several full-time Ph.D. scientists, technical staff, graduate students and undergraduates. In addition it provides opportunities for SDSM&T professors and their students to collaborate on projects that accelerate the transformation of advanced technical knowledge and cutting-edge science into information and technology that people can use to improve their lives and long-term sustainability,

C–Lock Teelmology is currently participating in the pre-regulatory phase of the U.S. carbon market and is focusing on the opportunities to impact the international carbon market created as a result of the Kyoto Protocol. Our company is actively participating in the education of undergraduate students, MS students and Ph.D. students who will lead the carbon companies of the future. Our industry will need professionals with skills in business, financial markets and derivatives, ecology and environmental science,

engineering, mathematics and computer science. It is especially important to note that our company will provide opportunities throughout small rural communities for individuals with special communication and technical skills to assist farmers, ranchers and businesses with strategies to reduce their emissions of greenhouse gases and sequester carbon in crops and soils.

We have estimated that for eight agricultural states in the Northern great Plains, greenhouse gas offsets generated by farmers who engage in agricultural practices that store organic matter in soil and trees, and ranchers who implement grazing practices that result in carbon dioxide removal and avoid emissions of methane and nitrous oxide, could increase the regional income by more than one billion dollars per year.[1] In addition, activities that reduce greenhouse gas emissions and remove carbon dioxide from the atmosphere and transform them into long-lived vegetation and organic compounds in the soil also provide important environmental benefits including improved water quality, decreased soil erosion, improved drought tolerance,

[1] Assuming half of the farmers and ranchers participate and prices of at least $5/T of carbon doxide equivalent for the next 20 to 30 years.

improved habitat, improved resistance to invasive species, and increased rural tourism and recreational opportunities.

As the policy debate unfolds about the programs to be put in place to reduce greenhouse gas emissions, I encourage you to keep in mind the following characteristics to ensure a robust and fair system:

• First, every economic sector in every state should have the ability to participate.

• Second, every carbon credit must be scientifically sound and reduce human- induced climate change. Legislation must demand high standards so that greenhouse gas emission reductions, avoidances and offsets remain credible. High standards require accurate quantification, independent third-party verification and sound science.

• Third, solutions that can be implemented now must be emphasized—we need to buy time as we develop and implement long-term technological solutions. Immediate removal of greenhouse gases is a higher-priority than permanence because we might reach the climate tipping-point before we can implement long-term-technology.

• Forth, solutions should divide the liability amongst many stakeholders to create more accountability and stability than those that concentrate it in a specific sector.

• Fifth, research investments should not favor specific technologies but rather should be designed to spark innovation. We cannot afford to pre-select the winners now.

• Sixth, to stimulate the fastest development of long-term solutions carbon credits must be valuable. It is a higher priority to maintain a carbon credit price floor than a safety valve.

• Finally, an effective Federal greenhouse gas policy will maximize the U.S. global advantage to provide greenhouse gas offsets now through agriculture and clean coal technology.

Specific Federal issues must he addressed for the greenhouse gas market to move from its current pre-regulated phase where markets are inefficient, standards are poorly defined prices are low and there is a high perceived risk, into the active market phase where resources flow efficiently from the those with potential liabilities to those who can remediate those liabilities in a way that immediately stimulates the production of avoidances, offsets and sinks. Agencies must define the ownership of carbon credits created on federal lands so that if a rancher implements a re-forestation project on Federally-leased land, the ownership of the carbon credits that accrue must be clear for the carbon credits to be marketable.

There should also be provisions that reduce market uncertainties as a result of policy uncertainties. Those who take early action to mitigate their greenhouse gas footprint should be rewarded. Rewards should be in the form of the provision of market certainty. Early action will provide valuable experience to inform wise decision- making In addition, provisions to indemnify and reward early action will stimulate greenhouse gas-related job creation.

Base-lines from which carbon credits are quantified must be anchored to documented improvements from the average business as usual practice. Any other system penalizes those who have taken early actions to minimize their greenhouse gas impacts. Agricultural offsets belong in the market system, not the Department of Agriculture subsidy system.

Federal and international greenhouse gas policies need to converge in order to maximize the liquidity and income potential of greenhouse gas markets. This will increase incentives to generate greenhouse gas reductions, avoidances and offsets, and keep market prices high to stimulate technological solutions and create well-paying jobs.

The U.S. has a huge advantage over many industrialized nations. More than 60% of the U.S. land area is under agricultural management. The global average is just 7%. It is therefore imperative that we take full advantage of our abundant agricultural resources to stimulate immediate greenhouse gas reductions and offsets while future technology becomes viable. This will not only preserve and enhance farm jobs, income, and traditions, buy will also stimulate the creation of new economic opportunities in rural communities.

Senator BOXER. That's very good points all. Thank you so much.

So our last and certainly not our least speaker is Kevin Collins, president and CEO of Evergreen Energy. Following his testimony I've got a few questions. Now, I need to ask my staff if we're going to go and do that press conference after or we're not going to go into the press conference. Yes, no, or maybe?

We need to leave at exactly 12:20. So here we go. Mr. Collins, welcome.

