UNLOCKING AMERICA'S ENERGY RESOURCES: NEXT GENERATION

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND AIR QUALITY

OF THE

COMMITTEE ON ENERGY AND COMMERCE
HOUSE OF REPRESENTATIVES

ONE HUNDRED NINTH CONGRESS

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UNLOCKING AMERICA'S ENERGY RESOURCES: NEXT GENERATION

THURSDAY, MAY 18, 2006

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ENERGY AND COMMERCE,
SUBCOMMITTEE ON ENERGY AND AIR QUALITY,
Washington, DC.

The subcommittee met, pursuant to notice, at 10:09 a.m., in Room 2322 of the Rayburn House Office Building, Hon. Ralph Hall (Chairman) presiding.

Members present: Representatives Shimkus, Wilson, Bono, Otter, Murphy, Burgess, Barton (ex officio), Boucher, Green, Capps, and Hall.

Also present: Representative Bass.

Staff present: Kurt Bilas, Counsel; Annie Caputo, Professional Staff Member; David McCarthy, Chief Counsel for Energy and Environment; Sue Sheridan, Minority Senior Counsel; Bruce Harris, Minority Professional Staff Member; and Peter Kielty, Legislative Clerk.

MR. HALL. I would like to welcome all of our witnesses here today for our hearing, entitled "Unlocking America's Energy Resources: Next Generation." Without objection, Mr. Boucher, the Chair will proceed pursuant to Committee Rule 4E and recognize Members for three minutes for opening statements. If they defer, this time will be added to their opening round of questions.

With electricity generation expected to grow about 50 percent by 2030, the need for alternative sources of energy will continue to grow. There are many innovative technologies currently being developed that will become part of our generation portfolio and take their place along side natural gas, coal, and nuclear. This hearing will give us the opportunity to hear from two panels of knowledgeable witnesses about the new technologies and what to expect down the road. It is important that we encourage their development now, in order to avoid future strains on the American people and American manufacturers.

We have with us today representatives and experts from the wind, solar, coal, and the biomass industries to discuss renewable research being funded publicly and privately. So we also have with us a representative from the city of Galena, Alaska, to talk about their plans to build the first small nuclear power plant. I would like to thank all of our witnesses for being here today and I look forward to your testimony.

[The prepared statement of Hon. Ralph Hall follows:]

PREPARED STATEMENT OF THE HON. RALPH HALL, CHAIRMAN, SUBCOMMITTEE ON ENERGY AND AIR QUALITY

I'd like to welcome all of our witnesses here today for our hearing entitled, "Unlocking America's Energy Resources: Next Generation". Without objection, the Chair will proceed pursuant to Committee Rule 4(e) and recognize Members for 3 minutes for opening statements. If they defer, this time will be added to their opening round of questions.

With electricity generation expected to grow about 50% by 2030, the need for alternative sources of energy will continue to grow. There are many innovative technologies currently being developed that will become part of our generation portfolio and take their place alongside natural gas, coal and nuclear. This hearing will give us the opportunity to hear from two panels of knowledgeable witnesses about these new technologies, and what to expect down the road. It is important that we encourage their development now in order to avoid future strains on the American people and American manufacturers.

We have with us today representatives from the wind, solar, coal and biomass industries as well as experts to discuss renewables research being funded publicly and privately. We also have with us a representative from the city of Galena, Alaska to talk about their plans to build the first small nuclear power plant.

I'd like to thank our witnesses for being here, and I look forward to their testimony.

MR. HALL. The Chair at this time recognizes Mr. Boucher, the ranking member.

MR. BOUCHER. Thank you very much, Mr. Chairman. I want to commend you for convening today's hearing so that our subcommittee can learn about cutting-edge technologies for electricity generation. A number of technologies are now under development that will assist in achieving our national goal of a balanced electricity generation portfolio and ensure that our Nation's growing need for electricity is met in a constructive way. I am particularly interested in hearing from our witnesses on their assessment of the progress in developing renewable technologies such as wind, solar, and biomass. Commentary on advances that are currently underway in nuclear technology and prospects for its expanding use will also be welcome.

I am particularly interested in technological developments with regard to electricity generation from coal, our most abundant domestic energy resource, with supplies adequate for 250 years. Given its domestic availability, it is appropriate that coal constitute a major and growing component of our electricity generation fuel mix. New technologies, including integrated gasification combined cycle, ultra supercritical pulverized coal combustion, and emerging technologies to capture the carbon dioxide emissions from coal-fired power plants, all hold great promise for the ability to continue to use coal in growing tonnages with very minimal, and in some cases, zero emissions. And testimony from our witnesses this morning about their view of the role of coal in our fuel mix for the years ahead, would also be very welcome.

Mr. Chairman, I appreciate your convening this hearing. I think it is certainly timely and I join with you in looking forward to the testimony of our witnesses.

MR. HALL. Thank you, Mr. Boucher. Mr. Shimkus of Illinois is recognized for an opening statement.

MR. SHIMKUS. Thank you, Mr. Chairman. And there are two hearings going on simultaneously, this one and a telecommunications subcommittee meeting, so if we are running back and forth, those of us who share those responsibilities, excuse us. I think those today are showing they have a great interest in electricity generation and all of the players in having a competitive open-field market. I, like my friend and colleague, Mr. Boucher, have been singing the praises and return of coal. And in discussion with just average citizens, they think we are just shoveling it out of the coal mine and sticking it into a burner and burning that coal and creating all of this nasty stuff, whereas, because of regulations and rules and new technologies, it is a whole new world.

I am excited about Peabody's investment in Illinois and the Prairie State Energy Campus, which uses a new wet electrostatic precipitator. That is actually going to start removing some mercury issues from there. It is, by definition, one of the cleanest coal-generating power plants on the board. We hope to break ground this fall, our first quarter. And the frustrating thing is, in the environmental comparisons that they have to fight against, the environmental comparisons have plants that are on the board that aren't up and running, that project all of these better environmental advantages that we will never see come true because these plants are not going to be built. So I just find that an interesting dilemma, when you are trying to move with new technology, proven technology, then you have to fight this environment of, well, it is not perfect, and trying to reach the perfection is the enemy of the good, many times, and these are great, great benefits. They are coming from all different environments. We are going to hear about nuclear power in a smaller package that I am excited about, and also the benefits. I know the President has talked about using solar power and the ability to have the shingles assist in a home and the like, so I think this is very timely, because economics 101 is supply and demand. You have to increase supply and you have to address the demand equation and you have to do all of them. You know, just cutting demand is not going to address price and concerns. You have to increase supply and you have to address demand and competitive choices out there with the standard.

So this is a very, very important hearing and we are very excited about it. Mr. Chairman, thank you for this time and I yield back.

MR. HALL. Thank you. The Chair recognizes the gentlelady, Ms. Capps, for an opening statement.

MS. CAPPS. Thank you, Mr. Chairman. I also am glad that we are holding this hearing this morning. I welcome our witnesses and I believe that putting more attention on the potential of renewable fuels and alternative energy is something that many people have been waiting for, advocating for, for many years. Increased use of renewables and alternative energy would clearly reduce our dependence on fossil fuels. And since this country is not exactly awash in oil and natural gas, reducing our dependence on them would be good, not only for our environment, but also for our national security.

To be honest, however, we have to do more than talk about the potential that renewables and alternative energy have for this country. Talking is something we have been doing for a very long time, but we have to put into place more funding for programs to bring these energy sources to market, and we have to make changes in our energy policy to encourage their use. Unfortunately, the budget that we just voted upon last night and that the President had submitted earlier this year, I believe shortchanges our Federal investment in this area. The overall energy efficiency and renewable energy part of the budget would actually go down if this President's budget then actually becomes enacted in Appropriations. In fact, under President Bush's proposal, I don't even think we are even spending what we spent in the last years of the Clinton Administration.

I would bring to the committee's attention a 2004 CRS report that projects the percentage of national energy demand supplied by renewables in the year 2030 would only be about 6.7 percent. It was 6 percent in the year 2004, so that isn't showing very much progress. We should be doing much, much more if we are really serious about making progress in this area.

I would also note that this committee missed historic opportunities, time and time again, during the repeated consideration of so-called comprehensive energy legislation to embrace renewable energy. Mr. Pallone's amendment to establish a renewable portfolio standard was repeatedly rejected by the Majority party in this committee, and we weren't even allowed to have a vote on it on the House floor. Adoption of that amendment would have required that our major utilities slowly increase the percentage of energy they derive from renewable sources, like solar, geothermal, wind, and biomass. At least 13 States have similar requirements in place, so we know this can be done without disrupting electricity production or raising prices. So while I am pleased that the subcommittee is looking at this issue, again, it is very disappointing that we seem to be starting over at ground zero.

Finally, I find it ironic that mere months ago, we passed legislation that was touted by its supporters as providing comprehensive strategy to deal with our Nation's energy challenges; and yet, here we are talking about the need for more renewables and alternative energy. Last week the Majority discovered that maybe making our cars more fuel efficient would be a good thing. I feel sort of vindicated in the arguments that many of my colleagues on this side and I have been making over the years in support of renewables, alternative energy, and increased efficiency standards. I only wish that our proposals had carried the day then so that Americans today could be benefiting from them. But that being said, there is no time like the present to get started and I thank you for giving us that opportunity today. I yield back.

MR. HALL. Thank you, Ms. Capps. The Chair recognizes the gentleman from Texas, Dr. Burgess, for an opening statement.

MR. BURGESS. Thank you, Mr. Chairman. I too want to thank you for holding today's hearing. In my district in north Texas, we run the gamut of renewable energy. There is a company that manufactures solar panels in Keller, Texas, and another manufactures wind turbines in Gainesville. I encourage anybody who is in the wind turbine business not to buy those cheap Brazilian blades. Those Gainesville blades will hold up a lot longer and do you really well.

The Lake Dallas Independent School District uses geothermal energy to heat and cool its schools. The Wal-Mart in McKinney, Texas, which is just outside my district, is one of their two new energy efficient stores that uses renewable technologies such as solar panels and roof wind turbines in the parking lot, to generate electricity for their store. And in Denton, Texas, under the leadership of Mayor Euline Brock, they have constructed the world's first renewable biodiesel facility. The facility is powered by the methane gas extracted from the adjacent landfill and has the capacity to produce approximately three million gallons of pure biodiesel per year. The City of Denton's use of biodiesel fuel mix is expected to reduce emissions by 12 tons per year in the county. That is significant because we are under some clean air mandates. The opening of this facility demonstrates the City of Denton's dedication to cleaning up the air that we breathe. This is especially important in the north Texas region because of the clean air mandates we exist under.

Well, Mr. Chairman, that is why the hearing is so important today. Our economy is growing in north Texas and of course our demand for energy is, as well. As we try to satisfy this demand in an environmentally friendly way, affordable renewable fuel sources will take on an even greater importance than they do already. Of course, I want to thank the witnesses that are appearing here before me. Since I haven't used all of my time, let me just address the renewable portfolio standard, because, in Texas, approximately 50 percent of our electricity is generated by natural gas and another 38 percent by coal; but Texas has one of the most aggressive renewable portfolio standards in the country. Texas RPS was increased by the State legislature in 1999, requiring that Texas use a total of nearly 3,000 megawatts of renewable energy by the year 2009. But in August of 2005, Governor Perry signed a bill which increased that requirement to almost 6,000 megawatts by 2009. The RPS mandate in Texas is a phased-in approach that offers flexibility through a renewable energy credits training program. Any company that does not satisfy their requirements by directly owning or purchasing renewables, may purchase credits to satisfy that requirement.

Thank you, Mr. Chairman. I will yield back the balance of my time.

[The prepared statement of Hon. Michael Burgess follows:]

PREPARED STATEMENT OF THE HON. MICHAEL BURGESS, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Mr. Chairman,

Thank you for convening today's hearing.

In my district, we run the gamut of renewable energy - there's a company that manufactures solar panels in Keller and another that manufactures wind turbines in Gainesville.

The Lake Dallas Independent School District uses geothermal energy to heat and cool their schools. The Wal-Mart in McKinney, which is near both my district and Chairman Barton's, is one of two of their new "energy efficient" stores and uses renewable technologies such as solar panels on the roof and wind turbines in the parking lot to generate electricity for the store.

And in Denton, under the leadership of Mayor Euline Brock, they have constructed the world's first renewable biodiesel facility. The facility is powered by the methane extracted from the adjacent City of Denton Landfill and has the capacity to produce approximately three million gallons of pure biodiesel per year.

The City of Denton's use of a biodiesel fuel mix is expected to reduce emissions by twelve tons per year. The opening of this facility opening demonstrates the City of Denton's dedication to cleaning up the air we breathe. This is especially important in the North Texas region as we work to comply with Clean Air Act requirements.

That is why this hearing is so important today. As our economy grows, so too does our demand for energy. As we try to satisfy this demand in a environmentally-friendly way, affordable renewable fuel sources will take on an even greater importance than they do already.

I'd like to thank the witnesses for appearing before us today; I am looking forward to hearing your testimony.

MR. HALL. Thank you. And I note the presence of the Chairman of the Energy and Commerce Committee, and being of sound mind, I recognize him at this time for as much time as he consumes.

CHAIRMAN BARTON. Thank you, Chairman Hall, for taking a little bit of the load off the full committee in holding this hearing today on R&D and the new technologies to provide electricity and natural gas for America's future. I want to thank our witnesses for appearing before us today. We value your input. Your discussion of new energy technologies is of particular interest to me, since I began my career as an engineer.

One way America will be able to secure its energy future is through technology. Our panelists today are on the cutting edge of the effort to bring new technologies to market. Their work is helping to secure America's energy future. There is another important component to the work that you are doing today. Much of it is with technologies that have a minimal environmental impact. Clean, safe domestic sources of energy are important to develop. Newer technologies such as wind, solar, biomass, and other renewables will help put the United States on the track for a clean energy-secure future. We must not forget, however, the more traditional sources of power. Clean coal, second and third-generation nuclear power, and distributed generation must all make important contributions to our energy future.

Last year the Congress passed the Energy Policy Act of 2005. I am very proud of that bill. It provides incentives for both traditional and new sources of electric power generation. Through the research at our national laboratories, public/private partnerships, and private research, the United States is moving ahead on developing new sources of energy. There is another benefit to developing these new sources of electricity, in addition to the economic and environmental benefits. It incrementally takes the price and demand pressure off of other fossil fuels, like natural gas, that are needed for other uses, like chemicals and fertilizer. These exciting new technologies will help America conserve its nonrenewable resources.

Of course, developing new technology is not the only thing we can and must do to secure our future. We must unlock our domestic energy resources by exploring for energy in the vast tracts that today are off limits. We must also conserve without punishing American consumers. Our auto efficiency reform bill is a major step towards that end, as are the many conservation and energy efficiency provisions in the Energy Policy Act of 2005. I think we should also adopt more common sense rules and processes that will enable us to move energy to consumers faster without compromising our environmental standards. One example of that effort is the refinery reform permitting bill that passed this committee, or came out of this committee and is expected to be on the floor of the House again in the very near future.

This hearing is important because it allows Congress to see the important research being done in this country on energy sources and shows us that the best is yet to come. Thank you again, Mr. Chairman, for holding the hearing, and I want to thank our witnesses for being here today. I yield back.

[The prepared statement of Hon. Joe Barton follows:]

PREPARED STATEMENT OF THE HON. JOE BARTON, CHAIRMAN, COMMITTEE ON ENERGY AND COMMERCE

Thank you, Chairman Hall, for holding this hearing today on research and development into new technologies to provide electricity and natural gas for America's future. I also want to welcome and thank our excellent panelists for joining us today. We value your input. Your discussion of new energy technologies is of particular interest to me since I began my career as an engineer.

One way America will be able to secure its energy future is through new technology. Our panelists today are on the cutting edge of that work to bring new technologies to market. Their work is helping to secure America's energy future. And energy security means jobs and a better standard of living for all Americans.

There's another important component to the work you are doing – much of it is with technologies that will have a minimal environmental impact. Clean, safe domestic sources of energy are important to develop. Newer technologies such as wind, solar, biomass and other renewables will help put the United States on track for a clean, energy-secure future. However, we must not forget more traditional sources of power, too – clean coal, nuclear and distributed generation must all make important contributions to our energy future.

Last year, Congress passed the Energy Policy Act of 2005. I am very proud of that bill. It provided incentives for both traditional and new sources of electric power generation. Through research at national labs, public-private partnerships and private research, the United States is moving ahead on developing new sources of energy.

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Of course, developing new technology is not the only thing we can and must do to secure America's energy security. We must unlock our domestic energy resources by exploring for energy in the vast tracts that today are off-limits. We must conserve without punishing American consumers. Our auto fuel efficiency reform bill is a major step toward that end, as are the many conservation and efficiency provisions in the Energy Policy Act of 2005.

We must also adopt more common sense rules and processes that will enable us to move energy to consumers faster without compromising our environmental standards. One example of our efforts here is the refinery permitting reform bill that the House will pass very soon.

This hearing is important because it allows Congress to see the important research being done in this country on energy sources and shows us that the best is yet to come. I look forward to what the panelists have to say.

MR. HALL. I thank the Chairman and note the presence of Mr. Bass, the gentleman from New Hampshire. We will ask unanimous consent that he be allowed to attend and to participate if he chooses. Is there objection? The Chair hears none. The Chair recognizes Mr. Otter, the gentleman from Idaho.

MR. OTTER. I may object. I want to know what he is going to say.

MR. HALL. Well, I was with him until one o'clock this morning and I think he said it all then. All right, I will recognize you, Governor Otter.

MR. OTTER. I am going to pass.

MR. HALL. We will go to Mr. Green, the gentleman from Texas, for an opening statement.

MR. GREEN. Thank you, Mr. Chairman. Obviously, I arrived right on time. I would like to put my statement into the record, but I appreciate the--

MR. HALL. Without objection.

MR. GREEN. I appreciate you calling the hearing and I would just like to put a statement into the record. In a time of high oil prices, we know we need to be able to diversify, and my biggest concern, Mr. Chairman, and I am glad for this hearing, is that--and I only wanted to look to the future in alternatives, but I also wanted to get through the next 20 or 25 years, so that is why we need to look at hydrocarbons, at least for the short term, until we can get to some other alternatives. So I will put my full statement into the record. Thank you.

[The prepared statement of Hon. Gene Green follows:]

PREPARED STATEMENT OF THE HON. GENE GREEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF TEXAS

Mr. Chairman and Ranking Member, thank you for holding this hearing.

I support diversifying our energy portfolio in any way possible—more efficient natural gas, solar power, clean coal, nuclear power, wind power, and other renewable sources of energy.

We need to avoid picking favorites, because the economy is likely to have a much bigger impact than anything the government can do.

The only good thing to come out of higher oil prices is an increased incentive to use alternative sources of energy for transportation.

While natural gas prices also sky-high relative to their historical prices, perhaps we will have a similar incentive to produce new alternative electricity technologies as well, such as solar power.

Coal power will continue to offer affordable and reliable power in places that are willing to site new coal facilities, like Texas, but other areas without coal generation are going to have to pay higher prices.

Natural gas used to be the preferred form of new power, since it burns cleanly, but as the Department of Energy has noted, the high prices of natural gas are leading people to rethink those planned investments.

We need natural gas in the petrochemical business, where it is irreplaceable. If short-term high natural gas prices lead to more coal, nuclear, and alternative energy hopefully natural gas prices come down.

Of course if we really want to improve our natural gas price situation and protect the hundreds of thousands of American manufacturing jobs at stake, we should support the language in the Interior bill which repeals the Congressional moratoria for natural gas drilling in the OCS.

Thank you and I yield back.

MR. HALL. All right, I thank the gentleman. The Chair recognizes the gentlelady from New Mexico, Mrs. Wilson.

MRS. WILSON. Thank you, Mr. Chairman. I also wanted to thank you for having this hearing today to learn a little bit more about what some of the future might look like as we expand our electricity generation and as the demand increases. We know that by 2030, we are going to have a 50 percent increase in demand over current levels. We are going to have to figure out how to supply that demand.

In New Mexico, we do some innovative things. The third largest wind generation project in the world went on line on October 1, 2003, out in eastern New Mexico. And in eastern New Mexico and the high plains of eastern New Mexico, we laugh at this time of year and say that in New Mexico, at this time of year, Arizona is on its way through to Texas and it is all being carried in the wind. It comes one particle at a time in the dust. But they have got 136 turbines there, standing 210 feet high and generating 200 megawatts of power. That is about enough power for 94,000 New Mexico homes. And of course Sandia National Laboratories in Albuquerque, New Mexico, develops energy technologies, solar energy, and new more-efficient solar technologies are emerging from those laboratories and into companies, like Advent Solar, that are making solar, highly efficient solar cells for the commercial market and manufacturing them in Albuquerque. They are also looking at a biomass plant in the east mountains of New Mexico and the east mountains of Albuquerque. That is not only going to help restore the watershed, but take the waste from that restoration, use it for electricity generation in a cogeneration facility, and the heat from the generators will be used to warm a greenhouse that employs 70 people full time, where it is otherwise not economically viable.

So there are a lot of important things happening in new ways with renewable energy resources, and we are really looking forward to looking at this generation of technologies to see where America is going to take us. Thank you, Mr. Chairman.

MR. HALL. Does the gentlelady yield back?

MRS. WILSON. Yes, sir, I do.

MR. HALL. The Chair recognizes Mrs. Bono, the gentlelady from California.

MS. BONO. Thank you, Mr. Chairman. I will submit my statement for the record.

[The prepared statement of Hon. Mary Bono follows:]

PREPARED STATEMENT OF THE HON. MARY BONO, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. Chairman:

I am very pleased you are holding this hearing today. Too often, Congress is so consumed with the here and now that we don’t take time to look towards the future. This hearing lets us talk about the future.

While government has a role to play in this debate, it is my belief that the private sector, as well as our colleges and universities, can and must play a critical role in bringing forth new and innovative technologies.

Too often, states and local communities are dependent on only a few sources of energy. As we see in California, when the cost of natural gas rises, so too do our cooling bills. In the California desert, the sweltering summer months must be met with plentiful and affordable cooling. It is not a luxury but rather a necessity. So in order not be wedded to a single large source of generation, I believe that we can and should look to diversify. But our efforts should not stop there – we need to look at a diverse portfolio that includes alternative sources of clean and efficient energy.

All of us have read about various forms of renewable sources of energy. Many of these sources, like solar, wind and geothermal, are not new to us. In fact, these sources of energy are thriving in California's 45th Congressional District. But the technologies associated with these forms of generation are changing and they are changing for the better. The government's goal should be to encourage honing and improving upon these technologies.

There are also lesser known sources of renewable energy that are a bit more cutting edge. Here, our goal should be to foster the growth of promising new resources and then find a way to incorporate those into the market.

It is my hope that this hearing will shed light on both well known and lesser known forms of energy that can and should be part of our nation's future. I want to know how Congress can play a positive role in partnering with others to help create new forms of energy that are clean and affordable.

Thank you and I yield back my time.

MR. HALL. All right. Mr. Bass, do you care to make an opening statement?

MR. BASS. Mr. Chairman, I appreciate the courtesy. I will pass.

MR. HALL. All right, we will get underway with the testimony. Dr. Arvizu and Mr. Yoder. Did I say it right? Close?

MR. ARVIZU. Yes, sir.

MR. HALL. For government work, it is pretty good.

MR. ARVIZU. Not bad at all.

MR. HALL. We want to thank you two gentlemen and the others that comprise the second. Don't judge our respect for you and our appreciation for you being here by the empty chairs here, because this is hopefully the last day we are going to be in session. People have about three or four other committees to go to and have a lot of other things going on. Your testimony will be heard by these people in the back row, and they will tell those of us on the front row what you said. So it is very important that you give your testimony so that they hear. It will be taken down by a very capable gentleman over here at the end of the table. It goes into the record for all the Members of the Congress to see. So it is not just talking to empty chairs. But thank you for that.

Doctor, I recognize you at this time to sum up, if you can, in 4 or 5 minutes, or whatever you take. We are not going to gavel you down, but be as brief as you can. That gives us time to ask questions. Thank you, sir.

STATEMENTS OF DAN E. ARVIZU, DIRECTOR, NATIONAL RENEWABLE ENERGY LABORATORY; AND MARVIN YODER, MANAGER, CITY OF GALENA, ALASKA, ACCOMPANIED BY PHILIP MOOR, DIRECTOR, PROJECT DEVELOPMENT, BURNS & ROE ENTERPRISES, INC.

MR. ARVIZU. Thank you, Mr. Chairman and members of the committee. It is indeed a big honor for me to be here. I appreciate the opportunity to talk and provide commentary to this topic of great importance, and I do submit my full written statement for the record and trust that that will be accepted in its entirety, and I will summarize that testimony in my opening remarks.

Mr. Chairman, I am the Director of the National Renewable Energy Laboratory, the Department of Energy's primary lab for research and development of renewable energy and energy efficiency technology. Let me begin by noting that it was the first energy crisis in 1970 that, while I was an engineering student in graduate school, that motivated me to pursue a career in renewable energy and I started with the Sandia National Laboratory to do just that. The Nation's attention at that time was on energy similar to what it is today. The good news is the Nation did respond with an R&D program that over the years has produced many benefits in terms of alternative energy. I will get to those here in a moment. Perhaps the more sobering news is that we have learned in the past three decades that the magnitude of the energy challenge is much greater and more complex than we imagined, and the consequences of inaction are quite significant. Our Nation needs to produce considerable amounts of new energy to serve our citizens and to keep our economy going. At the same time, we need to reduce our dependence on oil and continue to import--I am sorry--continue to protect our environment, and it is clear to me that significant sustained national energy research, development and deployment programs are essential across all of our energy options, including clean fossil fuel, sustainable nuclear power, and energy efficiency and renewable energy.

The history of the National Renewable Energy Laboratory, which I head, has demonstrated that focused research can yield valuable new technologies in the near term, with many collective benefits. Consider, for example, that over the past 25 years the cost of wind has declined from over 40 cents a kilowatt hour to now in the range of 4 to 6 cents a kilowatt hour in good wind sites. The cost of electricity from photovoltaics has been reduced by 80 percent over that same time and today it is in the utility scale at 15 to 30 cents a kilowatt hour. And it is because of the progressively lower costs in both wind and photovoltaics and other technologies that these two have become the fastest growing sources of new electricity in the United States and in the world today, and there are similar gains in other technologies as well.

President Bush underscored the need for continuing energy research when he visited our laboratory earlier this year. The President's Advanced Energy Initiative calls for a 22 percent increase in clean energy research at the Department of Energy, and his initiative would expand research in renewable fuels as well as solar electricity, and we believe this is a really important new development. The renewable energy industry is real. Tens of billions of dollars worldwide are presently part of that industry. It is rapidly growing and the market growth is spurred by a combination of technology advances and public policies. Further development of new renewable energy technologies will create many opportunities domestically. Renewable energy is plentiful across every region of our Nation. Renewable energy technologies can be an engine for local economic growth, job creation, and we are beginning to see that in a number of States.

While we clearly need supply side solutions, it is also clear that energy efficient solutions are often the most cost-effective way to meet future demands. Energy efficiency should be an ingredient of any comprehensive national program.

For non-hydro renewables such as wind, the technology is beginning to mature. Ten gigawatts, 10,000 megawatts of wind are installed in the United States, 60,000 in the world, and there is still a need for continued research to eventually eliminate the production tax credits that are required to make that market go in the United States, and importantly, to make this clean energy source more suited to lower wind regimes as well.

In solar photovoltaics, researchers at our national center are part of the President's Solar America Initiative. They are working to bring the cost down of photovoltaics to between 5 and 10 cents a kilowatt hour in the next decade. To get there we have to develop more cost-effective manufacturing techniques and advanced engineered materials. We are seeing those in the laboratory today. I am very excited to note that we have a couple of examples of some of those technologies here on display. Our troops are using solar battery chargers in the field in Iraq today, technology developed at our national laboratory. Additionally, we have thin-film photovoltaics on plastics that we fly in space presently, and this technology will be ubiquitous in the future; technology is advancing very rapidly.

On renewable fuels, we have great opportunity there. We believe that with domestic resources, we can get to 30 percent of our current U.S. gasoline consumption to be supplied by biofuels, and we think that can be done in a very short period of time, as well, with, certainly, competitively priced ethanol from cellulosic biomass that the President has put in as his biofuels program.

Each of these areas I have highlighted suggest that there are still challenges that remain and that we need to continue to get the cost down for renewable energies and fuels in order to accelerate their adoption. Renewable energy offers us a tremendous opportunity, and from my vantage point, the prudence of making serious national investments to achieve the full potential of energy efficiency and renewable energy is very clear and very compelling. Thank you.

[The prepared statement of Dan E. Arvizu follows:]

PREPARED STATEMENT OF DR. DAN E. ARVIZU, DIRECTOR, NATIONAL RENEWABLE ENERGY LABORATORY

Mr. Chairman, thank you for this opportunity to discuss the important role the next generation of energy resources and technologies will play in meeting the critical energy needs of our nation. I am the director of the National Renewable Energy Laboratory, the Department of Energy's primary laboratory for research and development of renewable energy and energy efficiency technologies.

Our nation is at a critical juncture. We need to produce considerable amounts of new energy to serve our citizens and keep our economy growing. At the same time we need to reduce our dependence on imported oil and continue to protect our environment.

The fundamental question -- Where will this new energy come from? – has no one answer. The reality is that if we are to solve our energy problems, and meet the phenomenal growth in demand for energy, we must have an energy portfolio that is at once, both smart and diverse. In my view, it is not a matter of nuclear energy versus solar energy, it's not wind power versus new fossil fuel technologies. The answer is that each will have an important place at the table – we will need all of these technologies, and more.

I cannot predict precisely what our energy landscape will look like, say, in 25 years, as technology and markets evolve. But I can say with some confidence that we do need a significant and sustained national energy research program to get us there.

With a vital research and development program working on behalf of our nation, I am optimistic that we will be able to supply all the energy we need – and develop new industries that help grow our economy, *and* further environmental progress – while doing so. Throughout my career in energy research, I have seen time and again just how much a well-directed and properly supported R&D effort can accomplish.

One need look no further than the relatively brief history of our research facility in Golden, Colo. Since our laboratory was founded in 1977 (known then as the Solar Energy Research Institute) the progress made on so many fronts has been nothing short of remarkable. NREL, along with leading academic institutions and corporations throughout the U.S., have demonstrated that focused research can yield valuable new technologies in the near-term, with many collective benefits for society added over the longer term.

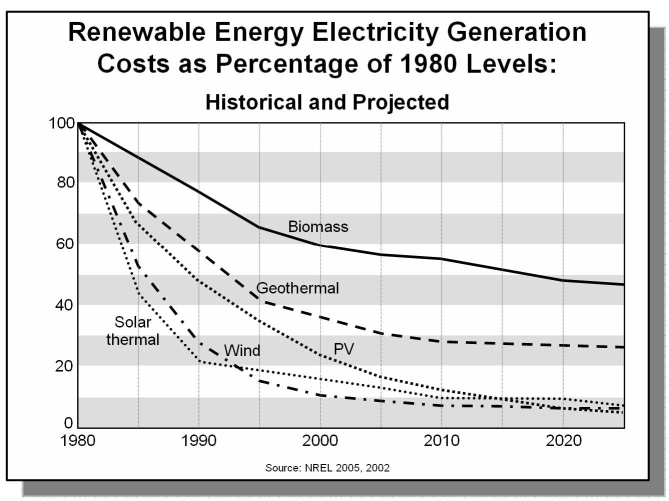
Consider that over the past 25 years, the cost of wind energy has declined from 40 cents per kilowatt-hour to four to six cents a kilowatt-hour today. The cost of electricity from photovoltaic technologies has plummeted 80 percent over that same time. These progressively lower costs have helped wind and solar energy become two of the fastest growing sources of new electricity in the U.S. and the world. Researchers at our laboratory attest to similar gains in other energy technologies, ranging from solar thermal power, biomass power, geothermal energy, hybrid vehicles and a host of advanced energy efficient technologies for industry.

President Bush laid out a timely and compelling energy vision when he came to our laboratory earlier this year. The President's Advanced Energy Initiative calls for a 22 percent increase in clean energy research at the Department of Energy. These proposals emphasize research into renewable fuels, as well as renewable solar and wind technologies.

Renewable energy can and should be one of the key players in meeting future demand for electricity and transportation fuels. We have hugely abundant renewable resources in the United States. The solar resource is good in every state, and even Alaska has the equivalent solar resource of Germany, which today is the largest solar market in the world. There are enough wind resources — concentrated in hilly areas of the country, coastal regions and the Great Plains — to meet twice the country's total electricity demand. There are major, untapped geothermal resources in the West, and you can find vast amounts of useable biomass resources in virtually every state.

Longer term, although hydrogen is often thought of primarily as an automotive fuel, its role as an energy carrier will be important in the electricity sector. Hydrogen can be produced from water using any available source of electricity — fossil, nuclear or renewable. This makes it possible to overcome the intermittency of wind or solar resources by using them to produce and store hydrogen, which can then be used to run a generator on demand.

The challenge that remains before us is to continue to bring down the cost of renewable electricity and fuels in order to accelerate their adoption. NREL and its industry and university partners have made impressive progress in this area over the past three decades but we still have a long way to go before each of the renewable technologies realize their full potential and become truly cost-competitive with traditional alternatives.



Our cost-reduction effort has a two-pronged strategy. One course is to work diligently on short-term, applied R&D to bring down the cost of existing processes and manufacturing methods. The other is to continue with mid-term, disruptive technology advancement, and long-term, higher-risk and revolutionary basic research that industry can't afford on its own, to identify and develop the next generation of renewable energy technologies.

A new, 71,000-square-foot Science & Technology Facility at NREL, to be completed this year, will allow us to do even more of this "transformational" R&D in solar, basic science and hydrogen research.

So exactly where are we today? And, moreover, what remains to be done to ensure that we have the most economic, the most secure and the most environmentally beneficial energy portfolio in the future?

Surely, while we clearly need supply-side solutions, it is equally clear that energy efficiency can be of significant value in reducing the *demand* for power. The goal may be simple – to use energy more intelligently, and not waste it. But achieving that simple goal often requires the same kind of complex and sophisticated concepts and technologies that we have come to expect on the energy production side of the equation.

Energy efficient solutions are often the most cost effective way to meet future demand and also provide additional non-energy benefits, such as improved productivity, increased durability and reduced air emissions.

Buildings account for 70% of the nation's electrical energy use. DOE's current research goal is to develop cost effective, grid-connected Zero Energy Homes by 2020. A net Zero Energy Home produces as much energy as it consumes over the course of year. A total of nearly 40,000 energy efficient homes have been completed within the Building America program, and individual research houses, including the Zero Energy Denver Habitat home, are demonstrating the feasibility of reaching the Zero Energy Home goals. Expanded investments in private and public research partnerships like DOE's Building America Program, are accelerating the adoption of new efficiency and renewable energy technologies within the housing and commercial buildings industries.

Energy efficiency technology also is having a tremendous impact in the transportation sector. DOE's Clean Cities program has encouraged use of alternative fuels, saving more than a billion gallons of oil since its inception. Gasoline-electric hybrid vehicles already are successfully boosting the fuel economy of our nation's vehicle fleet, and plug-in hybrids offer the promise of cars that can go 100 miles or more on a gallon of gas.

It is important that energy efficiency, in combination with energy supply, be a key ingredient of any comprehensive program for national energy research.

On the energy production side, some of the most dramatic cost reductions have been achieved in solar power technology. In real terms, electricity from photovoltaics - or PV, technologies that produce electricity directly from sunlight - cost one fifth or less of what they did 25 years ago. Concentrating solar power costs about one seventh of what it did then. The price of power from grid-connected PV systems today ranges from 15 to 32 cents a kilowatt hour. This year industry will ship PV modules capable of producing 1.2 gigawatts of power into the world marketplace. There is currently 450 megawatts of installed capacity from photovoltaics in the U.S.

Our researchers in the National Center for Photovoltaics at NREL are working to bring that cost down to around 4 to 6 cents a kilowatt hour by 2025. To get there, we will have to develop better, faster and larger scale manufacturing techniques, and create higher efficiency PV panels in the process. Solar technologies have the potential to shift a large proportion of daytime peak loads away from natural-gas-fired generators. And longer term, we believe solar nano-structured materials now being explored at NREL and elsewhere can revolutionize solar PV.

As for wind power, in the best wind regimes, wind-generated electricity today costs about 4 to 6 cents/kWh — one-tenth of what it did 25 years ago. Our engineers and industry partners at the National Wind Technology Center are developing new methods to drive that cost down to 3.6 cents a kilowatt hour at low wind-speed sites onshore by 2012, and down to 5 cents a kilowatt hour for shallow water offshore sites by 2014.

Wind energy is the most mature of the renewable technologies. In some regions, wind power can be the cheapest source of electricity. There currently are 10 gigawatts of wind power installed in the United States, and 60 gigawatts worldwide. While wind power is well established, and is growing at impressive rates, there remains considerable need for new research that will further drive down costs, and, importantly, make this clean, renewable energy source better suited to areas that have lower average wind speeds than the prime areas being developed thus far.

Our work today is focused on developing efficient, low wind-speed turbines, advanced power electronics and transferring wind technology to off-shore systems. If we continue to develop more advanced methods of accurately forecasting and integrating wind into the broader electrical generation system, wind energy has the potential to contribute up to 20 percent of the nation's electricity.

There is 10,400 megawatts of biopower generation in the U.S. Biopower today costs 8 to 12 cents a kilowatt hour, half of what it cost 25 years ago. Scientists at NREL's National Bioenergy Center and other labs are hard at work to lower that figure to 6 to 7 cents a kWh by 2020.

Geothermal resources contribute 2,400 megawatts to the nation's power needs. Electricity from geothermal resources costs 5 to 8 cents a kilowatt hour today – about one-third of the cost 25 years ago. With the technology improvements we see over the next two decades, geothermal power is projected to drop to less than 4 cents a kilowatt hour by 2025.

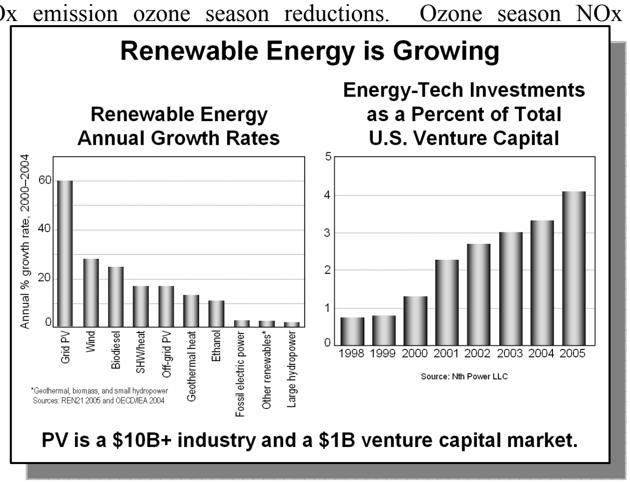
As for ethanol and other fuels made from biomass, there have been significant improvements as well. Whereas the cost of producing ethanol was more than $4 a gallon 25 years ago, it can be made for $1.20 a gallon today. Our nation currently produces about 4 billion gallons of ethanol annually, primarily from corn grain. However, corn comprises but a small fraction of biomass that can be used to make ethanol. A DOE and USDA study suggests that, with aggressive technology developments, biofuels could supply some 60 billion gallons per year – 30% of current U.S. gasoline consumption – in an environmentally responsible manner, and without affecting food production.

To gain greater use of "homegrown" renewable fuels, we will need new technologies that will produce competitively priced ethanol from cellulosic biomass, such as agricultural and forestry residues, municipal wastes, trees and grasses. New technologies like those we are now perfecting at NREL can break those cellulosic materials down into sugars and ferment them into fuel. The President has set a goal of making cellulosic ethanol cost-competitive with corn-based ethanol by 2012, and thereby reducing future U.S. oil consumption.

Essential to the success of each of these emerging technologies is the need to move from a predominantly centralized model of power generation to one that includes flexible, resilient and distributed energy systems. This will require a concerted effort to revamp our electricity infrastructure. By putting in place a more modern and flexible electric distribution system, we will be able to take full advantage of each new electric generation technology, and do so in a way that maximizes their benefits in differing states and regions across the country.

Most renewable power systems are distributed in nature, and thereby can enhance reliability of the electricity grid. Distributed generation can additionally be used instead of transmission and infrastructure expansion, and thus save money for utilities and consumers. Calculating the financial value of these benefits from renewables can be difficult. Renewable systems typically cost more initially, but most have low or no fuel costs, which can go a long way toward mitigating price volatility of more conventional fuels such as natural gas. We have to be able to put a dollar value on these benefits — and we're working on that at NREL.

Leadership provided by DOE, EPA, and national laboratories has helped state agencies encourage the use of renewable energy to help meet air quality goals. Maryland, Texas and New Jersey are incorporating energy efficiency and renewable technologies into their State Implementation Plan (SIP) planning process. In Texas alone, 4 million megawatt-hours of energy efficiency measures have resulted in more than 2,000 tons in NOx emission ozone season reductions. Ozone season NOx reductions achieved through energy efficiency and renewable energy measures in New Jersey are predicted to improve air quality by almost 900 tons/season/year by 2012. Illinois is using air quality improvement as a major driver in building 6 megawatt of new wind and renewable capacity in the state.



Having served on the Secretary of Energy's Coal Council for six years, and having been involved with nuclear issues throughout much of my career, I appreciate the challenges in each of these technology areas. Now, as director of NREL, I can tell you that the pathway to reaching the full potential of energy efficiency and renewable energy is clear and compelling.

Renewable energy and energy efficiency technologies can meet our nation's growing energy demand, largely without pollution or other trade offs. These technologies, however, can only achieve their ultimate potential through a significant and sustained national effort, focused on technology research, development and deployment.

Thank you.

MR. HALL. Thank you very much. The chair at this time recognizes Mr. Marvin Yoder, Manager of the City of Galena, Alaska, and I hope we will hear from him something about your city's efforts and discussion to plan to install a small nuclear unit for electricity, a generator to replace your diesel generators. We are very interested in that and would like to hear something of that. I recognize you to summarize it at this time, and then we will go into questions with you later.

MR. YODER. Thank you, Mr. Chairman, and subcommittee members, for the opportunity to testify here today. On the board here, you do see the layout of the plant and some of the components that go into it. The purpose of my testimony is to, one, review with you the urgent needs of Galena, Alaska, and other remote Alaska communities; two, emphasize that Galena's first concern is to develop a safe energy source for our citizens that is clean and cost effective; and three, describe for you the 4S small nuclear power plant design, which we believe satisfies our safety concerns and is ready for NRC review and licensing.

Galena is a small town of 700 people on the Yukon River. Sixty percent are Alaska natives. There are no roads to Galena, so travel is primarily by air or on the Yukon River in the summer. These transportation constraints increase the cost of goods and services. Milk is $10 per gallon, and gas is $4.20 per gallon. Another expensive commodity is electricity. The city operates a diesel generator electric plant and annually receives 700,000 gallons of fuel by barge. Since 2000, the cost of fuel has increased by more than 250 percent. Fuel is more than 70 percent of our generation cost, and electricity has risen to 33 cents per kilowatt hour--to three times the national average. The city is losing its largest customer, the U.S. Air Force base through the Base Realignment and Closure process. The Air Force purchased approximately 55 percent of our power. When BRAC is implemented, if we don't have any reuse plans, we are going to lose that load. We currently operate a boarding school for 100 high school students and offer post-secondary training as well. Low-cost electricity and heat are vital to the success of any Galena reuse plan.

Because of all of these challenges, the city has been searching for an alternative to diesel power for 10 years. We have considered coal, and for the ones who consider that, there is a coal bed about 10 miles from the city. We have considered methane gas, solar, wind, and in-stream hydro. In 2003 we heard of the 4S nuclear plant that is buried underground; it is safe and small and will last for 30 years. Built in modules, it will lower the cost of electricity by two-thirds, and it can generate excess power to serve nearby villages. In 2003, the Toshiba Corporation, along with others, traveled to Galena to discuss the 4S, and my observation is that Toshiba was pleased with the prospect of working with the community and the community present, though the 4S nuclear reactor held some promise to meet our needs.

In 2004, we worked with the Department of Energy and completed a study entitled "Galena Electrical Power: A Situational Analysis." The study compared electric rates and the environmental impacts of various electric options. The 4S was determined to be superior to other options on both counts. The report noted that this technology would reduce the greenhouse gases of our diesel generators and also mitigate the likelihood of diesel fuel barge spill on the Yukon River. For the first couple of years we pursued this goal we seemed to be swimming against the current. In the past few months the current seems to have reversed. We are encouraged by several events. First, in November, Mohammed Elbaradel, Director General of the International Atomic Energy Agency, suggested there could be hundreds of 4S-like reactors providing clean electric power and desalinated water in locations around the world. Secondly, we were encouraged when President Bush included small power reactors as integral part of his GNEP initiative. Third, we were given seed money from the Governor of the State of Alaska and the State legislature to begin a white paper process for eventual submittal to the NRC.

The 4S is a liquid metal reactor, and it is very similar to the EBR reactor that was successfully run at the Idaho National Lab for decades as an electric generator. The 4S reactor and the power generation equipment are designed to produce 10 megawatts of electricity. The facility is quite small, taking up only half an acre. The 4S reactor is designed to be fueled once, producing heat and electricity for 30 years. The citizens of Galena and I want to have a safe and secure power source. As mentioned in my opening comments, facility safety is absolutely our first priority, and the 4S plant meets or exceeds our expectations in this regard. In fact, tests were run on the EBR-2 that proves that the reactor would safely shut down without the need for active safety systems or human intervention. The plant is inherently safe in its passive design. I want to emphasize that the 4S is a technology that is ready to deploy today. Galena has evaluated the alternatives and we conclude that the 4S small power facility is the right choice for our energy and environmental needs.

Toshiba and other Japanese companies have developed the 4S design to the point where it is ready for NRC licensing. Other Alaska towns are closely following Galena's 4S program because of skyrocketing costs threatening their way of life. Mining interests in Alaska and Canada have also contacted us of their interest in the potential low-cost, nonpolluting energy source that would allow mining and processing of gold and other metals, oil-bearing sands and shale. Our Alaska Senators and congressmen view the 4S project as being the first of several projects having the potential to lower the cost to remote parts of Alaska and the lower 48, while improving the environment.

And we are looking for funding to carry this technology through the NRC licensing process. Ultimately, we want a design certification and license to construct and operate a 4S plant in Galena. We have visited the Department of Energy to request funding and appeal to this committee to help us meet our goals. Our immediate needs are for funds to prepare the environmental work, which will cost $20 million over 2 years, and we have requested the GNEP provide $2.8 million of that to begin immediate air, water, and ground data collection necessary for environmental analysis. A 4S small power plant is a source of energy that is ready to be built today. We are a small community with a big idea, and we ask for your help in deploying this new energy source.

Thank you, Mr. Chairman, for this opportunity to testify today. I request that Galena's entire written testimony be included in the hearing record. In attendance with me is our nuclear engineer, Mr. Philip Moor of Burns and Roe Engineering, and we would happy to answer your questions.

[The prepared statement of Marvin Yoder follows:]

PREPARED STATEMENT OF MARVIN YODER, MANAGER, CITY OF GALENA, AK

<u>GALENA'S NEED</u>: Safe, clean, reliable, economic, and environmentally compatible energy to replace current diesel-fired electrical production

- o Technology came from the Department of Energy's EBR-2 reactor at the Idaho National Lab (INL)
- o Not new technology – adaptation of technology that is decades old
- o Passively safe (operator can shut off all power and walk away)
- o Provides electricity (10 megawatts), heat and hydrogen for several thousand people

<u>SOLUTION</u>: Small Nuclear Power Plant

- o 30 year reliable energy production without refueling
- o Safe, secure underground facility requiring no periodic maintenance
- o Simple, passive safety systems
- o Produces electricity, heat and hydrogen
- o Near-term availability – 2010 to 2012 operation

<u>GALENA'S ROLE</u>: Galena an ideal site for first Small Nuclear Power Plant

- o First reactor must be in United States to get U.S. NRC license
- o Progressive, educated community – representative of rural Alaska
- o Economic growth limited by energy availability/costs
- o 4S is cost competitive in Alaska:
  - ▪ 4S costs — $60 - $100/MWh (fully amortized)
  - ▪ Alaska diesel cost: — $290/MWh
  - ▪ Lower 48 costs: — Coal - $33 to $41/MWh +$15 to $75 for carbon permits; Gas - $35 to $45/MWh +$10 to $50 for carbon permits; Large Nuclear - $32 to $50/MWh
- o Transforming technology – hydrogen center of excellence
- o Citizenry involved and willing to undertake a project
- o Initiated Nuclear Regulatory Commission discussions

<u>FEDERAL FUNDING REQUEST:</u> Nuclear Regulatory Commission review

- FY07: $2.8 million – Regulatory analyses ("white papers"); Early Site Permit ("ESP"), and Combined Operating and Construction License (COL) preparations.
- FY08: $10.0 million to initiate ESP/COL.
- FY09: $7.2 million to complete ESP/COL.

<u>Overview:</u>

Mr. Chairman and Members of the Subcommittee my name is Marvin Yoder. I am the City Manager for the City of Galena, Alaska. I want to thank you for the opportunity to testify today.

The purpose of my testimony is to (1) review with you the urgent energy needs of Galena, Alaska and other remote Alaska communities, (2) to emphasize that Galena's first concern is to develop a safe energy source for our citizens, that is clean and cost-effective, and (3) describe for you the 4S small nuclear power plant design which we believe satisfies our safety concerns and is ready for Nuclear Regulatory Commission (NRC) review and licensing.

Galena, Alaska:

Galena is a small community of 700 people, 60% Alaska Native, living on the banks of the Yukon River. There are no roads to Galena so travel is primarily by air.

Because of our small size it may be difficult to conceptualize the fact that Galena is a "hub community". There are four smaller villages in our region that are partially dependent on Galena for transportation and health care.

Freight is moved by air in the winter because the river is frozen over; however, the river is open from June through mid-September, and we do get barge service from Fairbanks in the summer. These transportation constraints increase the cost of goods and services. For instance milk is $10 per gallon and gas is $4.20 per gallon.

Another expensive commodity is electricity. The City operates the power plant which produces power from diesel generators. The power plant annually receives approximately 700,000 gallons of fuel from barges on the river. There is storage for enough fuel to operate all winter.

As everyone knows the cost of fuel is rising dramatically. Since 2000 the cost of fuel has increased by more than 250 percent. Fuel is more than 70 percent of our generation cost, and electricity has risen to 33 cents per kilowatt hour.

Impact of BRAC and follow-on plans:

The effect of this has been exacerbated by the fact that the City is losing our largest customer, the U.S. Air Force base, to the Base Realignment and Closure (BRAC) process. The Air Force purchases approximately 55% of our power. When BRAC 2005 is fully implemented the city will lose that load unless a reuse for those facilities is found. Our aim is to utilize the facilities on the Air Force property by developing commercial businesses, and to expand our educational and trade school program. Galena currently operates a boarding school for 100 high school students and also offers post secondary training. Low cost electricity and heat are vital to the success of any Galena reuse plan.

Because of all these challenges the City has been searching for an alternative to diesel power for 10 years. We have considered coal, methane gas, solar, wind and in-stream hydroelectric. Galena's situation is preferable to some of the other Alaskan remote villages where the cost of utilities is even higher. There is now concern that some of these native villages will be forced to close their doors if alternatives to high energy prices are not found.

4S Small Nuclear Power Plant:

In the summer of 2003 we heard of a "4S" (super-safe, small, simple) nuclear power plant that is buried under ground, is safe, small, will last for 30 years, is built in modules, and will lower the cost of electricity by two-thirds. Furthermore, it will generate excess power beyond the City's needs that could provide additional power to nearby villages.

In August of 2003 the Toshiba Corporation along with others traveled to Galena to discuss 4S and look at our community. Several members of the City Council attended that meeting.

My observation is that Toshiba was pleased with the prospect of working with the community, and the community members present thought the 4S nuclear reactor held some promise to meet our power needs.

Alternative energy sources studied:

In 2004 we worked with the U.S. Department of Energy to complete a study entitled Galena Electric Power – a Situational Analysis. That study compared the electric rate and the environmental impacts of various electric power options. The 4S was determined to be superior to the other alternatives on both counts. It was noted in the report that this technology would reduce the greenhouse gases of our diesel generators, and also mitigate the likelihood of a barge spill of diesel fuel on the Yukon River.

Based on the results of that study, the Galena City Council, in December of 2004, passed a resolution to continue our efforts to determine if the 4S plant was suitable for Galena. In February of 2005 the City met with the NRC to inform them of our intentions to further evaluate the feasibility of installing a 4S plant in Galena.

GNEP:

For the first two years that we pursued this goal we seemed to be swimming against the current. In past few months the current seems to have reversed and we are encouraged by several events.

First, in November of last year Mohammed Elbaradei, Director General of the International Atomic Energy Agency (IAEA), in a speech at MIT, suggested that there could be hundreds of small reactors with designs like the 4S providing electrical power and clean desalinated water in locations around the world. (It should be noted that the 4S is well suited for hydrogen production as well.)

Second, we were further encouraged when President Bush included small power reactors as an integral part of his Global Nuclear Energy Partnership (GNEP) initiative. GNEP contains elements that endorse small reactors with a long fuel cycle that are proliferation resistant.

Third, we were given seed money from the Governor of Alaska and State Legislature to begin the "White Paper" process for eventual submittal to the NRC.

And finally, in the past year there have been numerous articles published addressing the role that nuclear power may play in reducing greenhouse gases, stabilizing the cost of energy, and reducing world demand for fossil fuels. While most of the emphasis is on large nuclear facilities we are convinced that small nuclear power plants will also play a significant role world-wide.

4S power plant specifics:

The 4S is a Liquid Metal Reactor (LMR) and is very similar to the EBR-2 reactor which was successfully run at the Idaho National Lab for decades as an electric generator. The 4S reactor and the power generation equipment are designed to produce 10 megawatts of electricity. The facility is quite small taking up only about one-half acre of land.

The 4S reactor is designed to be fueled once, producing heat and electricity for 30 years. In this design all the nuclear heat producing equipment is below grade, and contained within separate underground structures. This design prevents access without specialized lifting equipment. There is no spent fuel storage on site. Because of its small size and simple design the facility can be air cooled during normal operation. The design also uses air cooling for the nuclear equipment after it is shutdown.

Galena's focus on safety:

The citizens of Galena and I want to have a safe and secure power source. As mentioned in my opening comments, facility safety is absolutely our first priority, and the 4S plant meets or exceeds our expectations in this regard. In fact, tests were run on EBR-2 that proves that the reactor would safely shutdown without the need for active safety systems or human intervention. The 4S plant is inherently safe in its passive design. I want to emphasize that 4S is a technology that is ready to deploy today. Galena has evaluated all the alternatives and we conclude that a 4S small nuclear power facility is the right choice for our energy and environmental needs.

Nuclear Regulatory Commission review:

Toshiba and other Japanese companies have developed the 4S design to the point where it is ready for NRC licensing. Work is being finalized now to prepare the NRC application documents.

Galena has met with the NRC to understand what needs to be done to permit a plant like this in the United States. Our aim is to have the 4S facility operational by 2012. We expect to pursue with the NRC an Early Site Permit (ESP) and a Combined Operating and Construction License (COL) process for the Galena project. We think the permitting will take between 3 and 4 years. We will meet with the NRC again in a few weeks to continue the dialogue.

With funding from Governor Murkowski and the Alaska State Legislature, the City was able to contract with Burns and Roe, Inc to prepare a series of White Papers. (These technical papers will provide further education regarding the safety of the 4S plant.) Other Alaska towns are closely following Galena's 4S program because skyrocketing energy costs are threatening their way of life. Mining interests in Alaska and in Canada have also contacted us. They are very interested in the potential of a low cost, non-polluting energy source that would allow mining and processing of gold, other metals, oil bearing sands and shale.

City leaders have met with our Alaska Senators and Congressman and have their support for this project. They view Galena's 4S project as being the first of several projects having the potential to bring lower cost energy to remote parts of Alaska and the lower 48 states while improving the environment.

Funding and Design Certification:

We are looking for funding to carry this technology through the NRC licensing process. Ultimately we want a design certification, and a license to construct and operate the 4S plant in Galena. We have visited with the Department of Energy (DOE) to request funding, and appeal to this Committee to help us meet our goals. Our immediate needs are for funds to prepare the environmental work which will cost $20 million over 2 years. We have requested the GNEP program provide $2.8 million of that amount to begin immediate air, water and ground data collection necessary for the environmental analysis. We see the GNEP program as a logical source for funding this program and encourage your support of Galena's efforts to build this 4S small nuclear power plant.

Conclusion:

The 4S small nuclear power plant is a "today" energy source that is ready to be built. We are a small community with a big idea that wants to build it. I ask for your help in deploying this new energy source. We are enthusiastic about the opportunity to change the cost of living dynamic, and preserve our Native Alaskan way of life in our little corner of the world.

Thank you, Mr. Chairman, for this opportunity to testify today. I request that Galena's entire written testimony be included in the hearing record. In attendance with me is our nuclear engineer, Philip Moor, of Burns and Roe Engineering. We would be happy to answer your questions.

MR. HALL. We thank you very much. I note the presence of the Chairman of Energy and Commerce. Mr. Chairman, would you like to propound any questions to the witnesses?

CHAIRMAN BARTON. Well, Mr. Chairman, I have been in discussions with Mr. Boucher on the refinery permitting bill, so my mind is not focused on new ideas on how to generate electricity. If you will give me about 5 minutes to get focused, then I would probably come up with some questions.

MR. HALL. All right.

CHAIRMAN BARTON. But at this point in time, I would like to defer for five minutes.

MR. HALL. All right. Then I will ask a question of Dr. Arvizu. Did I say that right that time?

MR. ARVIZU. It's Arvizu.

MR. HALL. Arvizu.

MR. ARVIZU. Yes, sir.

MR. HALL. And that is not what I said?

MR. ARVIZU. That is close.

MR. HALL. Remember, I am the Chairman.

MR. ARVIZU. Yes, sir, I will change it tomorrow.

MR. HALL. I thank you.

You mentioned hydrogen that was generated from wind power and it's turbine. It is a method to overcome the fact that wind power is intermittent. Is this cost competitive, and is anyone doing this today?

MR. ARVIZU. Thank you for the question, Mr. Chairman. Actually our local utility is the one that approached us about it. They have several fairly major wind farms that they currently operate and a couple more that they plan, and they are trying to look to the future, because what they would like to be able to do is capture that wind energy when there is no, perhaps, peak load demand on the system so that they can use it at a later time. So they are looking at hydrogen as an opportunity as a storage medium. Perhaps it could be used for transportation fuel at some time in the future, but that is their motivation. And so they have entered a partnership with us at the National Laboratory and we are looking at different components to make that cost-effective. Today, I would offer that it is not cost-effective, but we believe that it can be with additional development.

MR. HALL. In your opinion, which of the technologies that you have described are ready for deployment now because they are cost competitive and available, but are not being deployed to the extent that they should be, and what do you think the reluctance may be to deploy these technologies?

MR. ARVIZU. Well, certainly there are a number of factors that offer what I would call barriers to more rapid, accelerated deployment. Many of these technologies I mentioned in my remarks are being deployed in various markets where the business case can be made and the private sector can create a sustainable business opportunity. So in the case of wind, the technology is far enough along now when we have a good wind resource close to a load. You don't have to add new transmission capabilities. You can put wind into the system and essentially it is cost effective today. Photovoltaics, when the solar resource matches your demand peak, like in Southern California, where people turn on their air conditioners in the afternoon, there is an opportunity there to provide energy back into the system at a cost that is very competitive with what we pay today. So there are ways to do that. A lot of it has to do with some policies that are in place and also some structural things that are part of the infrastructure we have today.

MR. HALL. You state that there are 10,400 megawatts of biopower. And so for the record, tell us what you mean by biopower.