STATEMENT OF KEVIN R. COLLINS, PRESIDENT AND CHIEF EXECUTIVE OFFICER, EVERGREEN ENERGY INC.

Mr. COLLINS. Thank you, Chairwoman Boxer, for the opportunity to testify today. Clean energy including cleaner coal is essential to ensure a better environment. Our national security, economic prosperity, including new American jobs.

Governments, lawmakers, and industries are seeking solutions to lower harmful air emissions and reduce greenhouse gas emissions while meeting growing energy demand, keeping costs low, and achieving results now for the long term.

Our common goal is to put into place the infrastructure, policies, and other steps necessary to achieve success. I'm here today to share with you the story about a unique American technology developed in a Stanford University laboratory only 17 miles from here and financed by the private sector.

This technology provides energy, environmental, economic, and job creation benefits right now. It reduces CO_2 and other emissions. It's a precombustion approach that transform our traditional view of the coal-fuel cycle by improving efficiency and environmental performance. This technology is available not 5, 10 are or 15 years from now, but today.

The solution is Evergreen Energy's refined coal that we produce and market as K–Fuel. Cleaner coal must be a central part of any national energy security policy. The United States has the world's largest known recoverable coal reserves, 270 billion tons, which implies a roughly 200-year supply at current consumption rates.

U.S. coal reserves contain more energy than all the world's oil reserves. Today, about 50 percent of the coal consumed in the United States comes from western mines, up from almost 0 percent in 1970. That's because western coal, one type that works with our K–Fuel process, has less sulfur and therefore cleaner than coal from the east.

Wyoming is the country's largest producing coal State, producing over 480 million tons per year or nearly 40 of the U.S. total. The K–Fuel process chemically replicates nature by chemically and physically transforming coal before it's burned into a clearing burning fuel. Our proprietary precombustion process uses heat, pressure, and time to remove water and reduce pollutants from lower quality coal, thereby raising heat value.

By increasing the heat value of these low rank coals by approximately 25 percent, efficiency is improved so that less tons of coal are consumed to generate the same energy output. This translates into less CO_2 and other pollutants per kilowatt hour generated.

By doing so, I believe that Evergreen Energy can rightfully call itself one of today's solutions to the nation's energy challenges. Refined coal is available today by the ton because we built the world's first coal refinery in Gillette, Wyoming. No doubt the millions of dollars spent on this plant have a significant multiplier effect on the region.

Extrapolating these numbers we can reasonably project that construction and operation of these coal refineries will create thou-

sands of new jobs. K–Fuel stands as an example of how the need for cleaner energy creates new solutions and new opportunities for all Americans, including the potential for new jobs.

Our 750,000 ton per year plant uses modular equipment that can be scaled larger, and Evergreen's plant designs are targeted to produce between 2 to 10 million tons of refined coal per year.

Successful test burns and sales of refined coal to utilities and industrial coal consumers during the past 18 months have demonstrated lower emissions and higher efficiency. Up to 70 percent of the mercury is removed from the coal. We've demonstrated lower levels of sulfur dioxide and nitrogen oxide emissions.

Our engineering calculations show that simply by switching fuel, K–Fuel reduces CO_2 emissions per kilowatt hour generated. Evergreen Energy is planning to further verify CO_2 reduction benefits achieved by K–Fuel later this year through test burns.

By using cheap, abundant low-rank coal from areas such as Wyoming's Powder River Basin, the K–Fuel process adds value and creates markets for these resources. K–Fuel can increase generating capacity from derated power plants and provide a more cost effective emission solution by avoiding costly post-combustion control technology such as scrubbers.

K–Fuel can also be used by plants with existing scrubbers to provide improved efficiency and additional emission reduction benefits. The K–Fuel process is perhaps the only new energy technology that produces rather than consumes large amounts of water.

In the arid west where water resources are valuable, the industrial grade water that is drawn off the precombustion process may have indeed beneficial uses. Evergreen Energy is delivering on the need for cleaner coal today, but as we plan for the future we see significant marketplace opportunities made possible by the vast reserves of low-rank and low cost coal readily available around the world.

Accompanying this opportunity is significant potential for job creation. We're in ongoing discussions with several utilities about locating K–Fuel coal refineries next to their power plants, a concept we call K–Direct. The combined heat and power approach raises efficiency, reduces costs and emission per kilowatt hour.

Located next to a power plan a K–Direct coal refinery uses the plant's waste heat as a power source and produces refined coal and water for the plant's use. Naturally, all the benefits of K–Fuel are there as well, including the opportunity to restore efficiency to derated power plants and reduce or eliminate the need for new or additional back end control technology.

Looking ahead, there's been too much focus on the solutions offered by IGCC, FutureGen, and other advanced coal processes. While these are all promising technologies, they are years from widespread deployment, and I respectfully raise caution about overreliance on a limited number of futuristic number of clean coal technology solutions.

Cleaner coal solutions exist today. This country must have a balanced portfolio of cleaner coal technology comprised of precombustion, combustion, and post combustion technologies that will offer solutions today, years from now, and decades in the fu-

ture at reasonable cost. These solutions need to be accompanied by flexible policies that create balance and equal incentives.

Senator BOXER. I'm going to ask you——

Mr. COLLINS. I'm going to move on rapidly. As leaders and lawmakers you should embrace all energy options, including nuclear, renewables, and energy efficiency while recognizing that coal will and must remain a significant piece of the portfolio.

Evergreen does not view this refined coal as the solution, but as an important solution that deserves to play a role in the Nation's comprehensive energy strategy. We're making coal cleaner, we're creating new jobs, and we're doing it today.

[The prepared statement of Mr. Collins follows:]

STATEMENT OF KEVIN R. COLLINS, PRESIDENT AND CHIEF EXECUTIVE OFFICER, EVERGREEN ENERGY INC.

Thank you Chairwoman Boxer for the opportunity to testify today. My name is Kevin Collins. I am the President and Chief Executive Officer of Evergreen Energy Inc based in Denver.

Clean energy, including cleaner coal, is essential to ensure a better environment, our national security, and economic prosperity, including new American jobs. Governments, lawmakers, and industries are seeking solutions to lower harmful air emissions and reduce greenhouse gas emissions while meeting growing energy demand, keeping costs low, and achieving results now and for the long term. Our common goal is to put in place the infrastructure, policies, and other tools necessary to achieve success.

I am here today to share with you the story about a unique, American technology developed in a Stanford University laboratory only 17 miles from here and financed by the private sector. This technology provides energy, environmental, economic and job creation benefits right now. It reduces CO_2 and other emissions. It is a pre-combustion approach that transforms our traditional view of the coal-fuel cycle by improving efficiency and environmental performance. This technology is available not 5, 10 or 15 years from now, but today. This solution is Evergreen Energy's refined coal that we produce and market as K–Fuel®.

Cleaner coal must be a central part of any national energy security policy. The U.S. has the world's largest known recoverable coal reserves—roughly 270 billion tons—which implies at current consumption rates a roughly 200 year supply. U.S. coal reserves contain more energy than all of the world's oil reserves[1].

Today, about 50 percent of the coal consumed in the U.S. comes from western mines—up from almost zero percent in 1970. That is because western coal—one type that works with our K–Fuel® process-has less sulfur and is therefore cleaner than coal from the east. Wyoming is the country's largest coal producing state, producing over 400 million tons per year or nearly 40 percent of the U.S. total.

The K–Fuel® process simply replicates nature. Evergreen Energy chemically and physically transforms coal—before it is burned-into a cleaner burning fuel. Our proprietary pre-combustion process uses heat, pressure, and time to remove water and reduce pollutants from lower quality coals, thereby raising heat value. By increasing the heating value of these low-rank coals by approximately 25 percent, efficiency is improved so that less tons of coal are consumed to generate the same energy output. This translates into less CO_2 and other pollutants per kilowatt hour generated. By doing so, I believe that Evergreen Energy can rightfully call itself one of today's solutions to the nation's energy challenges.

Refined coal is available today by the ton. Evergreen Energy has built the world's first coal refinery in Gillette, Wyoming. The tens of millions of dollars spent on this plant no doubt had a significant multiplier effect on the region as a whole. Extrapolating these numbers, we can reasonably project that construction and operation of future coal refineries will create thousands of new jobs.

K–Fuel® stands as an example of how the need for cleaner energy creates new solutions and new opportunities for all Americans-including the potential for thousands of new jobs.

Our 750,000 ton per year plant uses modular equipment that can be scaled larger and Evergreen's plant designs are targeted to produce between two and 10 million tons of refined coal per year.

[1] American Coal Foundation website:http://www.teachcoal.org/aboutcoal/articles/ fastfacts.html

Successful test bums and sales of refined coal to utility and industrial coal consumers over the past year and a half have demonstrated lower emissions and higher efficiency. Up to 70 percent of the mercury is removed from the coal and we have demonstrated lower levels of sulfur dioxide and nitrogen oxides emissions. Our engineering calculations show that due to its higher efficiency, K–Fuel® reduces CO_2 emissions per kilowatt hour generated simply by switching fuel. Evergreen Energy is planning to further verify the CO_2 reduction benefits achieved by K–Fuel® later this year through test burns.

By using cheap, abundant low-rank coal from areas such as Wyoming's Powder River Basin, through the K–Fuel® process we add value and create markets for these resources. K–Fuel® can increase generating capacity from de-rated plants and allow for a more cost-effective emissions control solution than adding costly post-combustion control technology, such as scrubbers. However, K–Fuel® can also be used by plants with already installed back-end control technology to provide improved efficiency and additional emissions reduction benefits.

The K–Fuel® process is perhaps the only new energy technology that produces rather than consumes large amounts of water. In the arid West where water resources are increasingly valuable, the industrial-grade quality water that is drawn off the precombustion process may have many beneficial uses.

Evergreen Energy is delivering on the need for cleaner coal today, but as we plan for the future, we see significant marketplace opportunities made possible by the vast reserves of low-rank, low-cost coal resources readily available around the world. Accompanying this opportunity is significant potential for job creation. We are in ongoing discussions with several utilities about locating K–Fuel® coal refineries next to power plants, a concept we call K-Direct℠. The combined heat and power approach raises efficiency, reducing costs and emissions per kilowatt hour. Located next to a power plant, a K-Direct℠ coal refinery uses the plant's waste steam as a power source and produces refined coal and water for the plant's use. Naturally, all the benefits of K–Fuel® are there as well, including the opportunity to restore efficiency to de-rated power plants and reduce or eliminate the need for new or additional back end control technology.