MR. ARVIZU. Well, there are two ways that you can use a biomass or essentially a biomass resource for electricity generation, and many of these are smaller power plants that use some form of green waste, everything from yard clippings to some of the municipal solid waste kinds of things as well, but much of that biomass is also co-fired with coal to reduce the emission profiles out of many of the power plants that are out there today. So that is the technology that has been in place for some time now and it is relatively mature.

MR. HALL. Mr. Yoder, tell us just briefly about your city's plans to install a nuclear unit for electricity generation, the cost of it, and how you are going to finance something like that. It seems like it is a pretty big undertaking.

MR. YODER. It is a very large undertaking. We do realize that since it is somewhat of a first of its kind, that there are a lot of development costs that will not be there in the future ones, and some of that is going to be borne by industry, by the manufacturer, by whoever the eventual owner is. We will probably be a purchaser of raw power and our determination will be based on the cost of that power, not necessarily on the cost of the overall plant.

MR. HALL. What, if any, existing Federal or State rules are hindering deployment of the technologies that you have discussed?

MR. YODER. The biggest hurdle I think we have to cross is the Nuclear Regulatory Commission's rules. We expect that process, the licensing process, to take several years. Galena, basically as a city, is working on the environmental side of it. We expect the manufacturer or, rather, industry, to do most of the licensing for the plant itself. Our focus is on the environmental part of what goes in Galena, and both of those have huge components at the NRC that will take a considerable length of time.

MR. HALL. All right. My time has expired. The Chair recognizes the gentleman from Virginia.

MR. BOUCHER. Well, Mr. Chairman, thank you very much and, Mr. Arvizu--

MR. ARVIZU. Yes, sir?

MR. BOUCHER. --thank you for sharing your knowledge with us this morning. I notice in your testimony that you are talking about the potential for a zero energy home by the year 2020, and I assume that means that the home would generate as much electricity as it consumes, and so this is a home that can live totally off the grid. Is that a fair description of what you have in mind?

MR. ARVIZU. It is. On an annual basis, the amount of energy that it would generate would essentially be the same as the amount of energy that it consumes on an annual basis, maybe not at the same time. But we actually have a home in Denver that was part of the Habitat for Humanity project and we helped design this essentially net zero energy home. It has photovoltaic panels on the roof, it has a very tight envelope so that there is very efficient use of energy in the home, and we have a single mother with two boys that are the occupants and their electricity bills are not zero, but that is not because they are consuming energy. That is normally some of the things that the utilities charge for services that they otherwise use.

MR. BOUCHER. So the home is connected to the grid.

MR. ARVIZU. It is.

MR. BOUCHER. But it generates as much electricity as it brings in, I suppose.

MR. ARVIZU. That is correct.

MR. BOUCHER. Is it selling excess electricity back into the grid?

MR. ARVIZU. Precisely.

MR. BOUCHER. Yes. Well, let me ask you this. With regard to a broader deployment of zero energy homes, would there be a role for demand response in helping to make that possible? And I have a particular interest in smart meter technology, and I am wondering if you can enlighten us about, first of all, the role that demand response would play in the creation of a large number of zero energy homes, and the extent to which demand response technologies, including smart metering technology, is being deployed at the present time, and any barriers that you see to further deployment of demand response technologies.

MR. ARVIZU. A very important question, sir. I think one of the structural issues that will allow us to more rapidly deploy some of these distributed resource technologies, such as the ones we are talking about, is in fact both time-of-day pricing; and essentially smart meters which are meters that can manage that commerce on both sides of the meter so that we can begin to allow consumers to make choices about how they use energy, based on its value. And if you are at a point in the utility infrastructure where you are at or near peak, the cost of supplying that energy is very expensive and they pay a lot of money to do that. So as we are able to relieve that load, it displaces new generation, it displaces maintenance and operation costs, and at the same time gives the consumer the opportunity to manage their own energy needs in a way that can provide benefit to them and also to the economy and to the environment.

MR. BOUCHER. So to what extent are smart meters being deployed at the present time? Do you have a visibility for that?

MR. ARVIZU. Well, yes, it is a little frustrating because there are not many places where we do have the entire, what I would call, package of those types of incentives. California is the leader. They, in fact, have been doing this for some time and I think other States are beginning to get on board. There are other activities going on in various forms of maturity across the country. We don't have it in most States and in fact it is a fairly significant barrier, even in our own State of Colorado.

MR. BOUCHER. Is that a regulatory issue at the State level, or is it lack of will on the part of the incumbent utilities to deploy?

MR. ARVIZU. Well, I think it probably varies State by State. There are a number of different ways in which those policies get put in place, and without drawing a conclusion about whose responsibility it is, I look at it from the perspective of what can the technology offer, and then decisionmakers are in a position to know that this kind of a policy will provide this kind of a benefit. And to a large extent, we haven't had that level of transparency in the past that I think now is beginning to become known to lots of people, and all of sudden it becomes, I think, a very important and healthy debate in many of the State legislatures.

MR. BOUCHER. We included in EPAct 2005 just for your information, a provision that requires every State to undertake an examination of the merits of demand response and smart meter technology, and a potential requirement, State by State, that electric utilities offer real demand, real-time pricing so that that price signal would be sent and consumers would have a basis to choose the time of day in which they consume electricity in greater or lesser amounts. I suppose you haven't really looked around the States to see what they are doing with that requirement, have you?

MR. ARVIZU. No, sir, I haven't. I can tell you this, I applaud the language in the bill because it is absolutely what is necessary. I think my observations are that many States are still trying to figure how they do that and haven't yet come to a conclusion about what needs to be done. But it is something that we ought to really move on, I think.

MR. BOUCHER. Do you provide information to States on request? Do you have a service that does that?

MR. ARVIZU. Yes, sir, we do.

MR. BOUCHER. So they can come to you for information?

MR. ARVIZU. They certainly can.

MR. BOUCHER. All right, thank you, Mr. Arvizu.

MR. ARVIZU. Thank you, sir.

MR. HALL. All right, the Chair recognizes Mr. Shimkus.

MR. SHIMKUS. Thank you, Mr. Chairman, it is great to be here. I appreciate your testimony. Sorry, I had to run downstairs. That is adjourned. That was a quick hearing and so I get to spend the rest of the time up here. A couple questions that I would like to address. And Dr.--

MR. ARVIZU. Arvizu.

MR. SHIMKUS. Arvizu. Do you talk anywhere about geothermal? Do you consider that part of your portfolio?

MR. ARVIZU. We do. Geothermal is a mature technology. We have roughly two gigawatts, 2,000 megawatts of geothermal resource that has been tapped and generates electricity. Geothermal is still a technology that is not only viable, but can provide additional generation for our energy mix. In the grand scheme of things, it is one of the technologies that we need to pursue and use when the resources are available. The research that is required to improve that technology allows incremental cost reductions, perhaps doesn't have as much of an impact longer term as some of the other technologies that are moving on a much more rapid curve, but it is still a very important part of our portfolio.

MR. SHIMKUS. In my investigation, and especially in your discussions about the home, really the geothermal applications, it really is related to more home heating, but it then adds more to the electricity cost, because you are really recirculating the geothermal heating core. Through the use of more electricity, you can--with natural gas concerns and escalating prices, those in the Midwest or anywhere that relies on natural gas, there is a great benefit, especially with the high price of home heating, but it does really then address increase electricity use, which I am very interested in. I have actually done a lot of research on the home heating front and I think it holds great promise, also.

MR. ARVIZU. Yes. If I may respond, I think it is absolutely essential, and I should make a distinction between a geothermal resource, which is really things like tapping the geysers in California, versus a ground-coupled geothermal pump, we call it, which really takes advantage of that thermal gradient in the Earth to the atmosphere, to essentially be a sink and a source for heat and to reduce our heat load in our homes.

MR. SHIMKUS. Cooling load, too, in the summer.

MR. ARVIZU. So you can use that thermal gradient. You can use the temperature difference, if you will, for providing benefit to the inside of a dwelling.

MR. SHIMKUS. Right.

MR. ARVIZU. And that is what coupled thermal heat pumps are and they are very--

MR. SHIMKUS. I am sorry. Let me get to Mr. Yoder real quick. I am a big nuclear power proponent and I am very excited about your proposal. A major question, though, is, what do you plan to do with the waste? And if we don't open Yucca Mountain--we are not going to build any more nuclear power plants in this country unless we have a place to store the waste. Your plant is a smaller size than most that we deal with, so what are you going to do with your waste?

MR. YODER. I think that is a technical question. Mr. Moor is here, and he could clearly answer that.

MR. SHIMKUS. Is the mic on?

MR. YODER. Oh, okay. Mr. Moor is here from Burns and Roe, and he has done a white paper on decommissioning, and I would like him to answer that question, if he would.

MR. MOOR. This is a very small facility, much smaller than the commercial nuclear facilities that we are familiar with. It is 50 megawatts versus over a thousand. The way this facility is designed, it has a 30-year core life, so it would be installed once, and based on our current construction projection, the spent fuel would be ready for repository in 2045.

MR. SHIMKUS. A repository. And where is that repository?

MR. MOOR. I am not here to respond to whether there will be a Yucca Mountain or a recycling facility, but there will be some Federal repository.

MR. SHIMKUS. That is what we hope.

MR. MOOR. That is what we hope, too.

MR. SHIMKUS. So that is an interesting debate. Senator Domenici really did great harm in his comments yesterday. It is critical that Yucca Mountain goes forward and it is critical that we move the spent rods off these sites for our nuclear power plants so that they can continue to use their plants to generate electricity, and I would hope that you would use your connections with some senior Members of the Senate to help address the advanced siting with the Administration, or the licensing and then the expansion and the move forward on Yucca Mountain. Mr. Chairman, my time has expired and I yield back.

MR. HALL. I thank the gentleman. The Chair recognizes Mr. Green, the gentleman from Texas.

MR. GREEN. Thank you, Mr. Chairman. I don't have many questions and I will yield back the time. Mr. Yoder, you talked about the base closure and your main customer now is the Air Force base and you are going to develop that into other uses for commercial and educational. I assume most of your diesel now is barged in during the months when the river is not frozen.

MR. YODER. Yes, that is correct.

MR. GREEN. And I guess most of the equipment, because this is a pretty ambitious project and I congratulate you on looking at it, I guess that most of the equipment would be barged in to build the facility.

MR. YODER. Yes. In fact, one of the early diagrams we had from Toshiba showed the whole configuration sitting on a single barge and coming in, in whole, so they had considered off-site construction and bringing it in on a barge.

MR. GREEN. You know, that is interesting because I know of an experience in Houston where we will do an expansion for a chemical plant, for example, and all of the work will be done and it will be towed up the Mississippi River and the Ohio River Valley and literally dragged up the river bank and placed in one of the chemical facilities there on the Ohio River. That is really good. Dr. Arvizu?

MR. ARVIZU. Arvizu. Yes, sir.

MR. GREEN. I appreciate your testimony, especially on wind power and I know, coming from Texas, obviously hydrocarbons are important, but I know our State is doing some interesting things off the coast, both Galveston, Brazoria County, in the Houston area, but also just off the coast at South Padre, with windmills.

MR. ARVIZU. Yes.

MR. GREEN. And it is going to help the State's school education fund and there will also be an alternative to put power into the grid that we don't use anymore.

MR. ARVIZU. Right.

MR. GREEN. The biggest concern, though, is the environmental side because of our flyways that we have in lots of areas, and I don't know if that has been something the Department of Energy has addressed, or is that something someone else would, on expansion of wind power, because we already have wind power in west Texas, with windmills.

MR. ARVIZU. Sure. Yes.

MR. GREEN. And has there been any evidence of a loss, particular during migrations?

MR. ARVIZU. Yes. Well, it is first of all an issue that the Department of Energy is very much focused on. We look at all the environmental footprints that any of the renewable energy technologies do represent. And certainly what we have learned in 30 years of wind technology development and deployment is that you really do need to stay away from migratory bird flight paths, because there is an issue that relates to disruption of some of those avian issues. At the same time, I think a lot of these things tend to get a lot more press than they are entitled in many respects. We do need to manage those things and it is a matter of risk and reward, the benefit that you get from these technologies versus whatever risks they might represent. But in the case of things like the flight paths for aircraft and even for the military, on the offshore technologies and also the migratory bird paths, we are looking at those very, very closely. There is a number of studies that we fund through universities and other organizations to help us provide the greatest amount of knowledge and information so that you site and you permit these facilities in the places where they are going to cause essentially the least disruption, and we believe that this is not an insurmountable issue and in fact is one that we have, I think, made a great deal of progress on and I think we got our arms around that one.

MR. GREEN. Well, one of the perforations, I know that our offshore drilling is at some of the best fishing in the Gulf of Mexico, because typically it is just flat, and once you put a rig out there and that is a place where the fish can go and find shade, but a lot of sports fishing benefit from that. That is why the Ships to Reefs, and even the Rigs to Reefs Program, is important, at least for the western Gulf that we use--

MR. ARVIZU. Right.

MR. GREEN. --so if you put something in the water and it will become a fish habitat, whether you intend to or not. So thank you, Mr. Chairman.

MR. HALL. The Chair recognizes the gentlelady from California, Mrs. Bono.

MS. BONO. Thank you, Mr. Chairman. My district, the 45th District of California, is probably a district you are very familiar with. We have got a lot of wind power, a lot of geothermal, not enough solar. I think the Governor is doing a great effort in expanding our solar capabilities, so I am very proud of my district. And those of us in California think, with the extremely high cost, the crisis that we faced, are on the cutting edge, as you mentioned before, perhaps not by choice, but we were forced into it. But a lot us are faced now with policies here in Washington and it seems that if we could come up with a policy or something and focus our energies on sort of a man-to-the-moon type of mission, we could do a great deal. So in your written testimony you mention that our Government needs a sustained energy research program. Can you elaborate on that a little bit? Are you just supporting your current efforts, or do we need to do a lot more and what should we be doing and how far? Dr. Thomas Friedman, in this book, talks about the next 10 years, getting completely off of any foreign sources of oil. Can you talk a little bit more about this, please?

MR. ARVIZU. Yes, thank you. And thank you for the opportunity to do that. Actually, Tom Friedman has been out to the laboratory, he spent a day taping and he will have some sort of documentary that will highlight a number of the technologies that we are presently working on. The reason I talk about a sustained effort and the reason that there is still additional opportunity for new research and development is that the enormity of the problem that we have got to face, and as someone mentioned earlier, the projections that over the course of the next several decades, the percentage of renewable energy won't increase. If you just project a straight line, that is what the projections would indicate. My very, very informed opinion is that we can do a lot better than that. We can begin to think about 40, 50 percent of our new generation, mid-century, being supplied by energy efficiency and renewable energy technologies, and that is a bold statement. We need a lot of energy. In order to do that, we need to continue to drive the cost down and as I mentioned, the technologies that are in the laboratory today will be the technologies that will supply those markets.

I started in this business almost 30 years ago. The technologies that we worked on in the laboratory 30 years ago are the commercial products of today. And as I told the President when he visited, it is important that we not take another 30 years to get the technologies of today into the marketplace, and that is where I think additional R&D on manufacturing processes, on deployment, perhaps some policies to supplement that, to increase that deployment opportunity and accelerate it, those are the kinds of things that will lead us, I think, to that future that I know exists out there, if we make a national commitment to make that happen.

MS. BONO. Well, I will gladly work with you and fully support what you are trying to do. Yesterday, I and my staff were trying to kick this around quite a bit and arbitrarily, I can't assign a figure, that in 10 years we will be 100 percent off of foreign sources or whatever it would be, and I would truly seek your assistance in something like this. I actually was speaking with the President about this as well, and had the opportunity to be with him and a venture capitalist and to talk about the very issue, and this venture capitalist was saying that they are moving out of the tech industry now, into alternative fuels. Are you seeing that as well? And I know that perhaps that's not your area of expertise as much, but is the venture capitalist world going to be a big part of this role, the private sector, or does the Government need to be the largest player in this?

MR. ARVIZU. Well, I am fully convinced that the Government's role is to try to mobilize that private sector capital and that will certainly manifest itself early in venture funds and venture technology kinds of investments. What we are seeing is a rapid growth in clean energy investments and it is in fact growing at a very significant rate. It is over a billion dollars now. There is 4 percent of the energy investments now going into clean technologies and that is on a very rapid upswing. So all of the indicators that are in the financial markets suggest to us that we are at a tipping point, that we are going to have some things move quickly and it is a matter of how quickly they will move, depending on a variety of factors such as government policies and technology development.

MS. BONO. I understand, too, a lot of folks in Silicon Valley are very excited, very excited about this and I think are very willing to push it along. The first question on that note--I get a lot of calls and letters from constituents. This might seem like a silly question, but I get it a lot and I would love for you to answer. Is there really a project to convert water, not to extrapolate the hydrogen, but water, somehow, into energy and there is a water-burning engine out there that we are keeping from the people? I get this a lot. I don't know if my colleagues do as well, but we do. I hear it. It is when you are in California. That is northern California.

MR. ARVIZU. Yes, let me not go into a dissertation about that. We frequently get lots of people who are so enthusiastic, that they would like to create what we call the perpetual motion machines, and there are a number of those things. No. There is some really great innovation and without speaking specifically to what particular technology someone is talking about, I think it is worth taking a look at some of these things. A number of them, the first question we ask when we get asked a question like that, and certainly feel free to provide those kinds of questions to us and we will give you our opinions about things, but we look at, kind of, the first law of thermodynamics to make sure that the science hangs together and that is kind of the first step that we take. Frequently, that is not the issue for deployment. The issue is, how do you get the technology into the marketplace and the business planning that goes with it? But does the science work? Does it hang together? You know, we can give you an honest opinion about that, an informed opinion. I don't know of any water-based energy generators of any kind. It takes energy to convert materials to other forms. So I don't know of any and we are not hiding anything that I am aware of. So does that put your mind at ease a bit?

MS. BONO. Thank you. And it will help for me to say that you said that instead of just me. But also, is there a redundancy within the Federal government or too many different areas? Is money going out to too many different places and we should be basically concentrating our efforts more? It sounds like with you.

MR. ARVIZU. Well, there is always a trade-off with how focused do you get and where do you put your priorities. I think, in the Department of Energy, that is one of the functions that they perform, it is to assess for how much investment what benefit do we get, and that needs to be a very thoughtful process and it needs to be continually updated and evaluated. So I would say the process is more important than the outcomes in this particular case, because we do need to focus very precious taxpayer resource dollars into these areas. There is lots of opportunity and there are lots of things that we are not doing that we could do if we had more money. But for the most part, I think the Department of Energy does a pretty good job in prioritizing things.

MS. BONO. Thank you, that is good to know. I come from a family, a very interesting family. I have a brother who is an automotive engineer, another brother who is in the mom and pop oil business, a mother who is a chemist and actually worked on the Manhattan Project, and my father is a surgeon, so we kick this around a lot and I would have to say they are pretty cynical about renewables, and so I think I am the black sheep in the family with this. But I will yield back, my time is up, but I do look forward to working with you and I would love if you could come by and coach me a little bit and give me some ideas.

MR. ARVIZU. I would be pleased to do that.

MS. BONO. Thank you.

MR. ARVIZU. And you are welcome to come to the laboratory.

MS. BONO. I actually will do that. Thank you very much.

MR. HALL. I thank the lady and recognize the gentleman from Pennsylvania, Mr. Murphy.

MR. MURPHY. Thank you, Mr. Chairman, and I thank the distinguished panel for being here. I have a couple of questions on some of the aspects of renewable energy, because--and I read through your testimony here, but it has to do with how we are on the path of energy independence. First of all, some of the claims I hear sometimes is, we really don't need to pursue drilling for more oil or explore for more oil in the United States, because we can take care of our energy problems with conservation and with the renewable energy sources we have in America. Are we close to doing that? Is there any truth to that at all?

MR. ARVIZU. Well, that is a loaded question to some degree. Let me try to answer it as honestly as I know how. I don't believe that we are at a point today where we can suggest that renewable energy is our total solution, and energy efficiency. You know, 86 percent of the world energy consumption is based on a fossil fuel of some sort. The projections are that that will continue for some period of time. It would be, I think, presumptuous to say that we can get off of that quickly. I think eventually, and we are talking many, many years, that we can get the lion's share of our energy from renewable resources. It will take a much longer and protracted change in how we view energy infrastructure to get there. So as a result, my short answer is I would like to think that we can get a large fraction of our energy from renewable energy.

MR. MURPHY. Well, let me ask another thing, when it comes to ethanol, because you do research on that. One of the criticisms about ethanol we hear is that it takes more oil to make ethanol than it really replaces. Is that true, not true?

MR. ARVIZU. The short answer, not true, and I can understand why there is a debate about that. When you talk about corn ethanol, what you are really talking about is the fermentation process of the corn cobs, if you will, into ethanol. If you do the energy balance on that, based on the best information we have, it is about 1.4 units of energy out for every one unit of energy you put in and that includes everything that it takes to grow the corn, to fertilize, to do the production and all the things with it.

MR. MURPHY. Are we improving in the efficiency of that?

MR. ARVIZU. Well, the other point that I would like to say is also that it is not the focus of the national program. The national program is focused on cellulosic biomass, which is not the food part of the plant. It is the corn stover. It is the balance of that plant. It is ag waste of all other kinds. It is forest residues. And if you do the energy balance on those, the energy balance is five or six, or perhaps more, to one, five or six units of energy out for every unit of energy put in. And that is where, you know, 90 percent of the biomass resource that we are talking about for our liquid fuel consumption of the future is going to come from. So it is a little bit of a red herring to talk about the energy balance on ethanol, from essentially a sugars or a fermentation process.

MR. MURPHY. Another area, and we are going to hear a little bit later on some of the solar issues, too, from Plextronics. But with regard to the solar cells, you made reference to the prices coming down dramatically on those. How about the--the price is going to be coming down, but you still need so much space to have enough of those solar panels to provide electricity. Are we improving the efficiency of that as well?

MR. ARVIZU. Absolutely. The efficiency is, in fact, what is so exciting to me. I started, again, in the business 20, 30 years ago and we thought about a single material like silicon that we typically think about for integrated circuits. Today's materials are a whole new set of really exotic, engineered materials. We are thinking about nanostructures today that get beyond the limitations of these bulk materials. And in fact, we can begin to think about efficiencies that are not in the 20 percent range, which is where laboratory scales are, the 20 to 30 percent range, we can start to think about efficiencies in the 50, 60, perhaps even more, percent range and the technology and the physics that go along with that being developed in the science programs, in the technology development of the national laboratories and universities today.

MR. MURPHY. How far are we away from the 50 to 60 percent range?

MR. ARVIZU. Well, I would offer that we will get there for space-type applications, we will get there in the next--in fact, we have got a DARPA project right now that we expect to have 50 percent scales in the next 5 years. Now those will be very expensive and they will be used primarily for specialty applications, but the learning we get from that and then taking those and putting those into these nano-structured materials is probably another decade away beyond that. But that is the technology that will take us to mid-century, to this end point that I was talking about earlier, where you get essentially a large fraction of our energy mix from things like solar photovoltaics.

MR. MURPHY. I thank you very much and I yield back the balance of my time, Mr. Chairman. Thank you.

MR. HALL. I thank the gentleman. I think the Ranking Member has other questions he would like to ask at this time. I ask unanimous consent to recognize him, though. He has used his time and we do not have anyone here to give time or to yield to him. Is there objection? The Chair hears none. The Chair recognizes Mr. Boucher. All right. Mr. Otter, the Chair recognizes you. I withdraw the recognition of Mr. Boucher.

MR. OTTER. Mr. Chairman, I will yield to Mr. Boucher.

MR. HALL. All right, let us get underway now.

MR. BOUCHER. All right, thank you, Mr. Chairman. I just have one brief follow-up question and it was actually stimulated by Mr. Murphy's question to you about the difference between corn as a feedstock for ethanol and cellulosic materials as a feedstock.

MR. ARVIZU. Yes.

MR. BOUCHER. Let me confess an absence of a lot of knowledge about this, which will become readily apparent as I propound the question. I had been told that one of the key differences that leads to a favorable energy balance versus what some would argue is a negative energy balance with regard to corn, and a more favorable balance on the cellulosic side, was the fact that, with regard to corn, you have to cultivate the crop every year, and that requires a substantial amount of energy input; whereas, with some of the cellulosic materials, perhaps all of them, they are more or less like perennials, they regenerate naturally. You don't have to expend energy every year in order to replant the crop. Is that a key differentiating factor between the two, or is it more--and if it is not that, then what it is? Why is it that you get a 1.4 to one yield with regard to corn, and a five to one yield with regard to cellulosic material? Just explain the factors that differentiate those, if you would.

MR. ARVIZU. Well, you have been coached properly. That is a good explanation of the primary difference. The resource in cellulosic biomass really comes from two sources. One is ag residue and it is not just corn stover or the leftovers in the crops. Typically, those things are plowed back under and so they are essentially a waste product. You need to save about 20 percent of that to re-nutrient the soil and to get the consistency back to where it needs to be. But across the agricultural landscape, you have got a number of different crops and they are essentially field waste. The residue is part of that biomass resource. The other biomass resource is what we might call energy crops. So when you are talking about things like switch grass and a variety of other things that you might, on a periodic basis, seed and grow, because they do grow naturally, that is really the other aspect of that. Those two sources combined make this broader resource that I was talking about earlier that could potentially serve 30 percent of our, you know, equivalent gasoline consumption.

MR. BOUCHER. Do you have any obvious candidates for the kind of feedstock materials on the cellulosic side that would be the most sensible for the United States to target as opportunities?

MR. ARVIZU. Well, the beauty is that there is really no one single crop that is best at this point. In fact, part of the research is to figure out how do you make ethanol very efficiently from various kinds of crops, and the beauty of that also is that those resources are distributed according to the microclimates across the country, and we really don't have to do a lot, other than to take advantage of the things that are already in place, forest thinnings and a variety of other things. That would be very valuable, I think, in terms of an ecosystem management.

MR. BOUCHER. Okay. Well, thank you very much.

MR. HALL. The Chair recognizes the very generous Mr. Otter for the remaining time.

MR. OTTER. Thank you, Mr. Chairman. Mr. Arvizu, am I saying that right?

MR. ARVIZU. Yes, you are.

MR. OTTER. Okay. Mr. Arvizu, mine is Otter, O-t-t-e-r. Mr. Arvizu, you made a statement in your opening statement that made me curious. When you said in a very short period of time, we can be independent, what is your short period of time?

MR. ARVIZU. Maybe you can help me with where in my statement. It was, in a very short period time, I believe we can get the costs of these technologies down to where they can provide a great impact into the marketplace. A lot of it has to do with those market forces and the business cases that have to be made and the investment that has to be made. When I say a short period of time, I am really talking about in the next 5 to 10 years.

MR. OTTER. Okay.

MR. ARVIZU. And so we don't have to wait decades. It can be done--

MR. OTTER. And a lot of these technologies we are already working on, in fact, we have implemented some, haven't we?

MR. ARVIZU. Absolutely.

MR. OTTER. And we are maybe in the first generation of some of those technologies and--

MR. ARVIZU. Well stated, yes, sir.

MR. OTTER. I want to aid you a little bit in your answer to Mr. Boucher about ethanol.

MR. ARVIZU. Yes.

MR. OTTER. In 1984, prior to coming to Congress, I worked for a potato company, oddly enough, in Idaho and we used to supply--my company used to supply all the potatoes to the McDonald's restaurants. And so once we endure the lawsuits for obesity, we will be able to go forward, I suppose. But one of the things we did in 1984 was, we found out that we had a biofuel and it was called potato peelings, and so we built about three and a half to four million gallon ethanol plants at the pipeline of the waste stream coming out, which normally we fed to cattle. But we built an ethanol plant on the end of each of those pipelines coming out of those processing plants. And so subsequently, we produced six to eight million gallons a year of ethanol out of what had been a waste stream and we did it economically. Getting through all of the permitting processes and everything was a marathon. Once we finally got to where we needed to go, we were very successful. I am wondering if you think some incentive by the Government would aid some of these waste streams that are coming out of the processing plants. All the food that we have today, we process about 80 percent of the potatoes now that are grown in Idaho. I am wondering if there is any kind of an idea or a scheme that you might have in mind. Maybe scheme is the wrong word, in these days of earmarks. But are there other sources of ethanol besides the switch grass and besides corn, which seems to be the most favorable? I am familiar with Brazil's ability to turn a few switches in a sugar plant--

MR. ARVIZU. Absolutely.

MR. OTTER. --and go from making granulated sugar, or some other kind of product, to ethanol, which has made them independent. Have you looked at that side of it?

MR. ARVIZU. Well, we looked at a variety of things and so many of these things are structural. You know, when you have a waste stream and you are trying to figure out what to do with it, it always makes sense to let us figure out if we can convert that into a benefit or a revenue stream in some way, and many times that works well. There are structural issues where sometimes you do that and you displace somebody else's market for feedstock for animals or whatever, and all of a sudden, now there are regulatory barriers to making those things economical. So a lot of what Brazil has done and others have done is start with a clean sheet of paper and you design in kind of what your outcomes need to be. A biorefinery where you can dial the switch from a food product to an energy product makes great sense for them. If we could do that, unfetter ourselves from the regulatory equilibrium that we are in now for all the various objectives that we have, we make this process a lot more efficient and move much more quickly. Now that is very complex and very complicated to do, and so my job is to provide the decision makers, and people like yourself who are in a position to try to formulate those policies, with what can the technology do, because I believe the technology opportunities are much greater than we are allowing them to contribute in terms of the overall energy mix, but it requires a policy framework that is consistent with the objectives. And so that is a very, very difficult thing to do, but I am bullish that there is an opportunity there.

MR. OTTER. I see. And one other question that I wanted to refer to is, making a product is just about half of the business to business. It is distributing it and getting it to market.

MR. ARVIZU. Right.

MR. OTTER. Because we already have some inherent problems with ethanol on early blending, like in pipelines.

MR. ARVIZU. Yes, yes.