As we plan for the future of a carbon-constrained world, Evergreen Energy has established a wholly owned subsidiary, C–Lock Technology, which uses a proprietary methodology to measure carbon emission reduction credits. Shortly, you will hear more about C–Lock from Dr. Patrick Zimmerman. With K–Fuel®'s carbon avoidance profile, we anticipate being a very active participant in the carbon market,

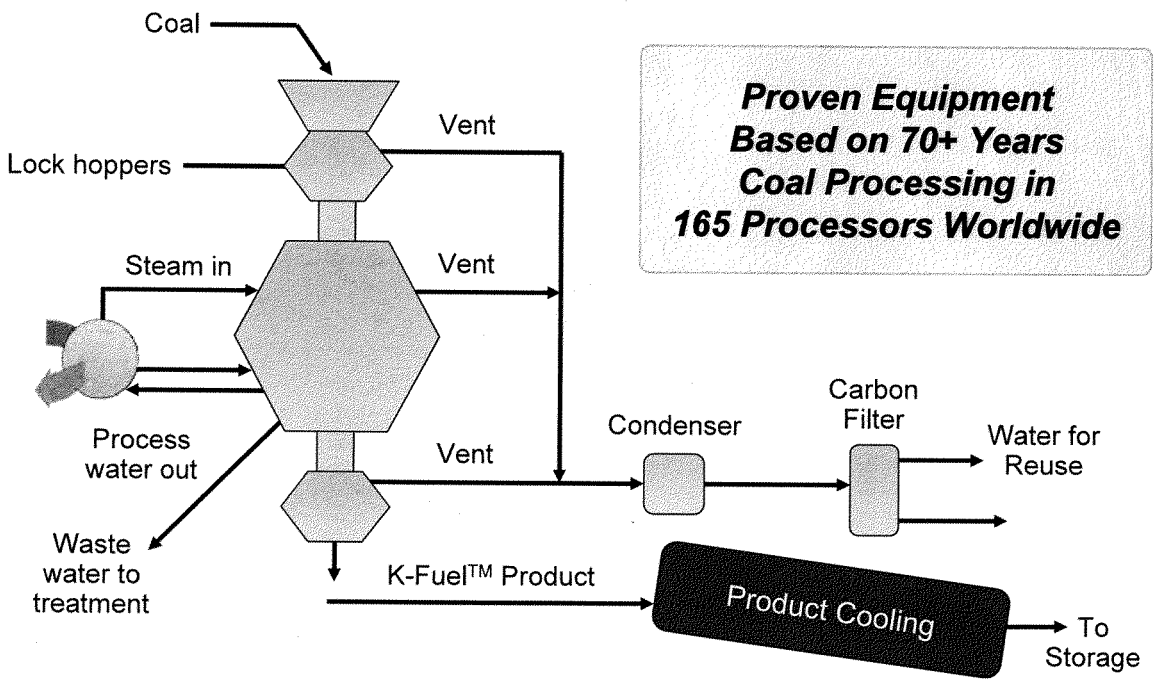
Looking ahead, there has been too much focus on the solutions offered by Integrated Gasification Combined Cycle, FutureGen, and other advanced coal processes. While these are all promising technologies, they are years from widespread deployment—and respectfully raise caution about over-reliance on a limited number of futuristic clean coal technology solutions. Cleaner coal solutions exist today.

This country must have a balanced portfolio of clean coal technology options comprised of pre-combustion, combustion, and post-combustion technologies—Future Gen but also NOW GEN—that will offer solutions today, years from now, and decades in the future at reasonable costs. These solutions need to be accompanied by flexible policies that create balanced and equal incentives.

As lawmakers and leaders you should embrace all energy options including nuclear, renewables, and energy efficiency while recognizing that coal will, and must, remain a significant piece of the portfolio. Evergreen Energy does not view refined coal as the solution but it is an important solution that deserves to play a role in the nation's comprehensive energy strategy. We are making coal cleaner, we are creating new jobs, and we are doing it today.

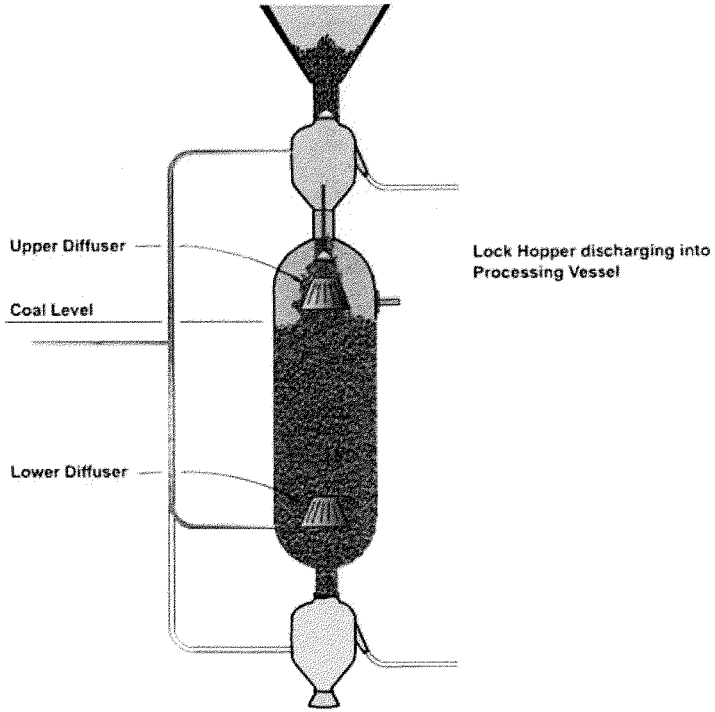
I thank the Committee for the opportunity to appear today and look forward to answering your questions.

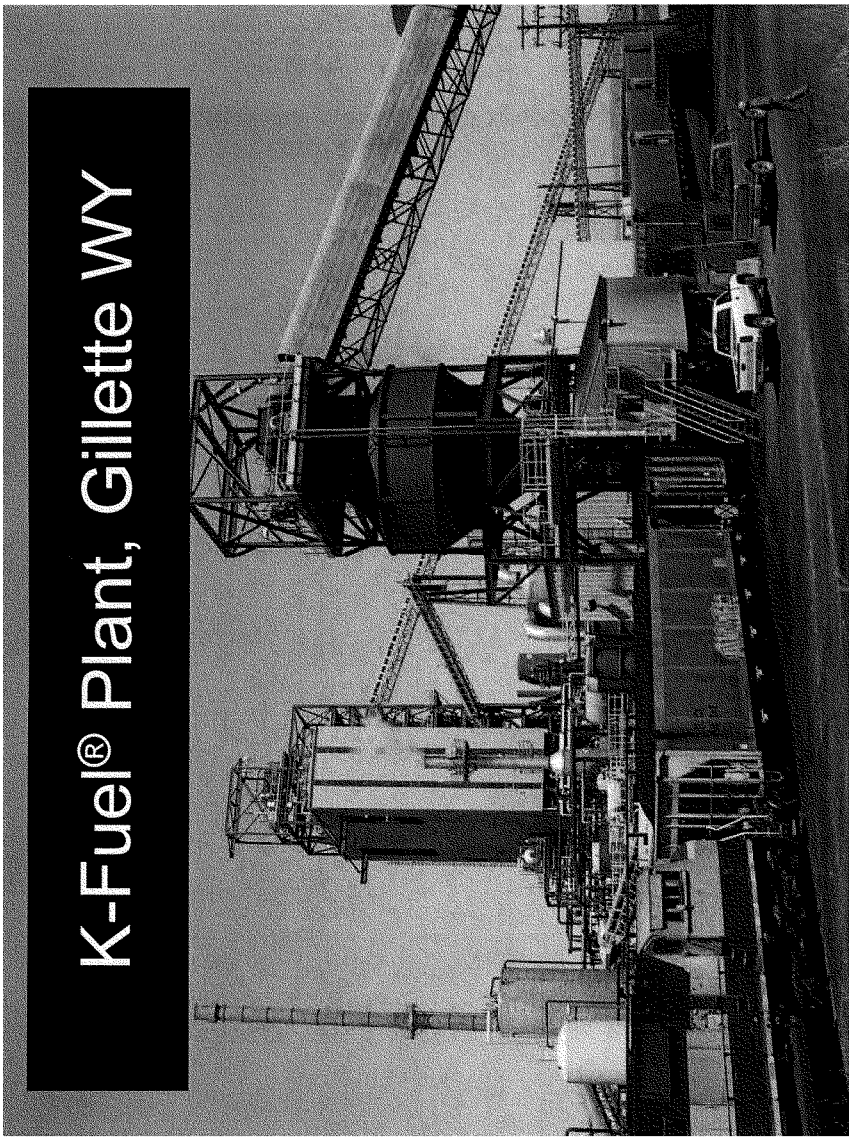
K-Fuel® Process

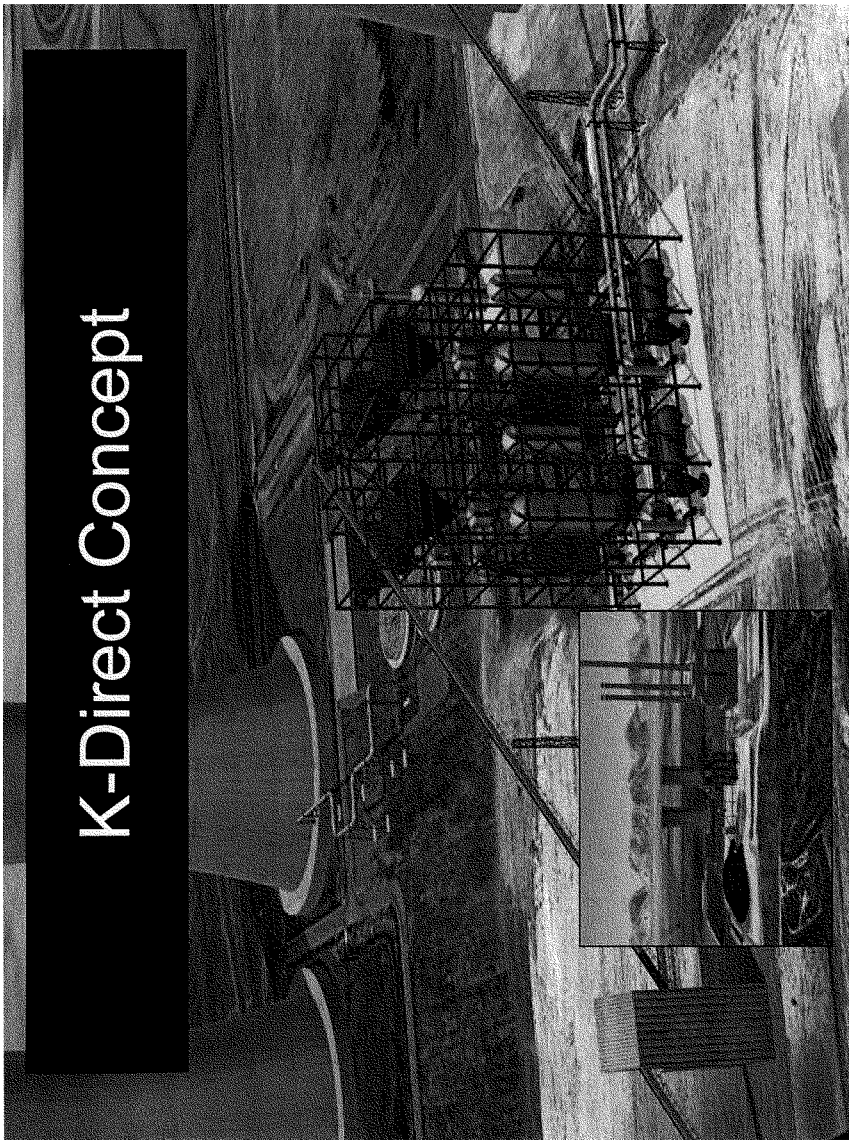


Proven Equipment Based on 70+ Years Coal Processing in 165 Processors Worldwide

K-Fuel® Processor




K-Fuel® Plant, Gillette WY


K-Direct Concept

Senator BOXER. Thank you, sir. Let me just start by asking you is this actually functioning today? Do you have certain plants? Where are these plants?

Mr. COLLINS. There's a plant in Gillette, Wyoming.

Senator BOXER. Have you talked to some of the coal State senators about this innovation? Have you had the opportunity to meet with say, for example, Senator Moynovich or Senator Warner?

Mr. COLLINS. Some of my colleagues have had a chance——

Senator BOXER. I think it's very important that the coal State senators understand that we have some movement here. So the idea is that you cut the amount of coal used and get more energy. You have the same amount of energy for using less coal? Is that the notion?

Mr. COLLINS. You take an unusable resource which is what these low-rank coals have, high moisture content, that's an unusable resource by using heat, time, and temperature we're able to reduce the amount of moisture in that coal, thereby raising the BTU value of that coal by about 25 percent.

Senator BOXER. So 25 percent less coal is used. Is that my understanding? To get the same equivalent amount of energy?

Mr. COLLINS. If you reduce the amount of water, then it takes less energy to burn that fuel.

Senator BOXER. I see. Got you. I just want to get this right. 25 percent energy to get the same amount of coal.

Mr. COLLINS. We are increasing energy content by 25 percent on average.

Senator BOXER. By.