MR. OTTER. Are we still working on technology to figure out how we can get that blend as quick as possible and still be able to wheel our energy through these pipelines? That is one part of my question. The other part of my question is the end distribution. We have had E-85 in this country now for quite some time, and throughout the United States there are only 400 pumps. There are only 400 places to get go it, yet we are encouraging the automobile industry to develop cars that can burn E-85. Now, we had that initial problem in the early 1980s to mid-1980s with ethanol. For those of us that were not using MTBE and we chose to use ethanol, we didn't know that we were doing the right thing, because we didn't know what was going to happen, like in last year's energy bill, where we took MTBE out of the equation for environmental reasons, which was a smart and an appropriate thing to do. So getting that distribution is important. Getting it to the marketplace so that the consumer can use it is important.

MR. ARVIZU. Yes.

MR. OTTER. I don't think we can study just the technology. We also have to study the matrix of transportation and marketing.

MR. ARVIZU. Yes.

MR. OTTER. Are you working on that as well?

MR. ARVIZU. Yes, sir, we pride ourselves in being what I call market relevant. We need to know what market problem are we solving and how does the technology play into that. Many times it is exactly what you said, it is the infrastructure and the distribution. So you start trying to look at how can I do that locally rather than doing it centrally, so that you don't have to create a whole new distribution infrastructure that simply is nonexistent. So there is a blend of those things and we try again to move the technology to where its nearest term market opportunity lies. So we are looking at, for instance, on the formulation side, we look at how does including ethanol in a blend of fuel, what are the impacts of that? What are the impacts on emissions? What are the impacts on performance? How does the vehicle operate? What does the vehicle have to do in order to accommodate that? We look at all of those things as part of our transportation efficiency prospect, as well as on the generation side, how do you make the stuff and make it economical. But your points are very well taken and yes, sir, we are working on all of that.

MR. OTTER. Thank you, Mr. Chairman, and thank you very much for your response.

MR. HALL. I thank you, and I presume that you have gone through, in your quest for Governor, how to spell potato. All right, Mr. Bass, we recognize you at this time if you have questions.

MR. BASS. Thank you, Mr. Chairman. And I am just fascinated, Dr.--

MR. ARVIZU. Arvizu.

MR. BASS. Arvizu.

MR. ARVIZU. May I help you? It is just a recreational vehicle, RV, going to the zoo.

MR. BASS. I am unaccustomed--all right. On the biopower issue, I am particularly interested in ethanol derived from cellulose and most notably, from my region of the country, wood products. I would like to visit your lab some time with a team of people from my State who are involved in biology and so forth, and I look forward to doing that. I just want to affirm that you have a robust research and development project in the use of bacterias and other bugs to convert various substances into ethanol. Is that a robust program, with showing some results, promising results?

MR. ARVIZU. Well, the answer is, we would like to make it more robust than it is today. We certainly are working on a number of enzymes. That is the primary organism that takes you from a cellulosic fibrous material into a simple sugar that you can ferment.

MR. BASS. Can you skip the sugar part?

MR. ARVIZU. Yes, you can. In fact--

MR. BASS. Is that something you are working on or not?

MR. ARVIZU. --there is a project called "Genomes to Life," in the Department of Energy. It is a basic energy science and what we are trying to do is perhaps even consider engineering the biomass resource so that it creates these enzymes naturally, in the wild, so that those--we can do one-step processing and essentially move the cost of cellulosic biomass down to as little as 60 cents a gallon, which would be phenomenal. That is kind of the Holy Grail. We believe that the science would allow that, with continued support, so we are very bullish on the basic piece as well as on the conversion piece now, which I think can solve a more immediate problem.

MR. BASS. Do you think there are--one of the challenges facing development of these enzymes is small versus large, and is there any effort underway to examine the possibility of establishing small-scale biodigesters that would create either methane or ethanol, methane gas, which, as I understand it, is a simpler process--

MR. ARVIZU. Yes, it is.

MR. BASS. --that could burn--I was going to come back for my friend from California, Ms. Bono, but I don't think it is appropriate with--

MR. HALL. Let us move along.

MR. BASS. Yes, sir. I can't even continue. To develop biodigesters that could use wood residues, cardboard, paper, even household garbage, to create energy, is this something that you are familiar with or aware of? Is there any potential there?

MR. ARVIZU. Well, yes. You know, the breakthroughs in enzyme formulation, if you will, is what I call a very Edisonian process. We had a couple of partners, Novozymes and Genencorp, that had a breakthrough, and what they were able to do is to create a cocktail of enzymes, we called it. It was about 25 different formulations of things that was just the right formulation to break down corn stover into ethanol, into sugars that allow us to put into ethanol. The breakthrough was the cost. They were able to reduce the cost of that set of enzymes down from--well, it was a factor of 30. It is like 25 cents a gallon for the actual enzymes. Science can teach us so much about how to engineer these materials rather than do what we were doing, which essentially is trial and error. And we did that and we ended up with some fairly significant results. You know, everybody kind of applauded and celebrated and said how do we use that? But there is still a lot of science left on figuring out how much you engineer that in ways to do precisely what you are talking about; is to take different kinds of feedstocks and convert them to the same simple six-chain sugars that are very easy to ferment, and then it becomes a much easier process. And in fact, the capital equipment to make these production facilities would be quite small.

MR. BASS. So if I were to bring people out to visit you who are interested in this subject, they would learn a lot from the visit, do you think?

MR. ARVIZU. Well, we would probably learn a lot as well.

MR. BASS. You have got plenty of expertise? Okay.

MR. ARVIZU. Yes, absolutely. And you are all welcome to do that. We learn so much by what people are trying to accomplish and then we can figure out how the technology can fit those needs.

MR. BASS. Okay, thank you very much. Thank you, Mr. Chairman, for the courtesy.

MR. HALL. All right, thank you very much. I would look to the next two witnesses that are going to testify here, and really want to thank the two of you for your good testimony, and a good service to your country.

MR. ARVIZU. Thank you, sir.

MR. HALL. It will be of great service as we pursue legislation to match the good information that you have given us, and we thank you very much. All right, we thank you, gentlemen. You are in place now and, Mr. Novak, you will go first. Mr. Abate? Did I say it right?

MR. ABATE. Abate.

MR. HALL. Abate?

MR. ABATE. Yes.

MR. HALL. Mr. Hammond, Vice President, Products, Plextronics, Inc; Mr. Linebarger, Executive VP of Power Generation Business; Dr. Katzer, a Visiting Scholar, Laboratory for Energy and the Environment; and Mr. Cresci, Chairman, Environmental Power Corporation. We will start off, Mr. Novak, with you, and if you can, give us 4, 5, maybe 6 minutes of generalization; then we will zero in on the questions we want to ask. I recognize you at this time, sir. Turn your mic on.

STATEMENTS OF JOHN NOVAK, EXECUTIVE DIRECTOR, FEDERAL AND INDUSTRY ACTIVITIES, ENVIRONMENT AND GENERATION SECTORS, ELECTRIC POWER RESEARCH INSTITUTE; VICTOR R. ABATE, VICE

PRESIDENT, RENEWABLE ENERGY, GE ENERGY; TROY D. HAMMOND, VICE PRESIDENT, PRODUCTS, PLEXTRONICS, INC.; TOM LINEBARGER, EXECUTIVE VICE PRESIDENT AND PRESIDENT, POWER GENERATION BUSINESS, CUMMINS, INC.; JAMES KATZER, VISITING SCHOLAR, LABORATORY FOR ENERGY AND THE ENVIRONMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY; AND JOSEPH E. CRESCI, CHAIRMAN, ENVIRONMENTAL POWER CORPORATION

MR. NOVAK. Thank you, Mr. Chairman. Good morning. I am John Novak, with the Electric Power Research Institute. EPRI is a nonprofit collaborative R&D organization headquartered in Palo Alto, California, and we appreciate the opportunity to appear before this subcommittee on this important topic.

Number one: the United States must keep all of its energy options open to meet the uncertainties of the future. For electricity, this means building and sustaining a robust portfolio of clean, affordable options for the future, and ensuring the continued use of the big five: coal, nuclear, gas, renewables, and end-use energy efficiency. R&D can and will make a big difference. With sustained levels of R&D, the cost of these five electricity options can be substantially reduced over the next decade.

Number two: investment decisions being made today about the next generation of electricity supply are complicated by four major uncertainties, the future cost of CO_2, the future price of natural gas, spent nuclear fuel storage, and CO_2 capture and storage.

Number three: we believe that prudent investment decisions for plants that have to produce electricity for the next 30 to 40 years will be increasingly based on the assumption of a carbon-constrained future. Whether decisionmakers assume the cost of carbon dioxide to be zero as it is today, or $30 per ton or $50 per ton, dramatically changes the relative cost of various supply options. We have taken an objective look across all the major supply options, using variable costs for carbon dioxide and natural gas, and factored in the technical progress that we think is achievable over the next 10 years and reached a central conclusion; that is, we have an extraordinary opportunity to begin building a low-carbon portfolio by 2020. This portfolio would be insensitive to the cost of carbon dioxide, and yet still be affordable. But R&D is needed to achieve the technical progress to begin to put this portfolio in place.

One reason this is so critical is that electricity is going to become more important in the future. We have run scenarios that show that electricity growth is relatively unaffected by global climate change goals.

Our scenarios show that the tighter the limits on carbon dioxide, the greater the percentage of total energy comes from electricity. You can think of it this way: electricity is the only practical way to deliver clean energy on a large scale. And for those of you who are interested in seeing this picture unfold, I would recommend that you watch a presentation by our President and CEO, Steve Specker, recently given at Resources for the Future and available on the website that I have included in my written testimony.

I would like to briefly mention some of the priorities for electricity-based research and development. For coal-based generation, EPRI believes research and development and demonstration to be accelerated for both advanced combustion-based technologies and for gasification technologies, or IGCC. I want to point out that IGCC stands for integrated gasification combined cycle. Some people have the misunderstanding the CC stands for carbon or CO_2 captured; it does not. Additional processes, equipment, and energy are required to capture the CO_2 from IGCC and to transport and store the CO_2 in a geologic formation. We think that CO_2 capture for existing and new pulverized coal-fired plants needs to be developed and demonstrated. Large-scale, long-term CO_2 demonstrations will be needed, such as those in FutureGen and ongoing DOE R&D programs. For air emissions, near-term work in mercury control and demonstration needs to continue.

On nuclear power, the long-term future of nuclear energy must be built on a solid foundation that is grounded in three current ongoing nuclear energy initiatives: continued safe and effective operation of our current fleet of reactors, near-term licensing and deployment of advanced light water reactors, and licensing and construction of a geologic repository at Yucca Mountain. Significant R&D needs to exist for the current fleet and the new fleet of advanced light water reactors, first, for development of a new generation of high reliability, light water reactor fuel with much higher burn-up. Other priorities include R&D in the areas of age-related materials degradation, fuel reliability, equipment reliability, and other areas. In the longer term, the United States needs to develop a nuclear system having hydrogen production capability. And finally, EPRI supports the long-term goals in the Global Nuclear Energy Partnership proposed by the Administration.

Renewable priorities include: integration of large intermittent resources, including power electronics, interconnection, communication and control of distributed generation; cost-effective energy storage technology; and demonstration ocean renewable wave, tidal, and wind/wave hybrid concept for power generation.

End-use efficiency and demand R&D priorities: development of advanced communication infrastructure that links electricity consumers with a fully dynamic electricity marketplace; continued development of smart end-use devices; and ensure that we have regulatory and market structures that support end-use efficiency and demand response objectives. For natural gas, we need to see cost reduction in natural gas supply, including the ability to site, obtain, and liquefy natural gas. Distributed generation cost reductions and efficiency increase allowed DG to compete on the system with larger generation. And finally, fuel cells will also find niche applications and require R&D until they are cost competitive with central stations.

Mr. Chairman, that concludes my testimony. Thank you.

[The prepared statement of John Novak follows:]

PREPARED STATEMENT OF JOHN NOVAK, EXECUTIVE DIRECTOR, FEDERAL AND INDUSTRY ACTIVITIES, ENVIRONMENT AND GENERATION SECTORS, ELECTRIC POWER RESEARCH INSTITUTE

Introduction

I am John Novak, Executive Director of Federal and Industry Activities for the Environment and Generation Sectors of the Electric Power Research Institute. EPRI is a non-profit, collaborative R&D organization headquartered in Palo Alto, California. EPRI appreciates the opportunity to provide testimony to the Subcommittee on the next generation of electricity based technology.

Electricity Generation Options

Each year, the Advisory Council and Board of Directors of the Electric Power Research Institute convene a diverse group of leaders from industry, academia and government to discuss critical issues facing the electricity industry and society. The seminar format is designed to air diverse views, to explore common ground and, where possible, to develop a new pathway forward. Last year's Summer Seminar was focused on "Making Billion Dollar Advanced Generation Investments in an Emission-Limited World." Attached is the background paper for last year's seminar.

The paper contains an outlook for generation technology for the years 2010 and 2020. We have updated information from the generation technology outlook to reflect more current events and trends and have provided some of this updated information in the table below.

Comparative Costs of 2010 Generation Options

Technology	Cost of Electricity, $/MWh	Key Assumptions
Pulverized Coal	41	Coal price: $1.50/mmbtu
Nuclear Power	46	Capital Cost: $1400 - $1700 per kW
IGCC without carbon capture	47	Coal price: $1.50/mmbtu
Natural Gas Combined Cycle	56	Fuel Cost: $6/mmbtu
Biomass	62	
Wind	75	Capacity Factor: 29%

Comparative Costs of 2020 Generation Options

Technology	Cost of Electricity, \$/MWh	Key Assumptions
Pulverized Coal	64	Coal price: \$1.50/mmbtu With CO_2 capture, transport, storage
Nuclear Power	46	Capital Cost: \$1700 per kW
IGCC with CO_2 capture	54	Coal price: \$1.50/mmbtu
Natural Gas Combined Cycle	52	Fuel Cost: \$6/mmbtu
Biomass	44	New technologies to reduce cost
Wind	52	Capacity Factor: 29%; substantial technology improvement

Key Points

EPRI would like to make six key points drawn from the analysis in the attached paper and from the discussions at the summer seminar.

1. The U.S. must keep all of its energy options open to meet the uncertainties of the future. For electricity, this means building and sustaining a robust portfolio of clean, affordable options for the future – ensuring the continued use of the "big five": coal, nuclear, gas, renewables, and end-use energy efficiency.
2. R&D can and will make a big difference. With sustained levels of R&D, the costs of these five electricity options can be substantially reduced over the next decade.
3. Investment decisions being made today about the next generation of electricity supply are complicated by four major uncertainties:
    a. Future cost of CO_2
    b. Future price of natural gas
    c. Spent nuclear fuel storage
    d. CO_2 capture and storage
4. We believe that prudent investment decisions for plants that have to produce electricity for the next 30-40 years will be increasingly based on the assumption of a carbon constrained future. Whether decision makers assume the future cost of CO_2 to be zero as it is today, or \$30/ton, or \$50/ton, dramatically changes the relative cost of the various supply options.
5. We have taken an objective look across all the major supply options, using variable costs for CO_2 and natural gas, and factored in the technical progress that we think is achievable over the next 10 years, and reached a central conclusion --- That is, <u>we have an extraordinary opportunity to put a low-carbon portfolio in place by 2020.</u> <u>This means the technology would be ready by 2015, and installed by 2020.</u> This portfolio would be insensitive to the cost of CO_2, and yet still be affordable.
6. One reason this is so critical is that electricity is going to become more important in the future. We have run scenarios, and invariably, the tighter the limits on CO_2, the more electricity that's going to be required globally. You can think of it this way -- electricity is <u>only</u> practical way to deliver clean energy on a large scale.

For those of you interested seeing this picture unfold, I would recommend that you watch a presentation by our CEO, Steve Specker, recently given at Resources for the Future. The web link is http://www.eande.tv/transcripts/?date=040406#transcript

R&D Priorities

Following is a summary of EPRI's priorities for electricity based R&D in five key areas: coal, nuclear, gas, renewables and end-use energy efficiency. EPRI would be pleased to discuss these in greater detail with the Subcommittee.

Coal

Coal Based Generation

- EPRI believes RD&D should be accelerated for both combustion-based technologies and for gasification technology. Three major areas of work need to be emphasized,
    - 1) Integrated Gasification Combined Cycle work on hydrogen turbines, reliability, cost reduction, and integration with CO_2 ;
    - 2) very efficient pulverized coal combustion with options for CO_2 capture and
    - 3) fluidized bed combustion with options for near zero pollutant emissions and CO_2 capture.
- Related technology deployment to reduce costs (initially without CO_2 capture until storage is demonstrated) as is being done in conjunction with EPRI's CoalFleet for Tomorrow® Program and as a result of the EPACT 2005 enactment.

CO_2

- To assure public acceptance, multiple (~5) large scale (> 1 MTY), long term CO_2 storage demonstrations in different geologies and locations will be needed in addition to FutureGen and DOE RD&D, to assure that storage is safe and effective.
- Post combustion capture for existing and new PC-fired plants needs to be developed and demonstrated.

Emissions

- Near-term work in mercury control and demonstration to assure that all equipment and coal types can be reliably controlled require completion of the field testing program currently underway by industry and government

Gas

- Cost reduction in natural gas supply, including the ability to site and obtain LNG, since LNG use is projected to grow rapidly.
- Distributed generation (DG) cost reduction and efficiency increases in DG to allow DG to compete on the system with larger generation.
- Fuel Cells and applications which support combined heat and power will also find niche applications and require RD&D until they are cost competitive with central stations.

Nuclear

- Significant R&D needs exist for the current fleet and the new fleet, especially in areas of age-related materials degradation, fuel reliability, equipment reliability and obsolescence, plant security, cyber security, and low-level waste minimization.
- Development of a new generation of high reliability LWR fuel with much higher burnup that will better utilize uranium resources, improve operating flexibility, and significantly reduce spent fuel volume and transportation needs, resulting in additional improvements in nuclear energy economics. These are mid-term R&D

needs whose impact would be considerable if accelerated with government investment.

- n the longer term develop a nuclear system having hydrogen production capability. Many believe that a hydrogen economy is essential for revolutionizing transportation, in which case the demand for competitive and environmentally responsible hydrogen production will greatly increase. A large-scale, economical nuclear source would hasten that future.

Renewables

- Integration of large intermittent resources, including power electronics for more effective conversion, smoothing and control of renewable resources
- Interconnection, communication and control of distributed generation
- Incremental, low impact hydropower expansions, advanced hydro turbine concepts and performance optimization tools
- Cost-effective energy storage technology for utility T&D applications with renewable resources
- Demonstration of ocean renewable wave, tidal and wind-wave hybrid concepts for power generation (see also EPRI Ocean Energy work)

End Use Efficiency and Demand Response

- Development of an advanced communications infrastructure that links electricity consumers with a fully dynamic electricity marketplace. Information could be exchanged directly with smart end-use devices, for example, so consumers would not have to make hourly or daily energy choices. This "prices to devices" approach would allow the appliance itself to optimize its operation under varying costs and conditions.
- Ensure we have regulatory and market structures that support end-use efficiency and demand response objectives.
- Continue development of smart end-use devices. An essential premise of efficiency and demand response strategies (as well as of the provisions of the U.S. Energy Policy Act of 2005) is an infrastructure of intelligent electricity meters and end-use devices capable of two way communication with the electricity system. Many end-use technologies are beginning to evolve, through advances in distributed intelligence, from static devices to devices with much more dynamic capabilities.

The Electric Power Research Institute was established in 1973 as an independent, nonprofit center for public interest energy and environmental research. EPRI brings together members, participants, the Institute's scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span nearly every area of electricity generation, delivery and use, including health, safety, and environment. EPRI's members represent over 90% of the electricity generated in the United States.

Summary of EPRI Testimony – Key Points

1. The U.S. must keep all of its energy options open to meet the uncertainties of the future. For electricity, this means building and sustaining a robust portfolio of clean, affordable options for the future – ensuring the continued use of the "big five": coal, nuclear, gas, renewables, and end-use energy efficiency.
2. R&D can and will make a big difference. With sustained levels of R&D, the costs of these five electricity options can be substantially reduced over the next decade.
3. Investment decisions being made today about the next generation of electricity supply are complicated by four major uncertainties:

a. Future cost of CO_2
b. Future price of natural gas
c. Spent nuclear fuel storage
d. CO_2 capture and storage

4. We believe that prudent investment decisions for plants that have to produce electricity for the next 30-40 years will be increasingly based on the assumption of a carbon constrained future. Whether decision makers assume the future cost of CO_2 to be zero as it is today, or $30/ton, or $50/ton, dramatically changes the relative cost of the various supply options.
5. We have taken an objective look across all the major supply options, using variable costs for CO_2 and natural gas, and factored in the technical progress that we think is achievable over the next 10 years, and reached a central conclusion --- That is, we have an extraordinary opportunity to put a low-carbon portfolio in place by 2020. This means the technology would be ready by 2015, and installed by 2020. This portfolio would be insensitive to the cost of CO_2, and yet still be affordable.
6. One reason this is so critical is that electricity is going to become more important in the future. We have run scenarios, and invariably, the tighter the limits on CO_2, the more electricity that's going to be required globally. You can think of it this way -- electricity is only practical way to deliver clean energy on a large scale.

For those of you interested seeing this picture unfold, I would recommend that you watch a presentation by our CEO, Steve Specker, recently given at Resources for the Future. The web link is http://www.eande.tv/transcripts/?date=040406#transcript

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

EPRI Summer Seminar
Co-Sponsored by
Advisory Council and Board of Directors

BACKGROUND PAPER:

Making Billion Dollar Advanced Generation Investments in an Emissions-Limited World

August 8 and 9, 2005

San Diego, California

CONTENTS

I. Introduction

Each year, the Advisory Council and Board of Directors of the Electric Power Research Institute convene a diverse group of leaders from industry, academia and government to discuss critical issues facing the electricity industry and society. The seminar format is designed to air diverse views, to explore common ground and, where possible, to develop a new pathway forward. This year's Summer Seminar is focused on "Making Billion Dollar Advanced Generation Investments in an Emission-Limited World."

The format of the Summer Seminar consists of three panels, general discussion sessions and breakout groups. The first panel will be comprised of utility decision makers facing long-term, billion dollar advanced generation investments in a highly uncertain world. The second panel will focus on regulation and policies that influence decisions on new generation options. The third panel will focus on the state of, and outlook for, new electricity generation technology.

We expect approximately 80 participants, representing utilities, RTOs, equipment suppliers, state and federal regulators, government agencies, universities, and key individuals from environment, labor and consumer groups. Given the attention currently being paid to climate issues and the increasing cost of energy, this year's focus on the potential of advanced generation is especially timely.

II. How to Measure Success: The Purpose of the 2005 Summer Seminar

The objectives for this year's Summer Seminar are:

- To create new insights about the generation investment decision making process,
- To provide guidance on the content of EPRI's R&D generation portfolio, and
- To identify and better define critical "gaps" in policy, preparedness and public perception regarding generation technology.

This focus on new generation technologies is important and very timely. DOE's Energy Information Agency (EIA) forecasts that about 280 GW of new generating capacity will be required between now and 2025 to meet expected demand growth in the U.S. About 80 GW of this new capacity, much of which is already under development, will be needed by 2015. Of this 80 GW, about 5 GW could be from early deployment of advanced Integrated Gasification Combined Cycle (IGCC) and advanced nuclear plants and another 5 GW from wind and biomass. The remaining 70 GW will almost certainly be provided by primarily by pulverized coal (PC) and natural gas combined cycle (NGCC) units, with a small component from renewable energy sources.

This 2015 "reality" raises challenging issues for the electricity industry and society. In spite of growing concerns regarding both climate change and over-reliance on natural gas, the bulk of new generation out to 2015 will be CO_2 emitting (without CO_2 capture capability) and much of it will be fueled by natural gas. Will this be acceptable from a societal and political viewpoint? Will there be a backlash which blocks or delays needed capacity with resulting shortages? Could continued high natural gas prices and/or new costs imposed on CO_2 lead to an electricity "price crisis"? And most important, from the standpoint of this seminar: What can EPRI and the industry, working with the government, do to accelerate the development and commercialization of technology which could substantially improve this 2015 "reality"?

Looking beyond 2015, the EIA forecasts that another 200 GW of capacity will be needed by 2025. These capacity additions represent a huge opportunity for zero-emitting advanced generation technologies. A portfolio of advanced clean coal and combustion turbine technologies with CO_2 capture capability, the next generation of advanced light-water reactors, advanced biomass, and advanced wind turbines — all integrated into a smarter, more resilient grid — provide the real promise of technology to fundamentally change the production of electricity for much of the 21st century. But each advanced technology faces a variety of technical, economic, and regulatory challenges which must be overcome if it is to substantially contribute to new generation beginning in 2015. None of these technologies is assured: There is no silver bullet" technology. Each technology is in a race to be ready by 2015. What would be the cost to the industry and society if we fail to meet the deadline and are forced to continue with yesterday's portfolio of technologies just to "keep the lights on"? What must be done to ensure their readiness by 2015? What can be done to accelerate their commercialization? Where are the technology gaps and how should they be closed?

Developing and commercializing any particular technology is only part of the challenge. There are simply too many other uncertainties and externalities which can take any one technology out of the game. A recent EPRI scenario planning workshop identified the future availability and price of natural gas and the future "cost" of CO_2 emissions as the two most important external uncertainties affecting the choice of new generation technology. Plausible scenarios include circumstances with an \$8/mmBtu gas and \$50/T CO_2, with \$4/mmBtu gas and no cost of CO_2, with \$8/mmBtu gas and no cost of CO_2 and with \$4/mmBtu gas and \$50/T CO_2. Each scenario would require a different mix of generation technologies. Add in the uncertainties around storage of spent nuclear fuel and public acceptance of siting for new LNG terminals and underground CO_2 storage and the future becomes even more clouded.

Collectively, we face the very formidable challenges of developing and commercializing a robust portfolio of generation technologies which provides the full range of options needed to accommodate the external uncertainties confronting decisions on new generation.

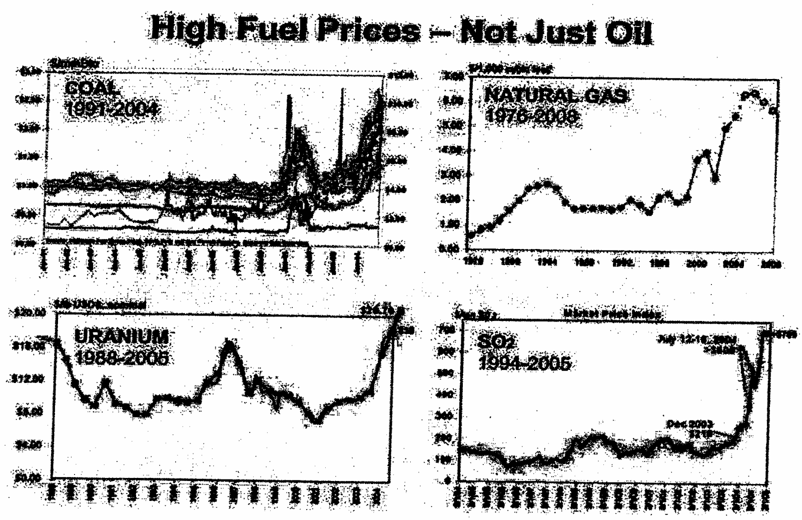
This year's seminar will drill deeply and objectively into these challenges. We welcome your participation in the seminar. As you read through the background information in the rest of this paper, please formulate your own questions and viewpoints so that you come to the seminar prepared to discuss, challenge and debate the very important issue of making billion dollar advanced generation investments in an emissions-limited world.

Sections III through VI of the Background Paper provide economic, performance and related information on advanced generation options as follows:

> ***Choice of Fuel to Generate Electricity,** including a careful review of the outlook for fuel availability and price,*
> ***Choice of Technology to Generate Electricity,** including capital cost, cost of electricity, reliability of the technology, and its "fit" with fuel choice and location,*
> ***Economic Circumstances of Advanced Generating Technologies,** including tables which distill technology, environmental, and economic performance factors of various technologies, and*
> ***Availability of Government Incentives,** which have been especially important for renewable energy options and promises to be equally important with regard to advanced coal-fired plants and new nuclear plants.*

III. Generation Options: Fuels Discussion

Fuel availability and prices significantly shape the composition of generation portfolios. Over the past two years, prices for oil, natural gas, coal and uranium and for SO_2 allowances have increased substantially, contributing to higher prices for electricity. In 2003, the power sector in the U.S. spent over $46 billion on fuel. It was higher in 2004 and will be higher still in 2005. One of the most dramatic changes is the tripling of daily SO_2 emission allowance prices in the 16 months between December 2003 and April 2005.



A. Coal

In the 1980s, the coal industry was highly fragmented with many small producers. There was an excess of supply, and labor and equipment were easy to obtain. Competition among producers was intense and prices declined in real terms.

During the 1990s however, the situation changed. Mining companies merged and excess capacity closed. Efficiency and profits improved with larger mines that operated around the clock using capital intensive technologies, such as longwalls and draglines. By the late 1990s, coal prices had become more volatile. Marginally profitable small mines had closed, mining companies faced greater difficulties with permitting and new mine development, and utilities were beginning to cut their carrying costs through leaner inventory levels. Further, after the larger coal companies went public, the financial community encouraged them to improve financial performance by avoiding overproduction. These trends culminated in two major spot price spikes, the first between 2000 and 2001, and the second from 2003 to the present.

High prices have continued, in large part because coal production has not increased since 1999. While as little as ten million tons per year of additional supply (in Central Appalachian) would bring the market into balance, buyers and sellers face a dilemma: buyers require flexibility to avoid paying above-market prices, and sellers require firm commitments to finance new capacity.

The consensus is that coal prices will not again settle near the low levels of the early 1990s. Costs of mining equipment, resource depletion, difficulties in permitting new capacity, uncertainty regarding the stringency of future environmental rules, and the escalation in transportation costs, are permanently moving the cost of coal to a higher plateau.

International demand for coal is expected to contribute both to increase price volatility and higher prices for coal. Relatively few countries produce coal for export, and many countries, both in Europe and the Pacific Rim, depend on imported coal. China's breakneck economic growth is causing it to experience shortages of coal, its most important energy source. China is the world's largest consumer and producer of coal, which accounts for about two thirds of its energy needs. The rapid expansion of China's economy is causing its demand for coal to grow rapidly and is a key factor in causing the substantial increase in the international prices of coal.

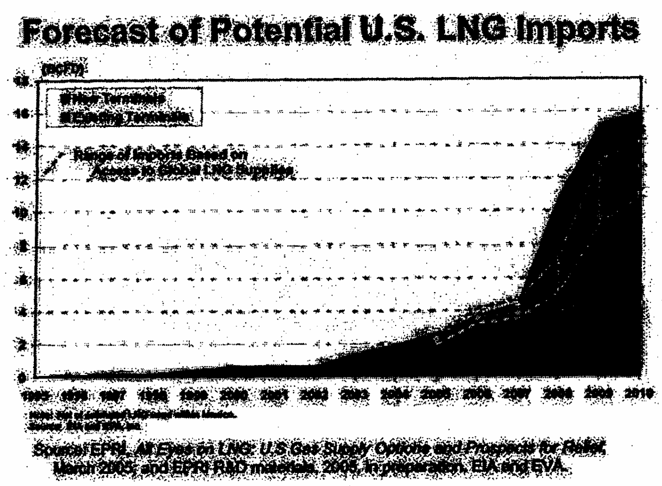
B. Natural Gas

In many regions gas-fired generation is required to meet peak (and sometimes off-peak) energy demands and thereby sets the price of power. Therefore, natural gas has become a vital element in power supply planning, even for companies without much gas-fired generation. Prices of natural gas remain at historic highs, with futures prices for January through March 2006 currently approaching $9.00/bmmBtu.

Natural gas reserves have been shrinking in size and pressure. Exploration has primarily targeted low-risk prospects, creating an ever-increasing need to drill and complete more wells to offset rapid declines in production from existing wells. On average, half of today's supplies come from wells that are less than three years old.

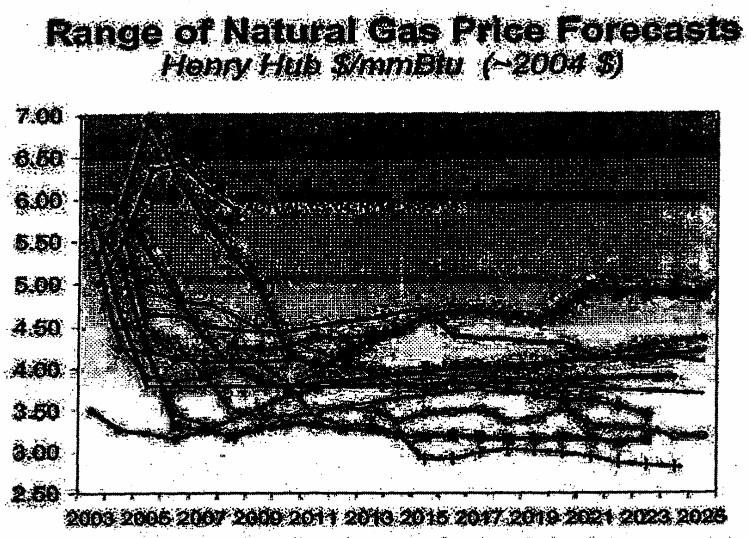
Beginning in 2002, record high natural gas prices have been accompanied by successive declines in total production, aggravated most recently by declines in imports from Canada. This prolonged decline has reshaped fundamental attitudes about natural gas supplies in the U.S. and forced attention to emerging sources of natural gas.

Of such emerging sources, LNG has the largest potential to relieve the supply-demand imbalance. While some analysts expect NIMBY pressures and global competition to limit the supply of LNG into the United States, EPRI's studies are more optimistic. EPRI is now projecting additional LNG supplies to the US approaching 4.0 TCF per year by 2010, up from 0.65 TCF in 2004. That level corresponds to the lower dashed line (10.7 BCFD in 2010) in the projection of U.S. LNG imports, below.



Increased reliance on LNG will increase the influence of global markets on North American gas markets, and will cause U.S. demand to influence global LNG markets. Thus, as a major source of demand for natural gas, the power sector in the U.S. will become an important participant in the international natural gas markets.

There is considerable uncertainty concerning the timing of demand growth and of major supply developments, yet the expectation is that gas prices will not remain at today's lofty levels, nor however, return to historic norms. The uncertainty is reflected in the wide range of forecasts by major natural gas consumers, shown below, with many market participants expecting long-term prices to trade between $4.25-4.50 per mmBtu. Such prices are sufficient to attract LNG development and to offset risk associated with major investments in gas supply infrastructure. There is little likelihood that prices will fall much below those levels.



Confidential – range of forecasts used by various companies; forecasts by natural gas forecasting consultants excluded.

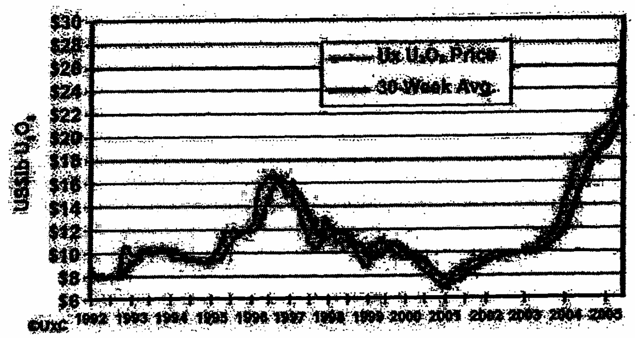
LNG in the Rest of the World

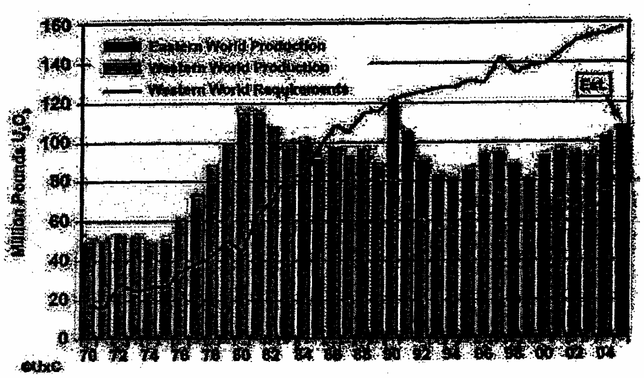
Viewed globally, international LNG trading is projected to grow from 15 billion cubic feet per day (BCFD) in 2002 to 40 BCFD in 2010, and could reach 50 BCFD with development of supplies whose timing is still very uncertain. By 2010, about 20 countries will be engaged in exporting LNG, compared to 12 in 2004. About 110 re-gasification terminals will be in operation around the world, compared to 37 in 2004.

C. Uranium

Over the past two years, the spot price of uranium has more than doubled to $29/lb of U_3O_8 (see chart below). There is a need for new mine capacity, yet there is tension between buyers, who need contractual commitments and prices that support adding mine capacity, and sellers, who need to avoid exposure from the risk that prices collapse.

Procurement of uranium supplies in the future will require larger contractual commitments than needed during the 1990s, when about half of uranium supplies were provided by existing inventories, conversion of weapons-grade uranium and enrichment of uranium tails. The second chart below shows that, without these secondary supplies, production would have had to be increased substantially in the 1990s. It is expected that this will happen now, particularly overseas, in response to price increases.





The contribution of secondary sources will diminish as inventories drop and the weapons grade uranium conversion program is completed, placing the primary burden on uranium producers to meet the need for nuclear fuel.

A study published in 2003 by MIT concluded that "the world-wide supply of uranium ore is sufficient to fuel the deployment of 1,000 reactors over the next half century and to maintain this level of deployment over a 40 year lifetime of this fleet based on currently available information and the history of natural resource supply." While it appears that it will be well into mid-century before a persistent uranium supply shortage could arise, much information on international uranium supplies has not been validated in over 20 years, suggesting that it is time to revisit the quality of information on which such conclusions have been reached.

Over the long term, with research programs that develop advanced nuclear power systems to convert natural uranium to fissionable plutonium through fuel recycle, nuclear fuel resources could exceed five times the capacity of all fossil resources.

IV. Generation Options: Technologies Discussion

This section provides an overview of the four major choices for power generation: Coal, natural gas, nuclear and renewable sources, as well as the prospects for the advanced generating options in each category.

A. Coal:

There are a number of advanced generating technologies currently under development for utilizing the vast coal resources of the US, Russia, China, and Australia. These technologies must satisfy anticipated emission constraints, meet the steady growth in demand for electricity, and in the US at least, replace a substantial share of the aging coal fleet over the next few decades and be competitive in the marketplace.

Pulverized Coal

Coal is used to produce more than 50% of the electricity in the U.S. Most of the plants use pulverized coal (PC) technology, in which coal is crushed and pulverized, mixed with air and blown into a boiler with water walls for high temperature combustion. Steam is raised in these walls and passed through a condensing steam turbine which drives a generator.

Emissions such as SOx, NOx and mercury are typically captured by running the flue gas through in series of "boxes" appended to the plant. While in this fashion PC plants have continued to evolve over the last decade, adding new PC plants is made more difficult by lawsuits claiming that Integrated Gasification Combined Cycle (IGCC, which is described in Section B) is the "best available" technology for controlling emissions.

The pressure and temperature at which steam is generated is a key design feature. The majority of coal-fired boilers in the U.S. are "subcritical" – meaning the steam pressure is below the critical pressure of water. However, "supercritical technology" -- using higher steam temperatures and pressures to gain efficiency -- is fast becoming the worldwide standard for large capacity boilers. Over 110 supercritical units are in operation in Japan.

Most supercritical plants use conventional technology for boiler and turbine materials and designs. This means steam temperatures in the range of 600 deg C, which raises metal temperatures to ~650 deg C. However, some of the more advanced designs would use even higher design conditions, with metal temperatures approaching 800 deg C. These "ultrasupercritical designs" will require a long-term technology development program to develop alloys and ceramic materials that will withstand these hostile environments. Work is underway in Europe, Japan, and the US to develop suitable materials.

In contrast to the large development requirements for ultrasupercritical designs, conventional supercritical designs are proven technology and the capital costs are relatively low. Moreover, regulators and members of the financial community are familiar with these technologies and are willing to provide the needed investments and approvals. Supercritical and ultrasupercritical designs appear to be the technologies of choice for pulverized coal-based generation for the next ten years.

Fluidized Bed Combustion

There are other approaches for coal combustion. Fluidized bed combustion systems were the subject of intense technology development in the 1970s and 1980s. Now, circulating fluid bed systems (CFB) are being bid for new generation, especially for hard-to-burn fuels, including lignite and waste fuels. CFB plants operate at relatively low temperatures, and therefore produce less NOx than PC plants. In addition, the "bed" in a fluidized bed unit usually consists of aerodynamically suspended limestone particles, which are very effective in removing SO_2 from the flue gas. This scrubbing technology produces large amounts of CO_2, which would put CFB at a cost and technology disadvantage if CO_2 capture and sequestration becomes necessary.

Oxycombustion

Recently, oxycombustion has emerged as another coal combustion alternative. In this approach, combustion takes place in a pure oxygen environment. The result is a high purity CO_2 flue gas, with minor amounts of H_2O. Oxycombustion variants include the recycling of flue gas to reduce furnace temperatures, and "chemical looping" systems, in which an oxygen transport material is used in lieu of oxygen. Oxycombustion has attracted attention in recent years because the high purity CO_2 flue gas is amenable to capture. However, advances in materials to withstand high combustion temperatures and the use of oxygen transport membranes (OTM) will be required before oxycombustion will be ready for commercial application.

B. Coal: Integrated Coal Gasification Combined Cycle Plants (IGCC)

Various parties are developing and pursuing the installation of advanced Integrated Coal Gasification Combined Cycle plants (IGCC). IGCC combines the environmental benefits of natural gas-fueled plants and the thermal performance of combined cycle plants.

In IGCC, coal is gasified with oxygen or air to make synthesis gas, or syngas, which consists primarily of hydrogen and carbon monoxide. The syngas is cooled, cleaned and fired in a combustion turbine. The hot exhaust from the gas turbine passes through a heat recovery steam generator where it produces steam that drives a steam turbine. This combined cycle greatly improves the thermal efficiency of the plant.

Removal of the emission-forming constituents from the syngas under pressure prior to combustion permits an IGCC power plant to meet extremely stringent emission standards. Because gasification takes place in a low-oxygen environment, the sulfur in the fuel converts to hydrogen sulfide (H_2S), instead of SO_2. The H_2S can be more easily captured and removed than SO_2. Removal rates of 99% and higher are common in the petrochemical industry, which uses the same technology. IGCG has the added advantage of being able to capture carbon dioxide in concentrated form early in the process, rather than from the diffuse flue gas stream.

The basic IGCC concept was first successfully demonstrated at commercial scale at the pioneer Cool Water Project in Southern California from 1984 to 1989. There are currently two operating coal-based IGCC plants in the U.S. and two in Europe. The two projects in the U.S. were supported initially under the DOE's Clean Coal Technology demonstration program, but are now operating commercially without DOE support. The 262-MW Wabash River IGCC project in Indiana started operations in 1995 and uses the E-Gas gasification technology, acquired by ConocoPhillips in 2003. The 250-MW Tampa Electric Co. Polk Power Station IGCC project began operations in 1996 and is based on gasification technology developed by Chevron-Texaco and now owned by GE.

IGCC technology without CO_2 capture is moving from the demonstration phase to the commercial phase by several equipment suppliers. CoalFleet for Tomorrow is a new collaborative initiative involving utilities, suppliers, EPRI and the government to help accelerate future deployment of advanced coal technologies, including efforts to optimize IGCC at the 600MW scale with five new demonstration plants. R&D is also required to help reduce capital costs. A substantial effort will be needed to improve the competitive position of gasification system technology. Some examples of these improvements include:

- Improving gasifier reliability through use of advanced high-temperature refractories.
- Improving the efficiency of gas turbines and combined cycle systems.
- Improving technologies for materials handling (e.g., coal, ash, coal-water slurries, pumping systems, etc.).
- Improving systems for separation of oxygen, CO_2, hydrogen and other gases.

Without the development of improved gasification technologies and systems, IGCC may have difficulty competing with older technologies, especially when using lower-grade coal. EPRI's CoalFleet for Tomorrow program is addressing these and other technical and economic challenges to make IGCC and other advanced coal power plants a realistic investment option.

C. Coal: Carbon Capture and Sequestration:

Coal-Fired Plants, as point sources of emissions, are likely to be regulated under any Green House Gas (GHG) constraint. Therefore, utilities need cost-effective options for managing and curbing CO_2 emissions. Studies show the current cost penalty for capturing and sequestering CO_2 from coal-based plants ranging from 30% to 60%. Ultimately, the CO_2 issue will determine the degree to which abundant and inexpensive coal is maintained in the electricity production fuel mix.

CO_2 Removal:
Before CO_2 removal becomes commercially available, the industry must achieve technological breakthroughs that materially reduce the cost of removal. Examples of emerging options for CO_2 removal include the following:

- Using new chemical methods for stripping CO_2 from the flue gas of coal power plants,
- Concentrating CO_2 in the flue gas by burning the fuel in oxygen instead of air, and
- New high-efficiency gasification systems.

EPRI is evaluating these options, and seeking to identify, develop and test with pilot evaluations the concepts that have significant breakthrough potential.

CO_2 Storage:
While different means of storing CO_2 have been studied (e.g., using the ocean for storage), geological storage is considered to be the most feasible from both the technical and political standpoints. The oil industry has substantial experience with CO_2 storage after years of injecting CO_2 to enhance oil recovery from certain fields. The utility industry will most likely borrow from this experience when developing its own plans for CO_2 storage.

Before CO_2 storage progresses, various issues need to be resolved including the following:

- Assure the integrity of the storage facility and how the integrity will be verified and monitored. Significant quantities of CO2 will need to be stored to prove storage integrity.
- Develop acceptable permitting regulations.
- Resolve issues regarding legal liability.
- Establish the potential risk to human health and ecological systems.
- Enhance public acceptance.

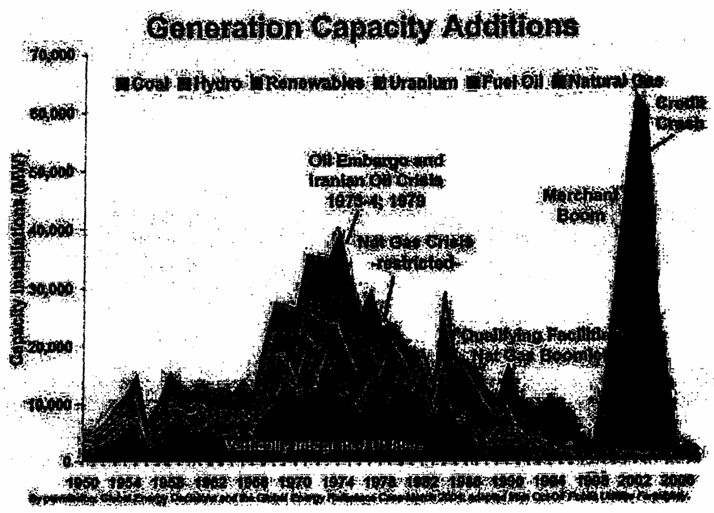
EPRI is maintaining up-to-date information on the suitability of geological storage, facilitating the development of large-scale CO2 injection from fossil-fired power plants, and developing approaches to deal with the technical issues noted above. EPRI is also a partner in a series of carbon capture and sequestration demonstration projects. These pilot-scale studies are evaluating several approaches for storage, and will examine variables such as fuel type, capture and storage technology, and long-term monitoring of the sequestered CO_2.

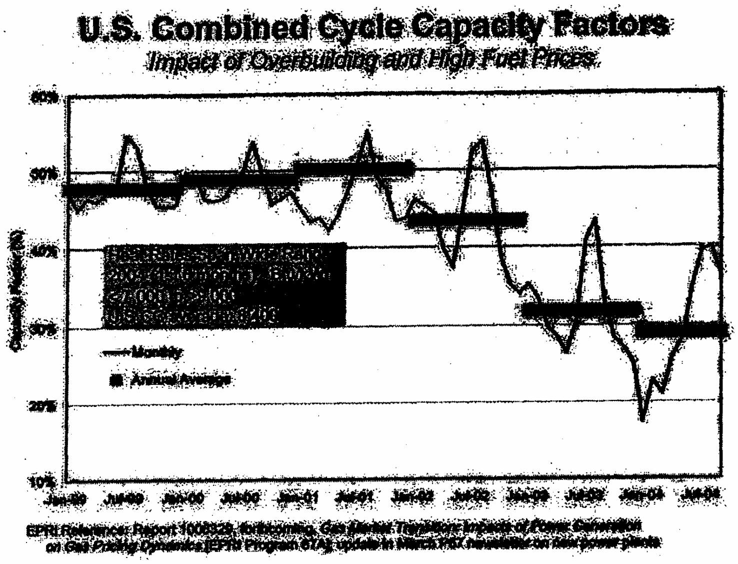
D. Natural Gas: Combustion Turbine Plants

Combustion turbines represent one of the well-established technologies for power generation. The efficiency of earlier generations of these turbines, generally operating in a simple cycle mode, ranged from 25% to 35%. However, new generation turbines have improved efficiency, reliability, and availability. Today's mid-size combustion turbines (25 to 50 MW) offer efficiencies ranging from 35% to 44%. Larger combined cycle plants, up to 500 MW, have efficiencies of up to 50%.

The key advantages of simple-cycle combustion turbines are: (1) relatively easy to site; (2) relatively low emission levels; (3) low capital cost; and (4) short construction time.

For prospective investors, the principal challenge of combustion turbines concerns the availability and price of fuel, in most cases natural gas. After an unprecedented peak in capacity additions (see first graph below), the price of natural gas increased substantially and utilization of combustion turbines fell dramatically (see second graph below). Any analysis of a new project would have to address the impact of future gas prices on the competitiveness of the project.





As indicated earlier, most analysts foresee natural gas prices falling back from current peak toward lower levels before 2010. The outlook, however, depends in significant part on the amount and timing of LNG terminal expansions and additions in North America and the amounts of LNG that these terminals are able to acquire. Depending on expansion of liquefaction capacity and global demands for these supplies, new and existing terminals may run at between 65 to 85% of full capacity. Many experts forecast supplies of LNG increasing enough to lower the price of natural gas in the U.S.

The difficulty of forecasting is illustrated by the fact that between the fourth quarter of 2007 and the end of 2008, as many as 10 new regasification terminals could come online. EPRI's studies indicate that by 2010, LNG imports will grow from 0.65 TCF in 2004 to nearly 4.0 TCF per year, or about 1.4 TCF greater than forecasted by DOE's Energy Information Agency.

E. Nuclear

There are 103 reactors currently operational in the United States; all were licensed during or before the 1970s. The current operating designs are Light Water Reactors (LWRs). LWRs fall into two categories: Pressurized Water Reactors (PWRs), which represent 67% of the existing fleet, and Boiling Water Reactors (BWRs), which represent 33% of the fleet.

Presently there are three new reactor designs certified by the Nuclear Regulatory Commission: the System 80+, the Advanced Boiling Water Reactor (ABWR), and the AP600. Two additional designs are engaged in the certification process and should receive design certifications within the next 1 to 3 years: the Westinghouse AP1000 and the General Electric Economic and Simplified Boiling Water Reactor (ESBWR). In addition, Areva is aggressively pursuing a plan to get its European Pressurized Water Reactor (EPR) certified in the U.S. All six of these designs are Advanced Light Water Reactors (ALWRs), which meet the requirements put forth in the EPRI Utility Requirements Document.

Much progress has been made concerning technical challenges facing nuclear energy. Nuclear technology is mature, as demonstrated by the impressive safety, productivity, and economic performance of the current fleet. New designs, based on proven LWR technology, are available that meet industry specifications and that are either already approved by the NRC or engaged in that approval process. Little or no research and development is needed for any of these ALWR designs to become available for near term deployment. However, there are unproven elements in the new licensing processes.

While the Department of Energy, the Nuclear Regulatory Commission, the Nuclear Energy Institute and selected industry leaders speculate that the potential for new nuclear plants is very high --up to 40,000 MW of new nuclear capacity on line in the U.S. by 2020 and 100,000 MW by 2030 -- there are many challenges that must be overcome in achieve this potential.

The challenges facing ALWR deployment are principally associated with economic, business, regulatory, and governmental factors. Utility executives consider favorable resolution of many of these challenges as "prerequisites" to ordering a new plant. These challenges include:

- **Capital Cost and Financing:** In contrast to nuclear energy's highly competitive production costs (including operations, maintenance and fuel costs), nuclear plant capital costs are high (e.g., relative to NGCC). The industry has responded to this challenge by committing to a high degree of standardization, by simplifying the designs where possible, and by employing advanced computer-aided design and modular construction techniques to shorten construction times. Two actions by the U.S. government are needed to address the capital cost issue. First is continued funding to NP2010, a DOE program that is cost-shared by industry to fund the first-of-a-kind engineering necessary to reduce first plant costs down to "n^{th} plant" costs, as well as funding the testing and demonstration of the new licensing process discussed below. Second, a portfolio of additional financial incentives is needed for a limited number of plants over a limited time, so that utility companies can obtain the support of the financial community. These incentives are discussed later in this paper, but primarily relate to addressing investment risk factors and uncertainties beyond the control of investors.

- **Regulatory Uncertainty:** A new NRC licensing process was established in the early 1990s that requires design and siting decisions and other key approvals before construction of a nuclear plant begins. This new licensing process is generally viewed by industry as a major improvement, but it is largely untested in the courts. Further, it was designed to minimize licensing risk by increasing up-front engineering work, and NRC review of that work, before construction could begin. Deregulation of electricity generation in much of the U.S. makes the financing of this new licensing process more difficult and presents the need for certain targeted government incentives. Three applications for an early site permit have been initiated. However, the most uncertain step in the new process – obtaining a Combined Construction and Operating License (COL) that marries an approved site with an approved design -- has not been tested. The President has recently proposed a form of "regulatory risk insurance" as a means of reducing this obstacle to companies applying for a COL.

- **Yucca Mountain:** Resolution of the nation's high level nuclear waste issue is an important step toward expansion of nuclear power. Technically, an operational spent fuel repository is not a requirement for new plant construction, since new plants designed for a 60 year life are designed to handle 60 years of spent fuel in on-site dry storage. However, many industry leaders view continuing progress toward licensing and construction of a spent fuel repository at Yucca Mountain as a condition of new plant construction.

- **Price Anderson Renewal:** Price Anderson legislation provides for the industry's self-funded liability insurance. Renewal of this legislation, a prerequisite for new nuclear plants orders, is a provision of both House and Senate versions of the Energy Bill.

- **Infrastructure:** Due to the long hiatus in nuclear plant construction in the U.S., domestic nuclear component fabrication and manufacturing capacity is minimal. In addition, there is a shortage of qualified workers to build the plants, particularly qualified welders and inspectors.

Outlook:
Assuming continued support in Congress for such measures as NP2010 funding, adequate provision of limited financial incentives, and support for Yucca Mountain, Combined Operating License (COL) applications for new nuclear plants are likely in the 2007-2008 timeframe and orders are likely in the 2008-2010 timeframe. By then, the ESBWR, the AP1000, and possibly the EPR are expected to be the market leaders.

A window of opportunity to build new plants has been created by:

- Increased public, government, and industry support for expansion,
- The excellent performance record of the present fleet,
- The greater appreciation for the need for diversity in the energy supply,
- The increasingly persistent demand for near-zero air pollutant and green house gas emissions, and

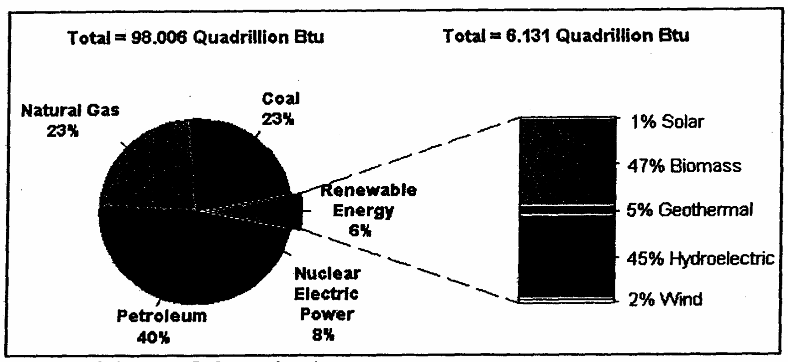
- The availability of NRC certified new designs with proven technology and superior performance.

However, the window for new nuclear plants in the US supply could close without continued support by utility companies or adequate government support.

F. Renewable Energy: Solar, Wind, Biomass, Geothermal, and Ocean Energy

Renewable energy technologies include solar photovoltaic, solar thermal, wind, geothermal, biomass, ocean tidal and wave energy. In addition, hydroelectric generation and low-impact hydro are considered to be renewable energy sources in some cases. Of these, all except ocean tidal and wave energy have reached commercial application, and there are demonstration-stage projects for ocean tidal and wave energy technologies at several locations.

Renewable energy sources, including hydro, provide about 6% of the U.S. primary energy supply today (see figure below).



Source: U.S. Energy Information Agency

Of electric generation, the worldwide installed capacity of solar, biomass, geothermal, and wind totals about 80,000 MW, and the estimated delivered cost of electricity for these technologies ranges from about $45/MWh for wind energy to over $450/MWh for rooftop solar PV (see tables below).

With respect to electric generation in the U.S., hydro represents approximately 10% of total capacity and 7% of electricity generated, while other renewable energy sources represent 2% of both capacity and generation.

The drivers for increasing renewable energy deployment include:

- Increasing concerns about global climate change and other environmental impacts of fossil fuel use,

- Strong public, political and regulatory support for renewable energy,
- Improving technology efficiency and cost performance, especially for wind, and
- Government mandates for renewable energy in the U.S. and elsewhere in the world.

Renewable Portfolio Standards (RPS), mandating that a percentage of an entity's generation be from renewable energy sources, are expected to materially increase the amount of such sources employed. Approximately 20 states plus the District of Columbia have adopted RPS programs. These states represent more than 52% of the national retail electric market. Partly as a result of such standards, it is expected that nearly 53,000 MW of new renewable capacity will be added in the U.S. by 2020. As more states adopt or expand RPS programs, this figure is likely to grow.

Wind is limited by intermittency and siting issues, but does not have any fuel risk. Nevertheless, global wind generation capacity, already approaching 50,000 MW, continues to grow at 20-30% per year. Global photovoltaic capacity, roughly 4,000 MW today, is growing at about 40% annually. Despite this rapid growth, it will take several decades for renewable energy to increase its share of the total generation and energy mix beyond a few percentage points.

The barriers to more-rapid deployment of renewable energy options include:

- Relatively high current cost,
- Difficulty of integrating these intermittent resources into the electricity grid,
- Remote nature of some resources from population centers, leading to transmission bottlenecks, and
- Growing negative public reaction on environmental, aesthetic, avian interaction and other grounds.

Despite these barriers, the renewable energy technologies are expected to sustain strong growth and costs are expected to decline. Wind power is already at cost parity with new fossil-fueled central-station generation and advances in wind turbines, air foils, and deployment techniques are expected to contribute to further cost reductions.

Non-Hydro Renewable Installed Capacity (MW)

	Biomass	Geothermal	Photo-voltaics	Solar Thermal	Wind	Total
United States	8,300	2,200	900	360	6,800	18,560
Europe	5,500	980	1,000	10	34,600	42,090
Asia	4,100	3,100	1,300	< 1	4,300	12,800
Other	3,100	1,700	600	< 1	900	6,300
Worldwide	21,000	7,980	3,800	370	46,600	79,760

Estimated as of end-2004. PV data reflect module sales; installed capacity is likely similar in total, but geographically different. Wind data from Windpower Monthly, April 2005. Biomass energy includes biomass combustion, gasification, and biological conversion to electricity.