Mr. COLLINS. By reducing moisture in that coal by taking that unusable resource, removing the moisture, and thereby increasing the heating value of that coal.

Senator BOXER. I see.

Mr. COLLINS. Therefore, it takes less energy to produce electricity from that coal.

Senator BOXER. Got it.

I have a few questions. Mr. Cinnamon and Mr. Musk, I hope you can chime in here. The solar industry is growing by leaps and bounds. It would grow even more it would seem to me if we had global warming legislation nationally. So if you really were to think big on the point that we would do this, that we would follow the lead of California and we did enact this kind of legislation, where do you see the potential for solar?

Mr. CINNAMON. OK. There was a study that was done by a management information services in the American Solar Generation Society, base case, moderate case, and advanced scenario, and if we were to fully support this industry, the advanced scenario, the photovoltaic business would have 750,000 jobs by 2030 and that would be a $48 billion industry. So we can get there. If we don't, somebody else will.

Dr. HANEMANN. I think that's an understatement, quite frankly. I actually think that this is closer to a trillion dollar industry, and talk a little bit about the timeframe for that, but I actually think it's about at least a trillion dollars' worth of business to be done in photovoltaic.

Senator BOXER. OK.

Mr. CINNAMON. I'd have to agree with that.

Senator BOXER. No argument from you.

Dr. Hanemann, Mr. Zimmerman pointed out something that I totally agree with. He said based on—you've got a base price. Do you agree with this in terms of sending a message here if we enact legislation for the safety valve and all of a sudden people may well back off their investments?