Performance and Cost Estimates for Current Renewable Energy Technology (2004 $)

	Biomass CFBC	Geothermal	Solar PV Flat-Plate	Solar Thermal Trough	Wind Class 4 w/o PTC*
Rated MW	50 MW	50 MW	10 x 5 MW	80 MW	67 x 1.5 MW
Capital Cost $/kW	$2,000	$1,600	$7,800	$2,700	$1,100
O&M Cost $/kW-yr	$80	$172	$13.5	$63	$30
Fuel Cost $/GJ	$1.00 – 4.00	-	-	-	-
Capacity Factor	85%	70 - 90%	15 - 25%	26%	30 - 42%
COE $/MWh	$56 - 92	$47 - 61	$450 - 760	$179	$46 - 64

Source: *Renewable Energy Technical Assessment Guide – TAG-RE: 2004* (EPRI 1008366, December 2004)

*PTC: Performance Tax Credit

G. Technology Directions outside of the United States

Outside of the United States, the investment concerns and technology choices are roughly the same, but the economics of each choice, and regulations pertaining to each choice, differ. Countries rich in coal (e.g., China, India, South Africa and Australia) will consider advanced coal-burning technologies, and countries with few natural resources (e.g., Japan) will pursue all types of advanced technologies and, because they will pay premium prices for fuels, will pursue efficiency relentlessly. Signatories to the Kyoto Treaty will look for innovative paths to meeting CO_2 requirements.

In Europe today, there is more attention being paid to combustion solutions for coal (e.g., Oxyfuel and Ultrasupercritical coal) and almost no attention to IGCC. Natural gas, with half the emissions of coal per kWh is also still a favorite when the economics are right. Many countries are imposing both carbon taxes (e.g., in Norway) and incentives for renewable energy sources.

Many countries in both the developed and developing world are coming to the conclusion that nuclear energy is an essential part of their long term energy strategy. This trend is being driven by many factors: Future cost and availability of fossil fuels, environmental concerns, and recognition that renewable energy sources will not be sufficient to meet their projected electricity demand growth. There are currently 23 new nuclear power reactors under construction throughout the world in eight different countries, most notably India, Republic of Korea, Russia and Japan. Further, many countries have aggressive plans for constructing new nuclear plants. For example, by the year 2020, China plans to boost its nuclear electric generating capacity to 36,000 megawatts – up substantially from the 7,000 megawatts of nuclear capacity it has today. Japan, with 54 reactors providing over 34% of electric generation, has three reactors under construction with commercial operation targeted between 2006 and 2011. Further, Japan has an announced schedule undergoing government approval that designates sites for another 12 power reactors totaling ~ 14,000 MWe.

Comments specific to different parts of the world follow.

European Union

A quarter of all electricity generated in the world (~3,000 TWh) is consumed in the enlarged European Union (EU 25). The "European Energy and Transport Outlook" forecasts annual growth rates averaging 1.3% in the "old" EU (EU 15) and 2.2% in the 10 "new" EU states. This will lead to an extra demand of 1,000 TWh by the year 2020. The current generating capacity in the EU 15 is around 600GW comprised of hydro (~120 GW), nuclear (~ 140 GW), coal (~ 140 GW), natural gas (~ 100 GW) and miscellaneous including renewable sources (~ 100 GW). Generating capacity in the 10 new member states is ~ 80 GW.

There will be significant power plant retirements in Europe by 2020. Combined with the potential phase out of nuclear energy in Germany and Sweden (which is appearing more and more unlikely despite current laws in effect), this will lead to a shortage of supply of approximately 2,000 TWh – half from retirements and half from increased demand. Accordingly, the EU will need to install between 260 GW and 300 GW of new generating capacity by the year 2020.

The new generating plants are expected to be coal-fired, gas-fired, nuclear and renewable energy. Advanced coal-fired and gas-fired plants are currently expected to comprise a large percentage of new generating capacity. In addition, throughout Europe there is greater appreciation for the advantages of nuclear power. Finland is now building a new nuclear plant, and France is planning to build more nuclear plants. In recent years, EU 25 countries have installed many NGCC plants and this is expected to continue as natural gas prices in Europe are lower than in the United States. A key issue, however, for this technology is security of supply associated with supply locations, pipelines and LNG transportation.

Europe's dependence on imported primary energy could grow from 50% today to 70% in 2020, due, in part, to depletion of economically recoverable resources, and in part on earlier decisions of four or five countries to phase out nuclear power. Absent a reversal of these decisions, electricity generated from nuclear power would drop from 32% now to 20% in 2020. Generation from renewable energy is expected to double to around 20% by 2020.

Studies by the EU suggest that the foregoing scenarios will produce an overall increase in carbon dioxide emissions in Europe starting in 2015. Coal is Europe's most abundant indigenous fossil fuel resource, but it is more expensive than in the United States. Fuel cost plus the cost of CO_2 reduction target makes improving plant efficiency a major goal in technology development. As a result, it is expected that a large proportion of new plant additions will be based in new advanced, clean coal technologies.

Unlike in the United States, the primary focus for advanced coal plant development in Europe is on higher efficiency through ultrasupercritical pulverized coal (USC) and supercritical CFB technologies. While IGCC technology is under development and of interest, combustion based technologies that are of considerably more interest. The goals of current ultrasupercritical pulverized coal programs in Europe are to advance USC technology to higher steam conditions (4,500 PSI and 1300° F with efficiencies close to 50%), to demonstrate CO_2 capture, to develop a platform for near zero emissions plants, and to reduce capital and operating costs. There are also significant efforts underway in Europe to develop Oxyfuel combustion technologies.

In Poland, PKE has awarded a contract to design and build a 460 MW supercritical CFB plant. This is the first of its find in the world and represents a major step forward in size and efficiency of CFB plants. This technology is now poised for commercial projects up to 600 MW in size.

China

China is one of the world's highest emitters of CO_2, due to heavy dependence on fossil fuels. In 2002, 82% of power in China was generated in thermal power plants, with coal providing over 95% of the fuel. Total coal-fired capacity at the end of 2003 was 265 GW of which 132 GW was comprised of over 600 relatively old units in the 100-300MW range. At the same time, the total coal burned by the power sector was 850 million tons. In 2004, some 40 GW of coal-fired capacity was installed and the projection for 2005 is for an additional 60 GW of coal-fired capacity. For 2020, the latest prediction is that the thermal power capacity (most of which will be coal-fired) will be 615 GW.

While there will continue to be massive investment in new coal-fired plants in China, the pace of economic growth means that existing plants will remain in operation for many years to come. These plants operate at low efficiency and few are fitted with pollution control technologies to remove sulfur dioxide, nitrogen oxides and particulates. Overall its coal burning plants contribute major acid rain and smog problems within China, and, at the international level, major CO_2 emissions issues.

In order to meet the enormous demand for power, various advanced technologies are being utilized in China. These include large, supercritical pulverized coal plants and CFBC plants for specialized applications. The State Government has approved supercritical PC plants as the most appropriate way forward for large scale generation with possible future use of ultrasupercritical PC. This is likely to create a drive towards 1000 MW PC power plants with advanced steam conditions and moderate environmental controls. IGCC and poly-generation are also being considered in China, although they are in the early stages of evaluation and development.

China is planning to build 27 new nuclear reactors between now and 2020. While such a ramp up in installed nuclear capacity is very ambitious, there is substance and action that indicates they will bring on line new capacity in the 2010 to 2014 timeframe. For example, China National Nuclear Corporation (CNNC), the nation's largest reactor builder, announced in June 2005 that it is developing its own reactor technology to build two 650 megawatt reactors and two 1,000 MWe reactors at its Qinshan plant, more than doubling the site's generation capacity to 6,200 MWe, up from the current 2,900 MWe generated by five running reactors.

Three foreign reactor vendors—Westinghouse, France's Areva and Russia's Atomstroiexport—are competing for an award to build four reactors of 1,000 MWe or larger, two to be built for CNNC at Sanmen in Zhejiang Province and two for the China Guangdong Power Company at Yangjiang in Guangdong Province west of Hong Kong. Additionally, the China Guangdong Power Company currently has two 1,000 MWe units under construction at the Ling Dong site adjacent to the Daya Baya Nuclear Station.

India

At the end of 2003, the generating capacity in India was 109 GW, made up of 59% coal, 25% hydro, 11% gas and some nuclear, wind and diesel. With projected annual economic growth of 7 to 8%, through the year 2012, capacity is expected to increase to 212 GW. As in China, coal is expected to be the dominant fuel source as coal is an important indigenous resource. Because the quality of Indian coal is poor, ash handling is a major problem.

Supercritical PC technology, viewed as a mature technology with good thermal efficiency, is being utilized in India. Standard sized units of 660 MWe are being built and larger units are being considered. Currently, there is little interest in ultrasupercritical units, and IGCC plant development is limited to consideration of a 100 MW demonstration plant. In addition, India has eight nuclear plants currently under construction.

V. Economic Circumstances of Advanced Generating Technologies

Set forth in the two tables below are projections of key economic indices for various advanced generation options in 2010 and 2020:

- Pulverized coal ultrasupercritical (Coal PC USC), with and without carbon capture
- Coal circulating fluidized bed (Coal CFB)
- Integrated coal gasification combined cycle (IGCC), with/without carbon capture
- Natural gas combined cycle (NGCC)
- Nuclear – evolutionary advanced boiling water reactor (ABWR), passive designs (ESBWR, AP1000)
- Wind
- Fuel cell gas turbine hybrid
- Biomass circulating fluidized bed (CFB)

Summary for 2010

Table 2010 summarizes the generation technology outlook in the year 2010, including the capital cost of various generation technologies, the overall cost of electricity (COE), and the CO_2 emissions. The corresponding Figure V-1 illustrates the impact on COE of adding CO_2 emission controls to fossil generation systems, as well as the value of non-CO_2 emitting technologies. Several observations are notable.

First, the range of gas prices (between ~\$5/mmBTU and ~\$7/mm BTU) leads to COE for NGCC generation that brackets the COE ranges of nearly all other technologies.

Second, Table 2010 indicates that COE increases if CO_2 capture technology is installed. CO_2 emissions technology can add as much as 30% to the COE of an IGCC plant for example, and 60% to the COE of a PC plant. These results reflect the high capital cost and energy requirements of today's CO_2 control equipment.

Third, in many cases, COE variations for different configurations of individual technologies are large compared with the variation among the technologies. The COE of advanced fossil generation technologies without CO_2 capture is sometimes less than that of zero-emitting technologies (nuclear and wind). However, the addition of CO_2 capture technology, or the imposition of a CO_2 emission credit system, shifts the cost advantage to zero-emitting technologies. For example, nuclear COE will be lower than CO_2 emitting generation with emission credit prices of greater than \$10 - \$15 per metric ton of CO_2.

Fourth, for the anticipated CO_2 removal technology of the year 2010, PC plants may have a higher capture rate than IGCC (95% vs. 85%). The differential arises because of limitations in the performance of current combustion turbine designs. However, the ultrasupercritical PC technology of 2010 will have a significantly higher capital cost than IGCC, due to high materials costs for the high-temperature ultrasupercritical steam cycle. As a result, the COE of the IGCC with carbon capture will be about 10% lower than the USC PC plant.

Fifth, nuclear and wind generation will be economically favored over fossil generation, especially if generators have to take steps to reduce greenhouse gas emissions. The challenges facing nuclear power remain the process and policy issues that make it difficult to get regulatory approval and financial backing to add nuclear power in the U.S.

Summary for 2020

The second table extends the time horizon to 2020. By that time, substantial improvements of coal-based technologies, using both combustion and gasification, are anticipated. The new technologies will reduce the capital cost and cost of electricity. For example, the capital cost of USC PC plants will decline from $2,100/kW in 2010 to $1,600 – 1,900/kW in 2020, while COE decreases to about $50/MWh.

For IGCC plants, EPRI has identified technology improvements that will reduce capital cost from $1,800/kW in 2010 to approximately $1,300/kW in 2020, including:

- Elimination of a spare gasifier
- Improving gas turbine output and efficiency
- Design of gas turbines optimized for firing H2
- Use of advanced membranes for CO_2 separation
- Adding an additional combined cycle train.

These improvements will reduce the COE and increase CO_2 capture to about 95% by 2020.

Natural gas combined cycle technology improvements are expected to focus on gas turbine design and widespread deployment of "H" class machines, capable of efficiencies of approximately 55%. Meanwhile, if gas price volatility persists, generators will seek technologies that offer the lowest financial and technology risks. This will favor conservative technology choices such as PC and NGCC, which will be difficult to backfit with CO_2 capture and storage.

In addition, hybrid designs integrating fuel cells with gas turbines are likely to become available by 2020. The hybrid cycle will use a high-temperature solid-oxide fuel cell (SOFC). The hot exhaust of the fuel cell will be fed to a gas turbine, to generate additional electricity. Development of the SOFC is underway, but additional research is needed to develop an integrated system, combining a gasifier with the fuel cell and gas turbine.

With respect to nuclear power, beyond 2020, some initial deployments of Generation IV nuclear plants are expected, especially if proven effective in a dual role of electricity and hydrogen generation. The design features of these plants have not yet been finalized – several designs are under consideration. However, they are expected to have a capital cost of 1,400 – 1,800 $/kW and a COE of about 45 $/MWh. The development of these designs will make extensive use of "first of a kind" engineering practices that will accelerate the learning curve and decrease the cost of early commercial-scale power plants. In addition, Gen IV nuclear plants increase the utilization of the fuel and thereby reduce nuclear waste.

Finally, the COE data show continuing reduction in cost and emissions for nearly all technologies over the period 2010 to 2020. This trend is evident in Figure V-2, which shows the COE data for selected technologies in 2020 (compare with Figure V-1 for 2010). This optimistic outlook can only be realized by continuing support for technology development on the part of a broad stakeholder group.

Table 2010: Economic Outlook for Various Technologies					
	Efficiency (%)	**Capacity Factor (%)**	**Capital Cost(1) ($/kW)**	**Cost of Electricity (COE)(1) ($/MWh)**	**CO_2 Emissions (metric tons per MWh)**
Coal(2) PC SC	**39**	**80**	**1250**	**41**	**0.80**
Coal(2) PC USC w/ CO_2 capture	**30**	**80**	**2100**	**67**	**0.052 (95% Removal)**
Coal(2) CFB	**36**	**80**	**1370**	**49**	**0.87**
IGCC(2) GE – Quench W/O CO_2 capture	**37**	**80**	**1380**	**47**	**0.86**
IGCC(2) GE - Quench w/ CO_2 capture	**30**	**80**	**1780**	**60**	**0.156(3) (85% Removal)**
NGCC(4) (@ $7/MM Btu)	**46**	**80(5)**	**460**	**63**	**0.39**
NGCC(4) (@ $3/MM Btu)	**46**	**80(6)**	**460**	**34**	**0.39**
Nuclear Evolutionary (ABWR)	**33**	**85-90**	**1600**	**46 – 49**	**None**
Nuclear Passive (ESBWR / AP 1000)	**33**	**85-90**	**1400 - 1700**	**41-47**	**None**
Wind (Class 3 to Class 6)	**N/A**	**30-42**	**1100**	**46 - 64**	**None**
Solar Thermal (Parabolic Trough)	**N/A**	**33**	**3150**	**180**	**None**
Biomass CFB	**28**	**85**	**2000**	**62**	**0.10(7)**

Notes:
1) 1) All costs in 2004$; COE in levelized constant 2004$ and includes capital cost. Capital Cost is overnight, W/O Owner, AFUDC costs.
2) All fossil units about 600 MW capacity; Pittsburgh#8 coal for PC, CFB, IGCC.
3) Based on Gas Turbine technology limitations to handle hydrogen
4) NGCC unit based on GE 7F machine or equivalent by other vendors; 5) Represents technology capability 6) Recent market data based on 2004 operation
7) Value shown is 7% emission of total. The remainder is assumed to be absorbed by the biomass plant crop growth cycle

Table 2020: Economic Outlook for Various Technologies	Efficiency (%) Goal	Capacity Factor (%)	Capital Cost(1) ($/kW)	Cost of Electricity (COE)(1) ($/MWh)	CO_2 Emissions (metric tons per MWh)
Coal(2) PC First of a Kind USC	46-48	80	1200 – 1500	38 - 44	0.57 – 0.59
Coal(2) PC USC w/ CO_2 capture	37-39	80	1600-1900	53 - 59	0.038 (95% Removal)
Coal(2) CFB	45-47	80	1250-1550	42-48	0.61 – 0.64
IGCC(2) GE Quench W/O CO_2 capture	42	80	1130	39	0.76
IGCC(2) GE Quench W/ CO_2 capture	37	80	1350	46	0.045 (95% Removal)
NGCC(3) Advanced (@ $7/MM Btu)	54	80(4)	500 – 740	56- 60	0.30
NGCC(3) Advanced @ $3/MM Btu)	54	80(5)	500 – 740	31 - 35	0.30
Nuclear Evolutionary (ABWR)	33	90	1400	40 - 45	None
Nuclear Passive (ESBWR / AP 1000)	33	90	1200 - 1500	40 - 45	None
Nuclear First of a kind (Generation IV)(7)	33	70-90	1400 - 1800	38-58	None
Fuel Cell GT Hybrid First of Kind	50 – 55	60-80	1500 - 2000	50-70	0.27
Wind	N/A	40	660	32	None
Solar Thermal (Parabolic Trough)	N/A	35	2800	160	None
Biomass CFB	34	80	1200	43	0.10(6)

1) All costs in 2004$; COE in levelized constant 2004$ and includes capital cost. Capital Cost is overnight, W/O Owner, AFUDC costs
2) *All fossil units about 600 MW capacity; Pittsburgh#8 coal for PC, CFB, IGCC. Advancements in CFB in larger sizes and higher efficiency are being carried out.* PC USC is 5000 psi 1112-1292F
3) NGCC unit based on GE H Type or equivalent by other vendors
4) Represents technology capability
5) Recent market data based on 2004 operation
6) Value shown is 7% emission of total. The remainder is assumed to be absorbed by the biomass plant crop growth cycle
7) *Technology available beyond 2020*

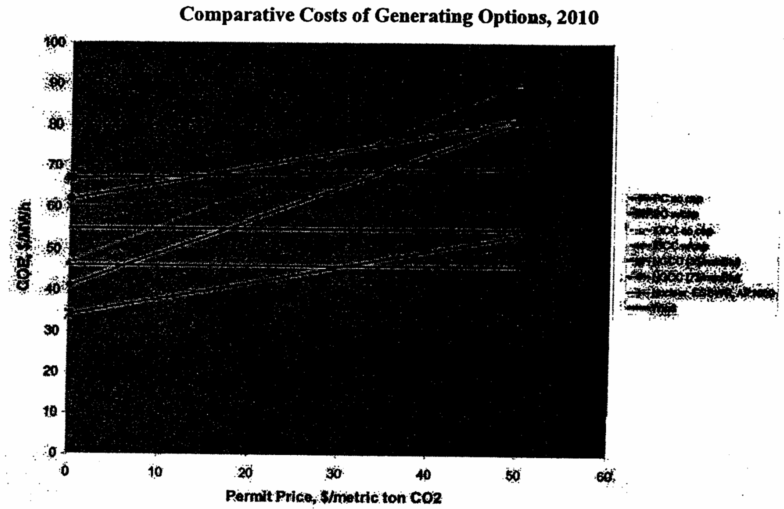
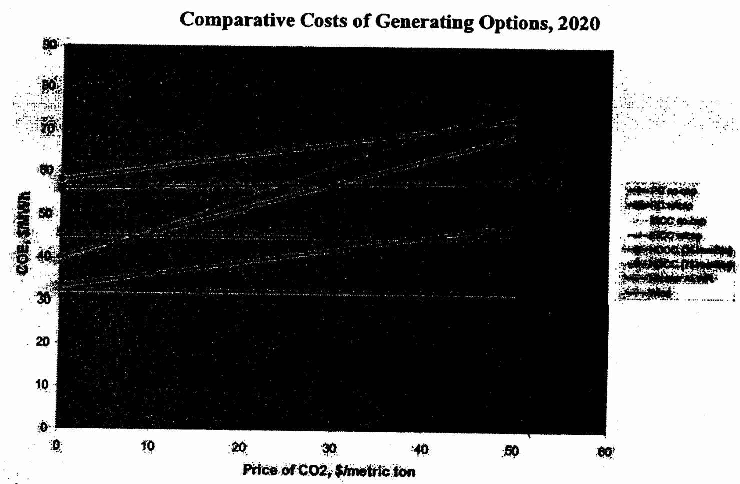


Figure V-1. Comparison of cost of electricity for different generation options, in 2010



FigureV-2. Comparison of cost of electricity for different generation options, in 2020

Cost-Effectiveness Evaluations of Greenhouse Gas Reductions

EPRI recently sponsored case studies to evaluate and compare the cost-effectiveness of key greenhouse gas reductions. These studies go beyond the analysis of generation options discussed earlier in this section, and include the broader set of operational changes and technologies outlined in Figure V-3 below. The figure shows the range of expected costs for a variety of on-system and off-system greenhouse gas (GHG) abatement actions. The costs to implement near-term CO_2 reductions can be expected to vary widely.

Key factors that affect the expected cost-effectiveness of GHG reduction actions include the age of the power plant, generation efficiency, gas and electricity prices, regulations of mercury, SO_2, and NOx, and the anticipated future role of nuclear power. Thus, different companies will face different challenges in implementing any of the GHG reduction actions.

In addition, these GHG reduction actions differ in other important ways. Some actions can be implemented quickly and inexpensively, while others will require longer lead times and significant up-front capital investment. Some actions utilize existing technologies, while others will require significantly more R&D before they are practical. Some additional considerations are listed below:

- Capital intensive projects may be difficult to finance.
- Long lead times can limit near-term GHG emissions reductions
- Diversified actions can reduce project risks
- Some GHG actions are "scalable" – that is they can easily be increased or decreased in size
- Some actions add flexibility to a utility's technology strategy. Retrofitting biomass firing capability is an example. The utility can then operate the unit either with or without biomass depending on fuel prices and the value of CO_2 reductions.
- Regulatory factors may discourage some GHG reductions. For example, DSM projects may help reduce GHG emissions, but it is increasingly difficult to obtain the necessary state regulatory approvals.

Meanwhile, the national and international debate about how to respond to global climate change continues. Tools that provide information on costs of mitigation efforts will grow in value as the nature and scope of the challenge become clear.

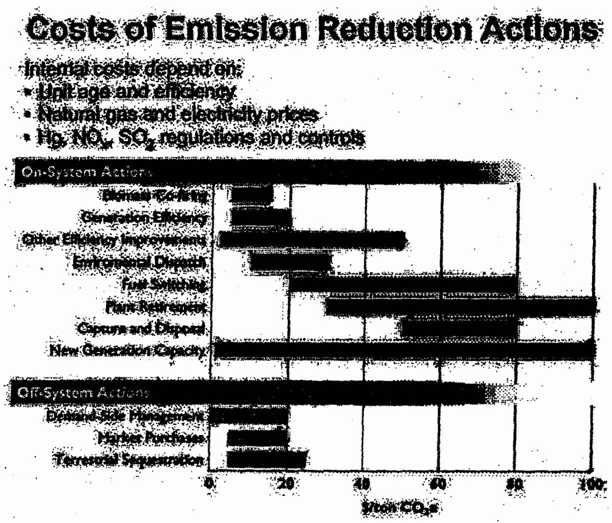


Figure V-3. Cost ranges for key electric sector GHG emissions reduction options.

VI. Generation Options: Incentives Discussion

Because of the higher capital cost and technological and regulatory uncertainties inherent in sponsorship of the first units, financial incentives provided by the public sector may be required to accelerate adoption of new technologies, as we have seen with renewable energy sources. Below is a summary of the types of incentives expected to have the most impact on developing advanced generating technologies.

A. Coal

Electricity from <u>initial</u> Integrated Gasification Combined Cycle (IGCC) plants is estimated to cost 15-20% more than electricity from conventional coal power plants. Incentives for deployment of initial gasification plants are essential to overcome both higher capital costs and technology risks. While four IGCC plants are currently operating in the world, and the various components of IGCC plants are in much wider use, there is no experience in operating integrated coal-fired systems at the scale of a 600MW plant.

Both Federal and state actions will be essential to help overcome this cost differential. Discussion at companies, state and Federal levels are on-going as technology deployment incentives play a key part of energy bill discussions.

EPRI has examined the potential financial value of a wide range of incentives from the viewpoint of an investor-owned utility (IOU), an independent power producer (IPP) with a power purchase agreement, and a public utility or cooperative. Without substantial incentives, it will be very difficult for IPPs to add any new baseload generation. Most new generation will be rate based – even in de-regulated states.

No single incentive examined was able to close the cost gap for all ownership structures. Rather, a portfolio of incentives seems more appropriate. For example:

- Loan guarantees could provide significant benefit to IPPs, allowing them to obtain financing at more attractive interest rates and with better terms, but is likely to provide little benefit to regulated IOUs and public utilities and cooperatives.
- Tax credits could provide significant value to IOUs and could provide similar benefits to IPPs, which can structure deals with partners to make use of the credits, but likely have no value to public companies unless the credits can be traded.
- Cost sharing is attractive to all company types.
- Concepts of "availability insurance" – government insurance which partially pays debt service in case an IGCC plant operates at less-than-design availability -- may provide carefully targeted value to all company types but needs to cover additional costs in order to better bridge the technology cost gap.

The incentives need to be structured to provide enough benefit to companies to get plants built. The cost to the government is also important. EPRI, DOE and EPA have a joint effort underway to examine these costs.

B. Nuclear

Views among member companies vary significantly on what constitutes adequate incentives to facilitate new nuclear construction. At one extreme, some CEOs have signaled general unwillingness to accept any significant business risk related to nuclear. For example, in an interview with Reuters on June 7, 2005 Dominion's CEO Thomas Capps stated that Dominion would not build a new nuclear plant under the current version of the energy bill proposed by the U.S. Congress. "If the government wants (nuclear plants) they are going to have to step in and help with the economics." Many other CEOs are willing to accept reasonable business risks, if the limited and targeted incentives currently included in various versions of the Energy Bill are passed by Congress.

The nuclear industry is already committing hundreds of millions of dollars and a significant amount of management time to new plants, and is not seeking any permanent subsidies for nuclear generation. Rather, it is seeking limited financial incentives for a limited number of plant projects over a limited period of time, in order to contain unique business risks related to licensing and constructing new reactors in the U.S., something that has not been done for about 30 years. Building new nuclear plants requires using an untested and expensive new process established by Congress and the NRC. Faced with this situation, limited incentives are needed to generate sufficient investment community support for new orders and construction.

Therefore, the nuclear industry believes that constructing the first new nuclear plants will require more than the Administration's proposal for some form of regulatory risk insurance, although that is an essential element of an incentive package. The details of how to create an effective regulatory risk mitigation strategy remain to be worked out. The industry also seeks limited, targeted federal support in the following areas:

- Support through the NP2010 program for demonstrating the NRC licensing processes and for cost sharing the detailed design and engineering work necessary to prepare licensing submittals and reduce first-of-a-kind capital costs,
- Government loan guarantees for nuclear energy in recognition of its role in generating emission-free electricity,
- Tax credits (e.g., production or investment types) and accelerated depreciation,
- Finally, the nuclear industry is seeking federal action in three additional areas:
    - Sustained progress on the Yucca Mountain project,
    - Renewal of the Price Anderson Act, and
    - Updated tax treatment of decommissioning funds

The industry seeks such support because the potential delays in the federal government's licensing process, which are beyond the control of the industry, pose a significant risk for parties contemplating construction of new nuclear plants.

C. Renewable Energy

Many state public utility commissions, the California Energy Commission and the DOE have provided or continue to provide incentives for adding renewable energy generation resources. Such government incentives include:

- Federal and State tax credits,
- Mandates for utilities to purchase the output generated by renewable energy sources at the utilities' "avoided cost",
- Federal and state government-sponsored renewable energy research and development programs, and
- Direct operating subsidies (e.g., 1 to 2 cents/KWh generated).

Supporters of renewable energy sources continue to advocate "tax shifting" with governments substituting higher taxes on carbon fuels and using the proceeds, through tax credits, for example, to subsidize renewable energy sources.

Going forward, mandates requiring a minimum percentage of renewable sources within generation portfolios may have the most influence on decisions to add renewable energy sources.

Additional research on renewable energy technologies as well as developments by venture-financed enterprises is improving the ability of various renewable energy resources to compete without subsidies with more traditional means of generating electricity.

VII. Decision Process

For some utility executives, the decision to "Make a Billion Dollar Advanced Generation Investments in an Emissions-Limited World" will be the most important of their careers. As shown in the preceding sections, among the most important factors that will determine the wisdom of investment are the following:

- **Fuels Choice:** Future availability and prices of fuels selected, as well as emission issues, influence the ultimate wisdom of the investment decision. At the outset of the decision process, tradeoffs among renewable energy, nuclear, coal, and natural gas are considered before proceeding with one fuel choice. The recent extraordinary and sustained increases in fuel costs have been transmitted rapidly in the case of natural gas, and are transmitted more slowly for coal and uranium, where long term or "vintage" contracts temporarily shield buyers and fuel producers alike from short term or "spot" market volatility. That shield is now crumbling as the period when coal prices remain elevated is extended.

- **Technology Choice:** The capital and operating cost and reliability of the technology selected as well as pertinent emissions issues also have large influence on the ultimate wisdom of the investment decisions. The technology choice, particularly in case of coal, must be carefully matched with a specific fuel for optimum performance.

- **Government Incentives:** The presence or absence of financial incentives provided by state and federal governments can have a large influence on the ultimate wisdom of the investment decisions. A number of financial and other incentives have been proposed to accelerate new generation of all types, and some, such as the wind production tax credits, have changed the pace and extent of the installation of technology. For new baseload generation, evaluations by EPRI and Nuclear Energy Institute have concluded that the incentives required for clean coal and nuclear are virtually identical. Even though coal and nuclear face different technology and licensing challenges, when it comes to the economic fundamentals of large, capital-intensive, baseload generation construction projects, the needs of the various investment communities, the impacts of diverse regional approaches to deregulation, congressional attitudes and constraints, etc., clean coal and nuclear are pretty much in the same situation. Both need a "portfolio" approach that provides flexibility based on the type of company (e.g., regulated IOUs, IPPs and other unregulated entities, public entities and cooperatives); region of country (with unique economic deregulation regimes), etc.