Dr. HANEMANN. I think the safety valve as it's being proposed as a price cap would be a hindrance to innovation. I think there are other mechanisms that would achieve the same basic objective that would be—and those include allowing for borrowing and the idea has been suggested for a sort of Federal reserve board. I think having a cap on price and announcing it in advance is a blunt instrument and a bad way to go about providing some degree of security.

Senator BOXER. Thank you, sir.

Mr. Musk, a couple of questions. I actually know the answer, but—to the first one because when I went to Tesla Motors we talked about this. But what I want you to talk about is the fact that your cars run on electricity but if you install a solar panel on the car you could drive a Tesla Motors vehicle on free zero carbon emissions from the sun; is that correct? I would like to ask what would that cost—add to the cost to the car to have a solar pack on the car?

Mr. MUSK. Sure. The best way to do that is not to put the solar pack on the car, but put it on your house or garage or something like that. That would be the most efficient way of doing it. Something like a 10 by 15 foot solar panel really pretty small.

Senator BOXER. On the house.

Mr. MUSK. That would then generate about the equivalent of about 400 miles a week of travel in the car. So the average is about 200 miles a week, roughly 30 miles a day, so it's roughly double what your average consumer would do. To get something like that installed, $7,000 or $8,000, something like that.

Senator BOXER. So it's very possible that we could be driving a car and not contributing any—pretty much any carbon, except, of course, what it costs to produce the car.

Mr. MUSK. Putting energy back into the grid.

Senator BOXER. Pretty remarkable. I have another question for you, too. Did you see the movie Who Killed the Electric Car?

Mr. MUSK. Yes, I did, actually.

Senator BOXER. Do you understand what happened there? That was—how many people in the audience have seen that? Raise your hand if you saw it. I had a really bizarre feeling after seeing that. Why would GM want to collect every last one of those cars? People were begging to keep their cars.

Mr. MUSK. It's a combination of factors. That's the ultimate conclusion of the movie. In part it was a consumer issue and in part it was a corporate issue, but I think really at the end of the day it made no sense what GM did. How many products have you ever seen held at a candlelit vigil for the destruction of a car?

Senator BOXER. Well, here the manufacturer came out and bulldozed their own product?

Mr. MUSK. Yes, it's crazy.

Senator BOXER. And didn't let anyone keep one.

It's just very—if you haven't seen the film I strongly recommend you see it just because to me it doesn't make any sense. So if anyone understands it they can let me know.

Mr. Unger, moving on to you, some argue that an increase in our research and development funds, as what you're involved in, which we're so grateful for, will be enough to foster development of new green technology. A recent CEO report found that both research and development funds and a mandatory—greenhouse gas emissions will be needed to foster low carbon technologies.

Do you agree that we need to marry the two?

Mr. UNGER. I think you have to marry the two. I think that if you go back to CAFE standards—I was just reading last night when CAFE standards were put on in, I guess—you know, we almost immediately got up to that number.

Then there was a little dip in the 1980s, and there was an attribution the if the market is left alone it was really the mandatory cap that forced that to happen. I think there's no way, you know, to depend only on market forces in something that is—if we're only talking about competition, clearly, I'm going to have an electric car sooner or later. It's going to last me longer and that will be wonderful, but I have a lot of time to make that decision. There are other places where I don't get to make the decision, like I don't get to choose where I buy my power from.

You know, somebody else decides it. So when you have these more complex issues, like who do I get my power from or during what period of time do I have to address an issue which may take us away from the opportunity to address global warming because we'll reach that tipping point and then maybe we have to have a whole new set of technologies to reach it, we need some help to drive the incentives.

I have not seen at least in my lifetime the opportunity to save an industry that wasn't already trying to save itself, whether it's the steel industry, whether it's the textile industry, whether it's the automobile industry. I think the real issue is that you have to be willing to take risks, and I'm biased because I'm a venture capitalist and we get paid for taking risks and yet in my 20 years in the business with few exceptions venture capitalists are quite risk averse.

Otherwise, why would so many of us be so successful? Up until the bubble burst, nobody ever lost money. What kind of risk is that? So here when we really have to take some risks we have to address them straightforwardly and find out whether it's coal or whether it's, you know, an all electric car or a hybrid model or what is it, but we have to have an even playing field to get out there. Only the government is powerful enough to make that happen.

Senator BOXER. I think that message is really key to this Administration because they pride themselves on being very pro business but they're not listening to business. They're not listening to business. That's what I find so extraordinary.

Driving me, a lot of things drive me to do this. First, my grandchild. Second, what business leaders are telling me, what scientists are telling me, what environmental groups are telling me, every-

one's telling me the same thing that you just confirmed. We need mandatory limits.

Without that we won't get those investments we know are going to save the day. They will save the day. You—a lot of you on this panel are starting to save the day and you need to do it in an environment where you feel comfortable that you can pursue that. So I just—I'm urging you, please, all of you who may be able to talk to the Jim Thompsons and the George Bushes and Dick Chaneys——

Mr. COLLINS. I'd like to insert one thing. The wind industry——

Senator BOXER. Yes.

Mr. UNGER. Really from the Sun but via wind, has been a victim of inconsistent Federal policy by renewing and not renewing investment credit, if you look at them there's almost this, you know, up expecting, you know, the credit expires and down in terms of the amount of business they can do, and make people fear and worry about investing in wind energy. We need to avoid that to let people like me and the people in my industry have a much longer view, we're willing to tie up our money for five or 10 years. Just try to leave the rules a little bit stable.

Senator BOXER. Right. Then if you wait too long, say the price goes up to the sky and it becomes profitable there's a lead time here. We're not going to be able to have these alternatives at the fingertips that we need.

Mr. Klafter, I wanted to talk to you about that coating glass that helps make the buildings more energy efficient, just press you on what's the payback for this if, let's say, I don't know if there's such a thing, an average-sized office building. How soon does it pay back in terms of the energy efficiency?

Mr. KLAFTER. I think if you installed that type of technology in new construction, the payback is fairly short and the coatings can be applied in such a way that it provides benefits both in hot climates and also colder ones so that in colder ones it has insulating value and prevents heat loss in the structure.

I think that some commercial building owners are finding that the cost of retrofitting may be a little more tenuous as far as the return is concerned, but we would like to see this technology proliferate and start going into all new construction.

The other thing that we are doing and many other companies like ours is also doing additional research on how you can use various types of electronics or electrical devices to change the tinting and so on with the flip of a switch, and so on, to provide additional benefits. This is where the future is going to be going.

Senator BOXER. That's terrific. Is this a substitute, this product, for double-pane windows or would it be in addition?

Mr. KLAFTER. I think it would be in addition to. Again, the type of equipment we produce is designed to make it inexpensive to apply these types of coatings. A double-pane window alone is kind of a lower-tech solution.

You do see double-pane windows with gases or other things injected between the panes. There are a lot of different solutions. There are many companies in this business. The other thing I point out about glass is it's also going to be distributed around the world because you're not going to shift glazing across the globe. You're

going to produce it where you need to consume it. So that means we're going to have low heat glass in every country.

Senator BOXER. Thank you.

Dr. Zimmerman, can you tell us about the importance of being able to calculate emissions of carbon from soil? What's the relevance of C–Lock technology and similar technology for legislation to cap emission of greenhouse gases?

Dr. ZIMMERMAN. Yes. Over the last hundred years about half of the secular trend, half of the CO_2 that has accumulated in the atmosphere has come from land use change and agriculture. It took 100 years of intensive nonsustainable agriculture to get that CO_2 in the atmosphere.

By modifying land use practices, encouraging things like buffer strips where there's high erosion you improve soil quality, you increase the amount of organic matter so it holds more moisture. You can actually—some modeling studies of colleagues have shown that increasing soil organic matter actually can increase drought tolerance for an entire region.

So there's a lot of positive benefits in—both ecologically, and it's something we can do right now to remove CO_2 and keep other greenhouse gases like methane and nitrous oxide from getting into the atmosphere.

The C–Lock system, what it does basically it uses the information superhighway as a backbone to reach out to communities of farmers and ranchers, it uses generic GIS Geographic Information System data for climate and so forth, plus land parcel specific data from individual ranchers.

It has verification built into it so it's really hard to cheat. It quantifies what we know. For years soil scientists have been telling me, the IPPC and others, soil is so complex we can't do this. We got to wait. The fact is we can do it.

The issues are almost the same for factories and other gas stacks. The other fact is we can quantify what we know and remove what we don't know, discount the offset on the basis of what we know, and the C–Lock system allows us to do it.

Senator BOXER. OK. Mr. Collins, there are a variety of ways to reduce greenhouse emissions from coal. Do you see this as a growth industry and is this which you're investing in technologies like K–Fuel?

Mr. COLLINS. This process reduces CO_2. It reduces other greenhouse gas emissions. We see once these plants start getting built the thousands of new jobs that would be created by building——

Senator BOXER. It can't be farmed out to other countries. That's the thing. A lot of these plants would be here in the United States.

I just want to thank you all very, very much. You know, for me when I come home it's a breath of fresh air and now it has again been that from everything I've done today from this panel it's sometimes lonely back in Washington when you're from California. People don't understand the ethic that we have here about our environment and the ethic that our corporations bring to the table.

Not everyone, but most of them, that they do want to do very well and they want to do good for society and they've found ways to do it, that they've never seen a clash between a clean environ-

ment and a strong economy. As a matter of fact, we see it in very different ways.

So taking that message back to my colleagues is sometimes very difficult. I hope that many of you will make yourselves available to testify in Washington. I would say particularly our coal friends who are working hard at this, I think we need to make the case to our colleagues that there is a way to move forward on coal. There is a way to move forward on ag. There's some people that think we can't say to the Ag industry "you're not part of the solution." I think we see now that we can all be part of the solution.

So I hope all of you by shaking your head nodding will tell me that you would be willing to come back if I call on you. Yes? I see that. Good. I trapped you now. And—because we have a long road. We've had a breakthrough in the committee. Senators Lieberman and Warner have teamed up so we have the first Republican on the committee who is ready to pass legislation.

We have work to do and it's going to accelerate when we get back. Everything that you've taught me today I'm going to take back to my colleagues, and so I really appreciate your all being here. The hearing's adjourned.

[Whereupon, at 12:24 p.m. the hearing was adjourned.]

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