- **Market Forces** – Technologies can be compared one to another on an "apples to apples" basis at the same capacity factors and design heat rates, but any projects that are built will need to perform in markets against other capacity (including capacity not yet built). Transmission access and load growth will significantly influence outcomes. The recent overbuilding of gas-fired capacity and increases in gas prices, for example, have resulted in extremely poor results in spite of efficient plant designs. Through 2004, the average capacity utilization of the new combined cycle units plummeted to below 30%, and heat rates have typically been unable to match design specifications since so few plants have been able to run continuously at optimum levels. The lesson for decision makers is clear: each new project must be assessed in view of future market conditions.

To make decisions regarding large investments, utility executives generally rely on the traditional discounted cash flow methodology, which solves for an expected Return on Investment. Some criticize this approach because it is based on a static, best guess set of input values and assumes passive management over the life of the investment. Generally, the decision using the discounted cash flow methodology rests on the assumptions used to prepare different cash flow forecasts. Executives decide to invest or not based on which set of assumptions they believe is most likely to occur.

When there is a degree of investment flexibility present -- for example, through deferral, expansion, scale-back or abandonment -- more companies are approaching investment decisions using "Real Options Analysis". Real Options "thinking" divides a go-no go investment decision into a series of milestones or investment decisions and seeks to measure the value of having the option of moving forward at each milestone.

As a means of investment analysis, Real Options Analysis recognizes the value of active management and flexibility in the face of uncertainty regarding fuels, technology, environmental constraints, government incentives and other factors. At each investment point, the future becomes clearer and the risks of investing to obtain the next stage become less uncertain. As a result, real options analyses allow executives to better manage the financial risks associated with building a new power plant.

VIII. Setting the Discussions:

Over the course of a day and a half, Seminar attendees will participate in the discussions on two levels:

- First, as a plenary group looking at the electricity generation decision making process from the vantage points of investment, policy and technology; and
- Second, as a participant in a breakout group considering the role of a specific technology -- coal, natural gas, nuclear and renewable energy -- in helping the industry prepare to meet the demand for electricity in a carbon constrained world.

Each breakout will explore the economic and environmental potential of a given technology, the policy drivers that would encourage its rapid development and deployment, and its ultimate role in the generation mix for a carbon constrained world. Participants will also be asked to explore what EPRI can do to accelerate the deployment of this technology, and where EPRI actions can add the most value in terms of reducing uncertainty, reducing cost and improving performance.

Underlying the Summer Seminar discussion is the presumed advantage to the nation and to the world of a broadly diverse portfolio of generation technologies and fuels. The advantages are strategic, economic, and environmental. The participants are asked to consider the validity of this assumption, the need to factor it into their decision making process, and the means to achieve this diversity on a national and international scale.

MR. HALL. I thank you. We have a vote on the floor and we will be in recess until 12:20.

[Recess.]

MR. MURPHY. [Presiding] All right. This hearing is back in session. I will be sitting in until Mr. Hall returns. We are going to continue on. Mr. Novak, you completed your testimony. We will go now to Victor Abate, who is the Vice President of Renewable Energy with GE Energy. Proceed. Make sure the microphone is on and close to you. Thank you.

MR. ABATE. Yes. Mr. Chairman and members of the committee, I am Victor Abate, Vice President for Renewable Energy at GE Energy. I appreciate the opportunity to testify today on the future of wind power.

GE is a technology leader in the design and manufacture of power-generating systems that operate on a wide variety of fuels. In 2002, we added wind energy to our portfolio because we recognized the global demand for cleaner and more cost-effective renewable power. We see wind as a viable energy solution capable of complimenting the world's energy portfolio, and benefiting greatly over time from advances in turbine technology.

To give you a feel for today's wind turbine technology, picture taking a three-bladed rotor the size of a football field, turning it vertical and sliding it 30 stories into the air, mounting it on a 100-ton locomotive that is balancing on a pole and spinning it into the wind. That is analogous to what we do with our 1.5 megawatt wind turbine, where this single wind turbine produces enough electricity to power more than 500 U.S. homes.

We see two critical factors driving the economics for wind power. The first is the quality of the wind resource, and the United States has abundant high quality wind resources providing us with a global economic advantage for the development of wind energy. In fact, the U.S. resources are significantly better than other countries, like Germany, that actually lead in terms of installed wind capacity. The second is wind turbine technology and its ability to efficiently capture energy from the wind. A critical indicator of technology level is illustrated in the wind turbine's capacity factor. The capacity factor is the ratio of energy produced versus the maximum nameplate rating of the machine over the same period.

Since 2002, the capacity factor of GE state-of-the-art wind turbines has improved from 36 percent to 47 percent, meaning more free energy is being captured per turbine, reducing the cost of electricity by more than 1 cent a kilowatt hour over this period. The capacity factor has improved because of technology advancements in wind turbine efficiency, reliability, and availability. Our wind turbines are currently available to generate power more than 97 percent of the time, which is up dramatically from 85 percent in 2002. This is the result of advancements in turbine design, remote monitoring, and system reliability modeling.

Since 1980, the cost of wind-generated electricity has dropped by 80 percent as the result of technology advancements. Today the cost of electricity from wind power, without any incentives, is around 7 cents a kilowatt hour. While this is clearly more expensive than today's mature nuclear and coal technologies, it is currently comparable to the cost of electricity generated from natural gas at the recent elevated gas price levels. And it also provides a natural hedge against rising fuel costs in the future, as wind energy provides us with a fixed cost of electricity.

The Federal Production Tax Credit provides the necessary economic incentive for power producers to generate power from wind, and keeps equipment suppliers, such as GE, investing in technology advancements, and reducing the cost of wind power. GE is investing more than $70 million annually in wind turbine R&D, focused at improving turbine performance, and hence wind power economics.

In 2005, the United States installed nearly two and a half gigawatts of wind energy, expanding its installed base to over nine gigawatts, which now provides enough wind energy to power over 2.3 million homes. The United States is well positioned to benefit from this ample, clean, and carbon emissions-free domestic resource. We believe wind energy will be an integral part of the world energy mix throughout the 21st century.

Thank you for allowing me to participate in this hearing, and I look forward to your questions.

[The prepared statement of Victor Abate follows:]

PREPARED STATEMENT OF VICTOR ABATE, VICE PRESIDENT, RENEWABLE ENERGY, GE ENERGY

Mr. Chairman and members of the Committee, I am Victor Abate, Vice President, Renewable Energy at GE Energy. I appreciate the opportunity to testify today on the future of renewable energy.

GE is a power generation technology leader with leading experience in biomass, solar and wind technology. At GE, we believe renewable energy will be an integral part of the world energy mix throughout the 21st Century. Today, I'd like to focus specifically on the wind industry, but would welcome questions on other renewables. I will address my testimony to three issues: the state of wind technology today; costs associated with wind energy; and opportunities to drive costs down in the future through continued technology advancement.

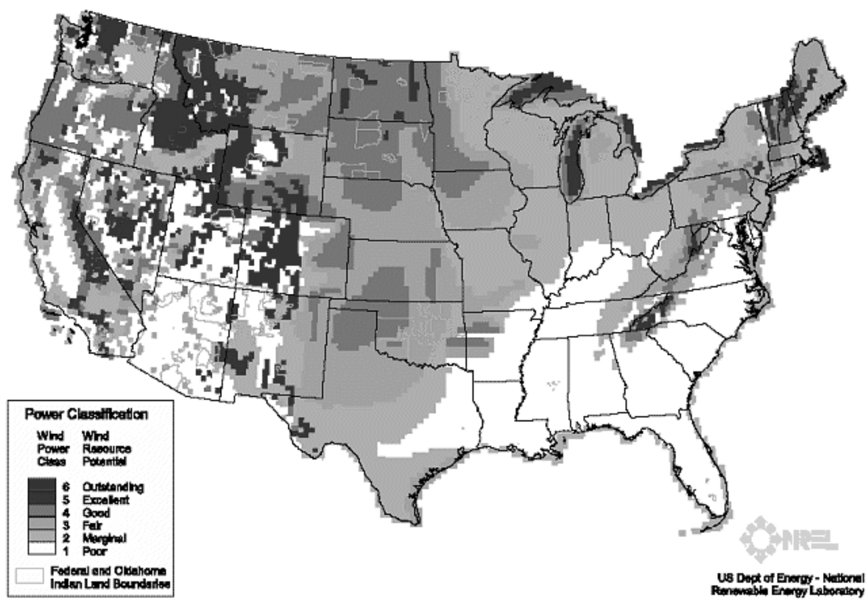
Wind Energy and the US Energy Future

Wind energy can become a significant player in the US energy portfolio and is the most commercially viable renewable energy resource today. The industry has recently seen record-breaking growth; in 2005, the US installed 2,431 MW of wind energy contributing to a total installed base of 9,149 MW, which is enough energy to serve 2.3 million homes. Although today's wind technology supplies less than 1 percent of US electric generation, the total installed base has nearly doubled over the last three years. Wind energy is currently being used to generate power in 30 states.

The two critical factors for success in the wind industry are 1) the quality of the wind resource, and 2) advances in wind turbine technology. The US is well positioned in both of these areas.

When compared to Germany, the country with the world's largest wind energy installed base, and other top country wind installers, the US has significantly better wind resources. In fact, the American Wind Energy Association (AWEA) claims that current US wind resources have the potential to supply up to three times the total electricity generated in the US today.

Figure 13. Wind Resource Potential



Tapping the potential of wind as an energy source makes use of this abundant, domestic, low to zero carbon emissions resource while reducing overall US dependence on imported energy. For example, a 100 MW wind farm in New York State would produce the energy equivalent to 590,000 barrels of oil per year and displace 260 million pounds of carbon dioxide per year. Furthermore, wind is a fixed cost source of electricity which hedges rising prices for other energy sources, such as natural gas and oil.

In January, President Bush stated that the US could one day generate up to 20 percent of its electricity needs through wind technology. We believe that this vision is achievable through continued technology advancement.

Current Wind Energy Technology

The key measure of the ability to generate electricity from wind energy is the turbine's "capacity factor." Capacity factor is defined as the ratio of the actual energy produced by a turbine over a time period versus the maximum energy the turbine could produce if operated at full nameplate rating over the same time period. For example, a 1 MW unit can produce a maximum of 168,000 kWh of electricity in one week. If the turbine actually produces 84,000 kWh, it would have a capacity factor of 50% for that week.

The capacity factor for state-of-the-art wind turbines has increased substantially since 2002. As shown on the chart below, in 2002, the best-in-class capacity factor of wind turbines was less than 36% at a wind speed of 8 meters per second (m/s)(a speed which is representative of the quality of US wind resources). In 2006, the capacity factor of the best-in-class machines has risen to approximately 47%. As a point of reference, a one-point increase in capacity factor over the US wind installed base could produce enough electricity to support 90,000 average US households.

Three key factors influence the turbine capacity factor: blade size, turbine efficiency and availability, and the wind resources at the site. Increases in rotor sizes and turbine availability have contributed to the significant jump in the capacity factor.

Since 2002 rotor sizes in similar wind regimes have increased by 17% from 70.5 meters to 82.5 meters, thereby increasing the energy capture of the turbine by over 35%. This also benefits energy production by allowing the turbine to begin generating power at lower wind speeds.

Availability refers to the percentage of time that a wind turbine is ready to generate power. In 2002, availability of then state-of-the-art wind turbines was less than 85 percent. As the result of technology advances in remote monitoring, diagnostics and the utilization of GE reliability modeling, today's wind turbines have availability of more than 97 percent. A one percent increase in availability over the US wind installed base could produce enough electricity to support 28,000 average US households.

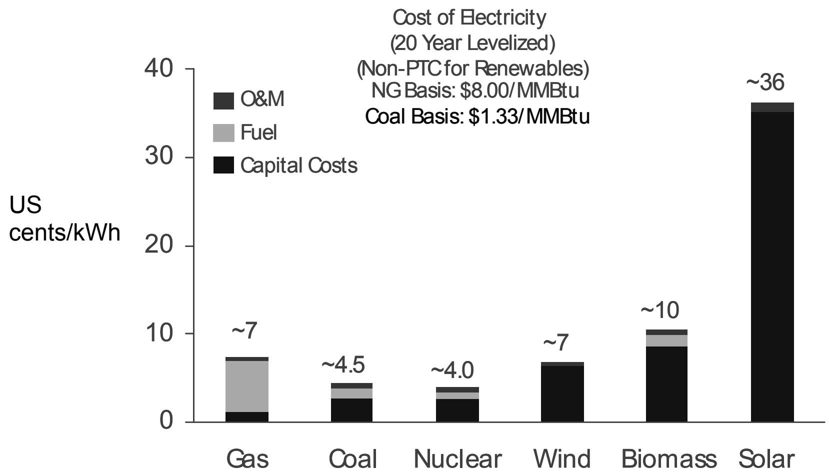
Proper siting of wind turbines also is critical to energy production and capacity factor. As shown below, siting the same 1.5xle unit at an 8 m/s average site versus a 7 m/s average site will create a 9 point increase in the capacity factor, from 38% to 47%.

Capacity Factor and AEP on GE 1.5s and 1.5xle Turbines

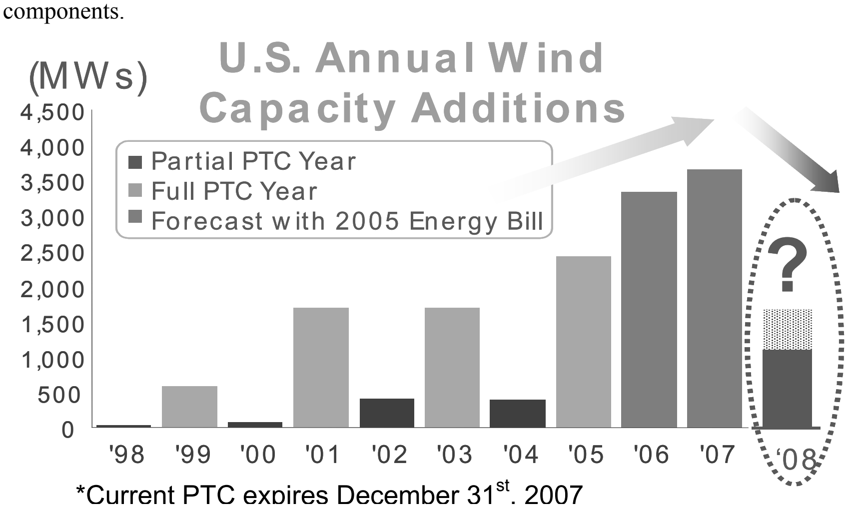
	1.5S 2002 State of Art Technology	**1.5XLE** 2006 State of Art Technology
Rotor Size	70.5m	82.5m
Availability	85%	97%
Capacity Factor @ 8 m/s	36%	47%
Annual Energy Production @ 8 m/s (Kwh)	4,730,000	6,176,000
Capacity Factor @ 7 m/s	28%	38%
Annual Energy Production @ 7 m/s (Kwh)	3,679,000	4,993,000

Costs

Since 1980, the cost of wind-generated electricity has seen an 80 percent price reduction as the result of technology advancements in availability, efficiency and output. Today, the Cost of Energy for wind, exclusive of any incentives, is 7 cents/kWh.



Wind is more competitive when the 1.9-cent per kWh production tax credit for wind is applied. The Federal production tax credit provides a necessary economic incentive for power producers to generate power from wind. As illustrated below, the role of the production tax credit in stimulating the installation of wind generation is clear. When the wind production tax credit has been allowed to expire, new installed capacity has dropped dramatically in the following year due to lack of component availability. Therefore, a more stable incentive for wind generation can support the long-term investment by suppliers needed to assure that manufacturing capability is available for critical components.



For example, today we are seeing a supply-constrained industry where suppliers are unable to provide key components such as blades and gearboxes, limiting the number of wind turbines being manufactured. To meet the market demand in 2006 and 2007, the supply chain needs to make multi-million dollar investments in production capacity.

However, unless OEMs can assure suppliers of a future market, suppliers may not make the long-term investments that are necessary. A predictable incentive policy is essential if we are to grow the wind industry in the US.

Wind Technology Advances for the Future

GE is investing more than $70 million annually in advancing wind turbine technology to further lower the cost of electricity. These efforts are focused in three key areas: larger and more efficient rotors, advanced loads management and enhanced grid stabilization.

The rotors on wind turbines define the energy capture capabilities of the unit. This energy capture is a function of two parameters: rotor diameter and blade efficiency. Larger rotors capture more energy, but typically increase the up tower mass of the unit and therefore, increase the weight and cost of the supporting structures. Utilization of higher technology and lighter weight material will allow longer blades without increased weight. In addition, advances in computer modeling will allow significant increases in blade efficiency through increased understanding of the complex flow fields around turbine blades.

The rotor is also a key contributor to the loads characteristics of the wind turbine. Advances in passive and active loads management techniques, through advanced controls and materials, will allow increases in turbine size without proportional growth in weight. Voltage regulation is key to electrical grid stability. Wind turbines have progressively increased their capability to stay on line during grid voltage fluctuations and assist with voltage regulation. In the future, wind turbines will be a vital part of grid voltage stabilization through advanced power electronics which will be capable of managing grid voltage, even when the wind is not blowing.

Continued development of low speed wind technologies – an important focus of government/industry research and development partnerships – will allow the use of wind turbines in lower class wind locations that would otherwise not be economically feasible.

Conclusion

In conclusion, wind power is a cleaner, viable offset to fossil fuel generation. The U.S. is well positioned to benefit from this ample, domestic resource and it is evident that wind can become a significant player in the US energy mix through its proven technology and strong growth. Predictable incentives, however, are still needed to sustain this momentum and drive costs down.

Thank you for the opportunity to present this testimony. I look forward to your questions.

MR. MURPHY. Thank you very much. And now we are joined by Dr. Troy D. Hammond, Vice President of Products with Plextronics, a company around Pittsburgh, and we are pleased that you could be here and we were able to have you here. Thank you so much for being with us today. Please proceed.

MR. HAMMOND. Well, I wish to thank Chairman Hall and the members of the Subcommittee on Energy and Air Quality for the opportunity to present and discuss my views regarding new and innovative solar technologies. I have submitted a written copy of my testimony for the record and I will summarize it for you today. First of all, I commend the Chairman for his leadership in having this hearing. This dialogue is important for America, and I thank the subcommittee for addressing the importance of innovation related to our current energy challenges.

My name is Troy Hammond, and I am the Vice President of Products for Plextronics, Incorporated, in Pittsburgh, Pennsylvania. Plextronics was founded in 2002, as a spinout of Carnegie Mellon University. It was co-founded by Professor Richard McCullough, Dean of the Mellon College of Science at Carnegie Mellon University, where he continues to play an active role in Plextronics. Our company is the leader of conductive polymer research, development, and commercialization. These conductive polymers are a type of plastic material that promises to shepherd in a new era of low-cost electronic devices, including polymer photovoltaics, or solar cells.

On January 31, in his State of the Union address, the President announced the Advanced Energy Initiative, stating that America's energy challenges, including our continued economic and national security, can be addressed in part through revolutionary solar technology. The President set out a clear objective for the contribution of solar photovoltaic energy to the Nation's energy supply; namely, to reduce the cost of solar photovoltaic technologies so that they become cost competitive by the year 2015. The President has good reason to support solar technology. Solar photovoltaic devices directly convert sunlight to electric power in a clean, renewable manner, with no direct emissions into the atmosphere; however, today's solar technology cannot yet deliver cost-competitive power.

While residential, commercial, and industrial customers pay less than 10 to 12 cents per kilowatt hour in their electric bills, solar energy costs 25 to 50 cents per kilowatt hour or more depending on the technology and the geographical location. As an additional hurdle, the cost of solar technology comes as a large capital investment at the time of purchase. A residential consumer buying today's products would pay $10,000 or more for two kilowatts peak of solar modules. Installation and necessary electronics increase the total cost to $15,000 to $20,000. Projected price decreases generated from the annual 30 to 40 percent market growth in solar have flattened, if not reversed. The President's objective will require a reduction factor of three to five in the installed system cost, which will translate into an energy cost of below 10 cents per kilowatt hour by the year 2015. Clearly, if America achieves these targets, it will begin changing for the global energy industry.

While some would propose that these goals can be achieved through evolutionary development of current technology, even advocating tens of billions of dollars of subsidies, we believe revolutionary thin-film technologies can unlock the sun's potential. Indeed, America's engine of research and invention has been making critical progress toward new solar technologies for many years. For example, polymer photovoltaics utilize a novel version of plastics that strongly absorb the sun's light and behave like a semiconductor, analogous to silicon in the generation of electricity. Rather than requiring expensive manufacturing equipment and processes, these polymers are turned into inks that can literally be printed much like a newspaper is printed. The total manufacturing cost can be as much as a factor of 10, less costly for each square foot of solar module.

Key discoveries in this technology were made domestically. Current state-of-the-art polymer solar cells utilize a technology invented by Professor McCullough and manufactured by Plextronics; to be clear, additional performance improvement is required. Plextronics' scientists have developed a portfolio of new polymer technologies that have the potential to double this performance and extend the lifetime of the technology. The focus of our technical development activity is the realization of this performance potential, and when achieved, broad commercialization is possible.

Federal support at this juncture is critical. The President's 2007 Budget proposes a Solar America Initiative, with a funding increase of $65 million over Fiscal Year 2006. Given the impact that economic solar energy could have on global energy supply, we urge Congress not only to fund this program fully, but also to ensure America's leadership in revolutionary new solar technologies is accelerated by the Solar America Initiative. Thank you.

[The prepared statement of Dr. Troy D. Hammond follows:]

PREPARED STATEMENT OF DR. TROY D. HAMMOND, VICE PRESIDENT, PRODUCTS, PLEXTRONICS, INC.

Thank you, Chairman Hall and members of the Subcommittee on Energy and Air Quality for the opportunity to present and discuss my views regarding new and innovative solar technologies. I have submitted a written copy of my testimony for the record and will summarize it for you today. First of all, I commend Chairman Hall for his leadership in having this hearing. This dialogue is important for America and I thank your Subcommittee for addressing the importance of innovation related to our current energy challenges.

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On January 31, in his State of the Union address, The President announced the Advanced Energy Initiative stating that America's energy challenges, including our continued economic and national security, can be addressed in part through revolutionary solar technology. The President set out a clear objective for the contribution of solar photovoltaic energy to the nations energy supply, namely to reduce the cost of solar photovoltaic technologies so that they become cost competitive by 2015.

The President has good reason to support solar technology. Solar photovoltaic devices directly convert sunlight to electric power in a clean, renewable manner with no direct emissions into the atmosphere.

However, today's solar technology cannot yet deliver cost competitive power. While residential, commercial and industrial customers pay less than $0.10 – 0.12 per kilowatt-hour in their electric bills, solar energy costs $0.25 to $0.50 per kilowatt-hour or more depending on the technology and the geographical location.

As an additional hurdle, the cost of solar technology comes as a large capital investment at the time of purchase. A residential consumer buying today's products would pay $10,000 or more for 2 kilowatts-peak of solar modules. Installation and necessary electronics increase the total cost to $15,000 to $20,000. Projected price decreases from the annual 30-40% market growth have flattened if not reversed. The President's objective will require a factor of three to five reduction in the installed system cost, which will translate into an energy cost of below $0.10 per kilowatt-hour by 2015.

Clearly, if America achieves these targets, it will be game-changing for the global energy industry. While some would propose that these goals can be achieved through evolutionary development of current technology, even advocating tens of billions of dollars of subsidies, we believe revolutionary thin film technologies can unlock the sun's potential. Indeed, America's engine of research and invention has been making critical progress toward new solar technologies for many years.

For example, polymer photovoltaics utilize a novel version of plastics that strongly absorb the sun's light and behave like a semiconductor, analogous to silicon, in the generation of electricity. Rather than requiring expensive manufacturing equipment and processes, these polymers are turned into inks that can literally be printed much like a newspaper is printed. The total manufacturing cost can be as much as a factor of ten less costly for each square foot of solar module.

Key discoveries in this technology were made domestically. Current state-of-the-art polymer solar cells utilize a polymer technology invented by Prof. McCullough and manufactured by Plextronics, yet additional performance improvement is required. Plextronics' scientists have developed a portfolio of new polymer technologies that have the potential to double this performance and extend the lifetime of the technology. The focus of our technical development activity is the realization of this performance potential; when achieved, broad commercialization is possible.

Federal support at this juncture is critical. The President's 2007 Budget proposes a Solar America Initiative with a funding increase of $65 million over FY06. Given the impact that economic solar energy could have on global energy supply, we urge Congress not only to fund this program fully, but also to ensure America's leadership in revolutionary, new solar technologies is accelerated by the Solar America Initiative.

Summary

1. The President's Charge
    a. Make solar photovoltaic technology cost competitive by 2015
    b. Address this energy challenge through revolutionary solar technology
2. The Rationale
    a. Direct conversion of solar energy into electricity
    b. Clean, renewable, no emissions
3. The Issue
    a. Today's technology is not cost competitive
    b. $0.25-0.50 or more per kilowatt-hour versus $0.10 or less
    c. Large up-front capital costs (e.g. $20,000 for the residential consumer)

   d. Evolutionary improvements, even subsidized, won't suffice
4. The Opportunity
   a. Thin-film technologies promise revolutionary costs
   b. Polymer photovoltaics can be printed like inks at 5-10x lower cost
5. Plextronics, Inc.
   a. Key discoveries by Prof. McCullough; developed by Plextronics
   b. Potential to double current performance and enable commercialization
6. Federal support is critical, including the Solar America Initiative
   a. Fully fund this Initiative
   b. Demand strong focus on revolutionary technologies

MR. MURPHY. Thank you, Dr. Hammond. Our next person testifying is Mr. Tom--is it Linebarger?

MR. LINEBARGER. Linebarger.

MR. MURPHY. Linebarger, Executive Vice President and President of Power Generation Business for Cummins. Thank you. You may proceed.

MR. LINEBARGER. Thank you, Mr. Chairman, and thank you, members of the committee. It is an honor to be here, and thank you for inviting me to testify. I have a written statement that I would like to put in the record, and I also have a brief oral testimony.

I will, of course, be brief. My name is Tom Linebarger. I am the President of Cummins Power Generation, and it is a division of Cummins, Incorporated. We supply a wide range of power generation equipment, from very small units of four kilowatts or so used for recreational uses to large power generators up to 2.7 megawatts for large industrial loads. All Cummins Power Generation equipment would be generally classified as distributed energy, and that is mostly what I want to speak to you about today.

Like the other witnesses, I think today's hearing is really important. Obviously, reliable and cost-effective energy for the long run is among the most important issues facing the country today. It is my belief that we need to capitalize on the full range of power generation technologies available in order to provide a balanced portfolio of energy, and I think the committee is wise to be looking ahead and looking broadly for solutions.

If I could, I would like to define distributed energy. Distributed energy is electricity that is generated near the point of use as opposed to a centralized power station, which would then send electricity over hundreds of miles, typically, in transmission lines. Most of our power today in the United States, of course, is generated by central stations, but already more than 5 percent of power is generated in distributed form. Distributed energy can use a wide range of fuels. Most of the fuels mentioned today can be used in distributed form, and our own equipment, for example, can use biofuels, coal bed methane, and many other fuels.

The benefits of distributed energy are many. I will just mention a few here. First, it is a compliment to the electrical grid. It provides more reliability to the grid by providing built-in support and also relieving bottlenecks in the grid. It is quickly deployed and flexible in size and location. I just brought a small model of a typical unit that we might supply in an emergency response, and we can fit the entire two megawatt unit in the back of a semi truck, ready to be installed, and we have used these units to respond to many emergencies. I will mention a few later. Emergency backup, in stationary form, obviously can protect our important industries and facilities, and this kind of backup is more and more necessary as we see grid failures and other disasters that impact our critical facilities. Distributed energy is environmentally friendly and also efficient, and that is increasingly so as we improve technologies.

I would like to just highlight a couple of examples that I am familiar with from experience. Cummins has had a distributed energy deployment that I think highlights some of these benefits. First, a couple of years ago there was a drought in Mexico, where a Mexican utility needed to bring 160 megawatts online, and they were shooting to get it online in 45 days. So using units just like this one that I showed here, we were able to get all 160 megawatts online and available for homes in the area in actually less than 45 days. In fact, we completed the project in 41. To put up new power stations would've taken them certainly more than a year and probably more like two years; so very quick and very flexible.

A similar example would be, today, we provide 72 megawatts to First Energy, the utility First Energy, and these units are based in New Jersey. It provides peaking support, which reduces the cost of providing energy to consumers in that area by taking off peak loads. And these same units, during the winter, we were able to redeploy them to help facilities, after Hurricane Katrina, come back online more quickly. We were able to, again, drive them down in trucks like this to provide quick response. Similarly, in a grid-support application, we have 96 megawatts on Long Island where LIPA is building a new transmission line, and while that line is being built, they will use these distributed energy resources to keep their consumers with power. In the emergency backup examples, there are many, but just in the Northeast blackout, for example, many of our units were deployed at hospitals, which, because they were there, people who were undergoing operations when the blackout occurred, those operations were able to continue, and obviously those backup units were really important to those that were on the operating table. Refineries were able to restart more quickly after

Katrina because they had emergency backup power ready to go and already deployed.

As an example of the efficiency and environmental benefits of distributed energy, we have one unit that is at Chicago's Museum of Science and Industry that allows them to use their unit for peaking power. They also have a combined heat and power application where they can use hot water to provide the cafeteria and other facilities at the museum with hot water and steam. And while this reduces the cost of energy for them, it also allows them to come off the grid at peak times in the summer, and their cost of energy is significantly reduced.

This committee has already recognized, I think, the value of distributed energy technologies. Last year's Energy Policy Act authorized $760 million over 3 years for distributed energy research and related technologies. However, I would note that the Department of Energy only spent about $60 million last year on distributed energy, and this year is asking for significantly less, around $30 million. My concern is that it will have a negative impact on research in this area when we are starting to make some significant advances in efficiency and cost.

This committee also adopted an amendment by Congressmen Buyer and Boucher on interconnection. This requires States to hold proceedings on developing interconnection standards. Also, Congressmen Terry and Doyle co-chaired the House Distributed Energy Caucus, and this caucus takes a lead in developing policies to promote and deploy distributed energy. Congresswoman Wilson, who was here earlier, has a long history with interconnection issues. All of these things are helping to get distributed energy deployed more widely and more effectively in the energy infrastructure.

However, I still believe that much more needs to be done for distributed energy to reach its potential. There is significant technology work that needs to be done for these units to reach their maximum efficiency levels, and to expand their use of bio and renewable fuels, further improve emissions and air quality, and understand their role in the grid more broadly. And I guess what I am asking here is that we make sure the money that has been authorized is spent on these critical priorities.

As an example of the R&D work that the Department of Energy can continue to do that would really help is the ARES project. I am familiar with this project because Cummins, along with two other industry participants, has been working on this ARES project for 5 years now with the Department of Energy. This project set out efficiency goals for natural gas generators. We started at a 37 percent efficiency. We have already been able to increase the efficiency to 44 percent, and our target is 50 percent on relatively low amounts of funding. The work needs to continue until the goals are achieved because we have made significant progress. In addition, we can identify other similar areas of technology that could be funded to provide some of the benefits I mentioned earlier.

Secondly, I think that we need to promote combined heat and power as a significant element of distributed energy. Combining heat and power offers efficiencies north of 85 or 90 percent due to the use of waste heat. Unfortunately, CHP is a significantly underutilized technology today. There are a number of barriers and risks to implementing these projects, and in order to get more projects done, we need to recognize the benefits to the public of 85 or 90 percent efficiency and provide incentives. Many more projects will get done with relatively small incentives, given how close some of the economics are on some of these projects. Many other countries have done similar kind of incentives and have had good results in terms of deploying combined heat and power. I offer that the same would be true with landfill gas, which is a good renewable source of fuel, but again, because of the risks in some of these projects, incentives are needed in order to get more projects off the ground.

Next, in order to help distributed energy to reach its potential, I think we need to focus on some of the barriers, and particularly the more unreasonable barriers that are preventing implementing distributed energy. Most important in this is interconnection. On the subject of interconnection, I would just like to highlight one piece of equipment I brought with me. This is a master control module which we use to hook up our generators onto the grid. This allows us to parallel with the grid and ensure that our energy can come on and off safely onto the grid. It protects other users that are downstream from the source of power. It also ensures that workers are not injured if they are working on the lines when we are generating power. This module meets the requirements of a standard IEEE 1547. This standard was developed over 5 years by a wide range of industry, regulatory, and utility participants. And the Energy Policy Act that I mentioned, the amendment by Congressmen Buyer and Boucher required that States at least review IEEE 1547 to see how it could be deployed. Unfortunately, States have been relatively slow to adopt the standard and in fact have adopted them in a very inconsistent way. The result is that many projects that could benefit from distributed energy do not get done because of inconsistent rules, and oftentimes some utility participants will require a roomful of relays and cabinets that might be $10,000 or $20,000, instead of a $1,000 module that can accomplish the same thing. And again, my recommendation is that we try to come up with an interconnection standard that is nationally consistent.

Lastly, I think that it would be wise for us to ensure that critical infrastructure is protected throughout the United States. We know that interruptions in the grid are possible and in fact even likely. Hurricanes, grid failures like the Northeast blackout, and homeland security threats have already demonstrated what can happen when we lose grid power. I think Congress needs to review standby requirements for key facilities and industries. Currently, there are very few Federal standards. There are many, many facilities, of course, that do have backup power in place, but too often managers of critical infrastructure do not fund the purchase of backup equipment, because it is much like buying insurance. You can either pay the money now or you can hope nothing bad happens, and if you are lucky, it won't. Unfortunately, when something bad does happen, the public is the one who suffers from not having power available. A few areas that I think deserve focus: petroleum refinery and deliver sector, to ensure that there is adequate backup power; water and sewage treatment, again, where we have seen evidence of not having backup power; communication networks and then emergency responders of all types. Reviewing these requirements after emergencies is obviously too late, so we if act proactively, we can ensure that our infrastructure is in place.

Again, I am pleased that you are having this hearing and I thank you very much for the honor of testifying today.

[The prepared statement of Tom Linebarger follows:]

PREPARED STATEMENT OF TOM LINEBARGER, EXECUTIVE VICE PRESIDENT AND PRESIDENT, POWER GENERATION BUSINESS, CUMMINS, INC.

Introduction

Cummins Power Generation, a subsidiary of Cummins Inc., is a global leader in the production and supply of power generation equipment, with specific focus on increasing the availability and reliability of environmentally responsible electric power around the world. We deliver cost-effective power solutions for a wide variety of customers – commercial and industrial businesses, recreational users, emergency responders, government agencies, utilities, and homeowners – through our global distribution network.

Background

Distributed energy (DE) is electrical energy that is produced at or near the site where the energy is consumed. DE is not one technology – it can be produced by generator sets using conventional fuels like diesel and natural gas and other newer fuels like biomass, biodiesel, ethanol, or hydrogen. DE can also include emergent technologies such as fuel cells, wind turbines or solar. Installation of DE in the U.S. will result in far-reaching benefits to consumers, businesses, industry and our national security. Government policies must encourage greater use of DE.

Benefits of deployment of DE technologies

The benefits of DE are numerous. It is energy efficient, it bolsters grid reliability, and provides backup power at the point of use when the grid fails. DE is also environmentally sound. In some situations it can also be a source of lower cost power. DE protects some of our nation's critical infrastructure including water and sewage treatment, emergency communications equipment, oil refineries, nuclear power plants, financial data centers and much more.

<u>What is needed to fully reap benefits of DE</u>

We believe there are four major policy areas that the government should pursue to allow the country to reap the full benefits of DE technologies: increased Federal R&D funding for DE technologies; a review of backup power requirements for critical infrastructure; tax policies that favor CHP; and national uniform interconnection standards.

Mr. Chairman and Members of the Committee, thank you for inviting me to testify. Today's topic is an important one and I am glad to represent the distributed energy point of view. Today's high fuel prices and energy security concerns highlight the importance of looking beyond centrally-fired power plants for solutions to meet our future electricity needs.

I am appearing here today in my capacity as President of Cummins Power Generation. Cummins Power Generation, a subsidiary of Cummins Inc. (NYSE: CMI), is a global leader in the production and supply of power generation equipment, with specific focus on increasing the availability and reliability of environmentally responsible electric power around the world. With over 80 years' experience, we deliver cost-effective power solutions for a wide variety of customers – commercial and industrial businesses, recreational users, emergency responders, government agencies, utilities, and homeowners -- through our global distribution network. Our products include engines, alternators, generator sets, and systems including power control and power transfer technologies. Our services range from system design, project engineering and management, large scale temporary power projects, and operation and maintenance contracts. We also operate several small scale power plants providing electrical power as well as hot or chilled water derived from waste heat.

Distributed energy (DE) is electrical energy that is produced at or near the site where the energy is consumed. DE is not one technology – it can be produced by generator sets using diesel or natural gas and increasingly other fuels like biomass, biodiesel, ethanol, or hydrogen. DE can also include emergent technologies such as fuel cells, wind turbines or solar. DE performs a number of important roles for power consumers and utilities including: emergency standby power to increase reliability, prime power where power is unavailable, peaking power to reduce the load on the grid at times of peak usage, the opportunity to utilize combined heat and power to reduce their total energy costs, and as protection against line or substation failure in a distribution grid.

It is estimated that there are approximately 160 gigawatts of emergency standby power installed in the US. There are also approximately 11 gigawatts of baseload distributed energy and another 6.5 gigawatts of distributed energy being used to meet utility peaking needs. It is also worth noting that in the US there are approximately 30 gigawatts of combined heat and power plants of less than 100 megawatts.

While these numbers are impressive, they are far short of the potential opportunities for DE. In one market study at Cummins, we estimated an additional market potential of 150 gigawatts for combined heat and power (CHP) installations below 100 megawatts in the commercial and industrial sectors. We believe the market opportunity is larger when you consider opportunities to expand the use of other types of DE. It is worth noting that favorable government policies in Europe have allowed DE technologies to enjoy far greater success in the marketplace. DE technologies account for approximately 13% of the electricity generated in Europe, more than double their penetration in U.S. markets.

The benefits of DE are numerous. It is energy efficient, it bolsters grid reliability, and provides backup power at the point of use when the grid fails. DE is also environmentally sound. In some situations it can also be a source of lower cost power. DE protects some of our nation's critical infrastructure including water and sewage treatment, emergency communications equipment, oil refineries, nuclear power plants, financial data centers and much more.

During emergencies like last year's hurricanes or the Northeast blackout of 2003, DE played a critical role in assuring first responders could do their jobs and critical facilities like hospitals continued to function. DE assured that communication systems continued to operate and that critical information, such as the financial data that underpins the banking system, was secure. It kept businesses running and mitigated the economic impact of these disasters. As a result of their investment in DE, many oil refineries were also able to continue to operate, gasoline distribution centers were able to load fuel into trucks, and gasoline was made available to consumers. Unfortunately, not everyone made such investments and there were interruptions in the fuel delivery system.

I would like to highlight a few specific cases of how distributed power provided critical support to Cummins customers during Hurricane Katrina and the Northeast blackout.

When any major weather event is predicted for the US, Cummins Power Generation and its distributors begin to prepare a storm response. In the case of Hurricane Katrina our response involved twice daily conference calls (every day for 9 weeks), to organize the marshalling not only of generating assets, but technicians, distribution equipment and fuel. To respond to the national emergency, generating equipment was relocated from around the country, and from Canada and Mexico. We estimate we deployed in excess of 160MW to the region. Some of that equipment remains in place today. We are proud of our ability to mobilize generating equipment in this manner; however, permanent DE installations would have provided better protection for the region.

A hospital that did have emergency DE in place, is Turro Infirmary in Kenner, LA. Turro Infirmary is one of the hospitals in the New Orleans area that managed to keep operating during Katrina on backup power. After the storm, the hospital recognized the value of having sufficient and reliable emergency power and has decided to upgrade its system by replacing generators that were over 50 years old with new Cummins Power Generation units so that it will continue to be well-prepared for the next emergency.

The communications industry has also realized the benefits of reliable backup power. Verizon Wireless installed Cummins generators at its cell towers and major switching stations in upstate New York. During the blackout of 2003, while some people stood in long lines at pay phones, these generators meant that Verizon wireless customers continued to have uninterrupted wireless access throughout the emergency.

Also during the blackout, Cummins generators enabled New York Mayor Michael Bloomberg to respond to the blackout because New York City Hall was supported by a Cummins emergency standby system keeping the lights on, the computers running and building systems operating. All airports have standby generation to power air traffic control systems and runway lighting, but at Newark Liberty Airport, a Cummins standby power system provided uninterrupted power to the entire airport terminal throughout the outage making travelers much more comfortable with air conditioning and lighted bathrooms. Water systems and sewage treatment facilities stopped working in Detroit, Cleveland and several other cities in the affected area, but in Mississauga, Ontario, outside of Toronto, a Cummins Power Generation prime power system kept the sewage and water system operating for the city's 800,000 residents.

Beyond emergencies, DE makes important contributions to grid reliability. For example, each summer Cummins places 168 megawatts of power in the Northeast to help utilities meet their seasonal peak. This is made up of two large projects, 72 megawatts at FirstEnergy in New Jersey and 96 MW at Long Island Power Authority.

At FirstEnergy our portable diesel generators are used to provide reliability support to the grid. During peak periods the generators are started, relieving constraints and lowering the chance of a system failure. This past fall 40 of those units were unhooked from the grid and moved to areas affected by the hurricanes. These generators provided emergency power to hospitals, like Forest General Hospital in Hattiesburg, MS; water systems, like Veolia Water Works in Kenner, LA; and to support FEMA operations. They were recently moved back to First Energy to be in place to meet this summer's peaking requirements.

The 96 MW's of Cummins generating capacity on Long Island provide reliability support to the local power grid to fill a gap between electricity supply and demand until new transmission capacity can be built to meet the needs of Long Island. Without this support from DE, on peak days, Long Island would have a serious electricity shortfall. Importantly, stringent emission control standards were applied to this project. Each 2 MW containerized generator is equipped with state-of-the-art emissions control technology designed to meet New York Department of Environmental Conservation's stringent air quality standards. The emissions control technologies applied to this site, along with the use of ultra-low sulfur fuel, resulted in more than 90% reduction in nitrogen oxide, carbon monoxide and particulate matter. The control package utilized on the generators reduces emission output to levels that are better than EPA Tier III standards.

Additionally, DE makes important contributions in the area of efficiency. Using DE in combined heat and power configurations (CHP) leads to very high efficiencies by using heat normally wasted in the electric generation process to do useful work, such as heating, air conditioning or serving industrial processes. An example of this benefit is a CHP system installed by Cummins at American Honda's corporate headquarters in Torrance, California. That project is saving the company 30% annually on its total campus energy expenditures. In addition to the energy savings, the CHP system allows American Honda to demonstrate corporate leadership and environmental responsibility. As the ethanol industry in the US continues to develop, it is looking increasingly to install CHP plants to support its production facilities.

One of the areas that could most benefit from distributed power technologies is utilizing landfill gas to generate electricity. Cummins has installed a landfill gas to energy plant at the Viridor Waste Management landfill in Dunbar, Scotland allowing a nearby cement plant to obtain a significant portion of its power demand at lower costs than can be supplied by the local utility. The Viridor plant not only allows the cement plant to save on its energy costs, but harnesses the methane gas produced by the landfill which when flared into the atmosphere has about twenty times the greenhouse effect of carbon dioxide. This project is also an example of how favorable government policies can encourage deployment of these highly efficient technologies. The project was eligible for increased revenue in the form of Renewable Obligation Certificates, a UK government trading program to encourage development of renewable energy projects making the cost of power from such sources more competitive. The Certificates allow Viridor Waste Management to invest in the environmentally friendly waste-to-energy project and supply cheaper electricity to the cement plant and still make money on the project.

The benefits DE provides to our nation's energy infrastructure are undeniable. Those benefits go beyond the individual benefits received by the owners or users of the DE asset – but benefit all Americans through enhanced reliability, efficiency, and critical infrastructure protection. However, more often than not, Federal and state policies treat DE as a burden to the electrical system rather than a benefit. DE technology advancements are also limited because of a lack of Federal research and development funding. Further, connecting DE technology to the grid is difficult because interconnection requirements are often inconsistent and expensive to implement. In addition, tax policy does not favor CHP as it does other clean efficient sources of electricity by giving production tax credits for the benefits it provides.

The traditional drivers for DE are being magnified by current global trends. Higher fuel costs, climate change initiatives and a push for environmental stewardship, and homeland security concerns all point to the use of increased use of DE to secure and ensure the viability of continued energy supply into the future. However, unless the US adopts policies that create a favorable marketplace for DE, the technologies will continue to struggle and much of the electricity generating capacity available in the US will not be allowed to feed back on to the grid. I am concerned that, as a result of less favorable policies toward DE, its adoption rate has been slowed and this has been to the detriment of our power sector and the security of our critical infrastructure.

What does DE need to reach its full potential? We believe there are four policy areas that the government could adopt to allow the country to reap the full benefits of DE technologies: increased Federal R&D funding for DE technologies, a review of backup power requirements for critical infrastructure, tax policies that favor CHP, and national uniform interconnection standards.

Federal Funding for DE R&D

There are potential technological breakthroughs that could have a significant effect on the efficiency, reliability and emissions from generators that run on natural gas, biomass and similar fuels. Federal funding to ensure that these technologies are developed rapidly could have a major positive impact on fuel consumption and emissions in the near or medium term. Federal funding, particularly through the Department of Energy, also ensures that the best research by all competitors in the field is brought together to get results more quickly and to define how DE can contribute most effectively to the grid.

Similarly, federally funded research on fuel cells for power generation applications has already resulted in significant breakthroughs on this important technology. However, significant work remains to be done before this technology will be able to meet the performance and cost targets required for it to have an impact in our country.

With the progress that has been made to date, it is critical that funding not be stopped mid-stream or we will lose the benefits we have gained. These are technologies that can help us fulfill a number of our critical priorities: low cost and reliable energy infrastructure: diversifying our fuels to reduce dependence on any single fuel; improving the security of our critical infrastructure; using more renewable fuels; and improving the efficiency and reducing the emissions of our power sources. Moreover, these technologies can contribute to these goals in the near or medium term rather than the distant future. We must continue our research focus on DE.

Last year, this Committee worked to develop the Energy Policy Act of 2005 (EPAct). That legislation authorized $730 million to be spent on DE technology and policy development over the next three years. Unfortunately, the Administration has not requested funding at any where near that level for FY07. In FY 2006, DOE allocated approximately $60 million for DE work. For FY 2007, it requested only $30 million. As Congress finishes the FY07 Appropriations process it should provide additional funding for DE research and development. Without full funding, progress on DE will remain limited. Key programs may be ended short of their goals and other programs will not begin at all.

One example of the type of work DOE is doing with respect to DE is the Advanced Reciprocating Engine Systems (ARES) program. Three engine manufacturers, including Cummins, participate in this cost-shared program. The goal of the program is to develop a cleaner, more efficient natural gas reciprocating engine. These engines are workhorses of the industry, used in nearly every DE application. While making these engines more efficient doesn't sound as glamorous as technologies using unconventional energy sources, if the goals of the ARES program are achieved and our estimates of market demand are correct, there will be a fuel saving of 491 trillion Btu's of natural gas, NOx emissions will be reduced by 170,000 tons, and 26 million tons of CO2 will not be emitted into the atmosphere over a ten year period. To make this point another way, for every 10GW of ARES products deployed, over 100 trillion Btu's of energy will be saved, reducing oil consumption by 17.2 million barrels annually. We think this is an important program and appreciate DOE's continued support.

ARES is just one of the many programs industry and DOE are working on to encourage advancement of DE technologies and market penetration of those technologies. Other important DE programs include the Gridwise Architecture Board, DOE Regional Application Centers that promote CHP implementation, and DOE's Landfill Methane Outreach and Coal Bed Methane Outreach Programs that promote the useful and environmentally friendly utilization of these waste energy sources nationwide.

Another area where there is work to be done to advance DE technology is on microgrids. Microgrids are defined as single or multiple clean distributed power resources serving multiple customer loads (e.g., residential subdivision, mixed-use residential and commercial centers, business and industrial parks). Microgrids can provide cost savings and enhanced reliability to consumers while simultaneously making the grid more robust to outages caused by nature and security breaches. In the event of such disasters, microgrids because of their capability to operate in an "island mode" can help restore the power grid more rapidly.

Microgrid research and development has positioned the concept for real world application. R&D is currently funded by DOE and the California Energy Commission and is aimed at studying the interaction of distributed resources with the grid, performance of power electronics, and the seamless transitioning of the microgrid when necessary between "island" and "normal" or "parallel" operations with the utility grid. It is imperative that funding for such programs be continued and expanded.

Internationally, Cummins Power Generation is working to develop DE technology that uses a variety of readily-available biofuels. In India, Cummins is working with the Indian Institute of Science on technologies that use wood chips, rice husks and coconut shells, among others things, to generate electricity in a distributed form. We are using this technology to support rural electrification in India. These small scale systems (20-40KW) power entire villages providing new economic opportunities to areas that would otherwise be unserved by the grid. Globally, biofuels are becoming an increasingly important source of feedstock for power generation. Increased use of these fuels will help dampen growing worldwide demand for petroleum. These international programs highlight the additional research that is necessary to enable DE power generation to fully realize the benefits of biofuels.

Critical Infrastructure Backup Power Requirements

Congress should consider expanding the role that DE technologies play in assuring our homeland security and in disaster relief and recovery. Last year's hurricanes highlighted the fragility of our fuel delivery system. With much of our oil production and refining in the Gulf Coast, the impact of a power outage to these key facilities can have ramifications well beyond the region; causing fuel supply disruptions in other parts of the country. In recognition of this vulnerability, Homeland Security Secretary Chertoff and Energy Secretary Bodman recently sent a letter to the oil refining and distribution industry asking them to review their current backup generation capabilities and needs and to enhance them if necessary. Other industries are equally vulnerable to power supply interruptions. In an example close to home, lack of backup power meant Fairfax County residents had to boil water after power was knocked out to the local water system after Hurricane Isabel hit the east coast -- even well after power restored. Cleveland residents faced a similar problem after the Northeast blackout of 2003.

Congress, the Administration and the States should review existing backup power requirements in light of today's changing requirements and then implement new requirements where there are gaps. We believe Congress should begin to develop a power security policy. Such a policy should include a review of current backup power capabilities for critical facilities, and authorization for DHS and/or DOE to require key industry sectors to have sufficient backup power available.

Tax Incentives

We believe tax policies should be adopted to encourage DE, and CHP in particular. Specifically, because distributed energy, when used in a CHP application, has significant environmental and efficiency benefits, its deployment should be encouraged. CHP systems have an overall energy efficiency level of 85%. Compare this with an average of 34% for central power stations. One way to encourage CHP is through a tax credit and faster depreciation. Market penetration of combined heat and power systems would increase dramatically with such a credit. This type of tax credit was critical to the development of the wind industry in the US. We believe a similar credit would have a beneficial impact on the development of new CHP projects. During consideration of EPAct, production tax credits for CHP were considered but ultimately removed during conference. We believe Congress should reconsider adoption of CHP tax credits.

Uniform Interconnection Standards

In EPAct, Congress passed legislation to require States to develop their own interconnection rules. This was a major step. Prior to the legislation many states had no interconnection requirements at all. As a result of the legislation, states are beginning to develop interconnection processes, but there is still a great deal of variation from state to state and utility to utility. Importantly, many of the safety and technical questions about interconnection have already been resolved through an industry driven process conducted by the Institute of Electrical and Electronics Engineers (IEEE). IEEE 1547 is a technical standard for interconnection developed through a consensus process that included utilities, DE equipment manufacturers, end-users, and state and regional regulators.

We believe Congress needs to take another step on the development of uniform interconnection standards. Because each state has not adopted IEEE 1547 as written, there remains inconsistency in the interconnection process with which those seeking to install DE projects must comply. DE project developers are often met with requests for unnecessary protective equipment or unreasonable commercial terms that can make an otherwise good project uneconomic. Further, a consistent standard would speed the interconnection process and lower the costs of DE equipment by allowing manufacturers to develop pre-certified interconnection equipment. We believe Congress should require the development of a national uniform interconnection standard for small generators, which would include the adoption the IEEE standard.

Mr. Chairman, I thank you for holding this hearing. I think it is important for the nation that you fully consider the benefits of DE and adopt policies to encourage its continued development and deployment. Again, I thank you for this opportunity to testify.

MR. HALL. Mr. Linebarger, thank you. Dr. Katzer.

MR. KATZER. Thank you, Mr. Chairman and members of the committee. Good afternoon. My name is James Katzer and as the Chairman noted earlier, I am a Visiting Scholar at the Laboratory for Energy and the Environment at MIT, focusing on the future of coal. I am pleased to be able to testify to you today about the aspects of coal-based power generation. I will focus on generation technology and associated emissions, including carbon dioxide emissions. My formal testimony has been submitted for the record.

Coal presents significant challenges in large-scale power generation. At the same time, the United States has 27 percent of the total global recoverable coal reserves, enough for 250 years at current consumption, as was noted earlier. Over 50 percent of U.S. electricity was generated from coal last year and coal is expected to shoulder its share of the demand growth in the future.

A primary coal-generating technology is pulverized coal combustion, PC combustion. It is a well-established, mature technology, generating efficiency increases from about 35 percent for low-severity, subcritical units to about 44 percent for high-severity, ultra-supercritical units. This efficiency increase reduces the coal required per unit of electricity generated by about 25 percent. This also means that CO_2 emissions are reduced by 25 percent and other emissions produced are also decreased by about 25 percent per unit of electricity generated.

Most PC plants in the United States are subcritical units, the bottom of this range. We have no ultra-supercritical plants. On the other hand, Europe and Japan have built almost a dozen ultra-supercritical plants over the past decade. We need to have higher efficiency technology available for our changing future, and I will comment on this if I have some time at the end. Application of advanced emissions control technology to PC units can reduce PC emissions to very low levels. Further, emissions control technology is continuing to evolve and improve, and at this point we do not know just when or where the end will be reached. I would say, in general, the issue of PC emissions is not technology capability, but breadth of its application.

Stepping on, integrated gasification combined cycle, IGCC, technology is a competitor to PC generation. Four coal-based IGCC demonstrations plants, each between 250 and 300 megawatts, have been built, each with government assistance, and each is operating well. Two of these are in the United States. In addition, there are about five refinery-based IGCC units, three of them at the 500 megawatt level each, that are gasified petroleum coke, residua, tars, asphalts, and other residues in refineries to produce electricity. IGCC is well established commercially in the refinery setting. IGCC should also be considered a commercial technology in the electricity generating setting, but in this setting it is neither well established nor mature. As such, it is likely to undergo significant change as it matures.

The estimated cost of electricity for PC generation or bituminous coal is about 4.8 cents per kilowatt hour. Under similar conditions, an IGCC plant produces electricity for about 5.1 cents a kilowatt hour, or about three-tenths of a kilowatt hour more than the PC unit; thus, today IGCC is not the economic choice. For supercritical PC generation, about 1 cent per kilowatt hour, or about 20 percent of the total, is associated with achieving high levels of emissions control. Reducing emissions control by a factor of two further, well beyond or well below any permitted levels that are being set today in the United States, increases the costs an estimated two-tenths of a cent per kilowatt hour, further raising that about 5 cents a kilowatt hour for PC. These added emissions costs narrow the gap for IGCC, but do not produce a shift in technology choice based on COE. However, IGCC has a potential for order of magnitude criteria emissions reductions below PC for 99.5-plus levels of mercury and other toxic metals reductions, for much lower water use and stabilize solid waste.

MR. HALL. Begin to wind up, please.

MR. KATZER. Yes. These may become a larger factor in the future and may begin to shift the balance toward IGCC. My testimony contains details on CO_2 capture.

The conclusion I would like to come out of this with is, when we look at all of this and the role of low rank coals in the United States, we conclude that among IGCC, oxygen-fired combustion, and air-fired combustion, the three competing technologies, at this point, each is in a developing stage, they each have a lot of maturity to gain, and it is too early to conclude winners and losers at this point in the game. The challenges to meet our power needs and protect air quality and the environment are substantial, but coal, teamed with the proper technology, can be part of the solution. I thank you.

[The prepared statement of James Katzer follows:]

PREPARED STATEMENT OF DR. JAMES KATZER, VISITING SCHOLAR, LABORATORY FOR ENERGY AND THE ENVIRONMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. Chairman and Members of the Subcommittee. Good morning. My name is James Katzer, and I am a Visiting Scholar in the Laboratory for Energy and the Environment of Massachusetts Institute of Technology. For about the last year, I have been working with a group of MIT faculty who have been looking at the future of coal. I am pleased to have been invited to discuss some key aspects related to this work with you today. I will focus on coal-based generation technology and certain associated environmental issues, including carbon dioxide emissions and their control. I am submitting my written testimony herewith.

Coal presents the ideal paradox in power generation. On one hand, it is cheap, abundant, and concentrated typically in countries with large human populations and limited oil and gas. On the other hand, its use can have significant environmental impacts, requires capital-intensive generating plants, and produces large quantities of carbon dioxide. Both U.S. and global electricity demand will continue to grow at a brisk rate, and coal is certain to play a major role in meeting this demand growth. As you are aware the U.S. has 27% of the total global recoverable coal reserves, enough for about

250 years at current consumption. Over 50% of U.S. electricity was generated from coal last year.

The primary technology used to generate this electricity is pulverized coal (PC) combustion. It is well-established, mature technology that generates most of the world's coal-based electricity. Although the efficiency of generation depends on a number of variables, including coal type and properties, plant location, etc., the most important efficiency determinant is the temperature and pressure of the steam cycle that is used. I will come back to this in a minute.

Integrated Gasification Combined Cycle (IGCC) is a competitor to PC generation. Four coal-based IGCC demonstration plants, each between 250 and 300 MWe, have been built, each with government assistance, and are operating well. In addition, there are about 5 refinery-based IGCC units, three at 500 MW_e each, that are gasifying petroleum coke, or refinery asphalt, residua, tars, and other residues to produce electricity. These units often also produce steam and hydrogen for the refinery. IGCC is well established commercially in the refinery setting. IGCC can also be considered commercial in the coal-based electricity generation setting, but in this setting it is neither well established nor mature. As such, it is likely to undergo significant change as it matures. Currently, the biggest concern with coal-based IGCC is gasifier availability.

Because a large number of variables, including coal type and quality, location, etc, affect generating technology choice, operation, and cost, my comments here and my technology comparisons will center one point set of conditions. This includes one coal, Illinois #6 coal, a high-sulfur bituminous coal and generating plants designed to achieve criteria emissions levels somewhat lower than the lowest recent permitted plant levels. For example, the designs that I refer to here achieve 99.4 % sulfur removal. I will first compare these technologies without carbon dioxide capture and then compare them with 90% carbon dioxide capture. Plant capital costs are based on recent detailed design studies and industrial experience of the last 6 years, which represented a relatively stable period. I have not attempted to account for recent cost escalation. Here I will focus on technologies that are either commercial or well on their way to becoming commercial.

PC Combustion: The most important variations affecting PC generating efficiency is the severity of steam cycle operation: subcritical, supercritical, and ulta-supercritical. Generating efficiency is about 35% for subcritical generation, about 38% for supercritical generation, and about 44% for ultra-supercritical generation. Increased generating efficiency means less emissions per unit of electricity, including less CO_2 emissions. In moving from subcritical to ultra-supercritical generation, the coal required per unit electricity is reduced by about 22%, which means a 22% reduction in CO_2 emissions and also reduced criteria emissions. Moving from subcritical to supercritical offers about a 10% reduction. Most PC plants in the U.S. are subcritical units. We have no ultra-supercritical plants in operation, under construction, or being planned. One reason is that low coal cost has not provided sufficient economic incentive to offset the slightly higher capital costs associated with higher steam cycle operating severity. On the other hand, Europe and Japan, which have higher coal costs and stronger culture supporting high efficiency, have built almost a dozen ultra-supercitical units over the last decade. These units are operating as well as subcritical units, but with much higher generating efficiency. The key enabling technology here is improved materials to allow operation at higher severity conditions. An expanded U.S. program to advance materials development and particularly improved fabrication and repair technologies for these materials would advance the potential for increased PC generating efficiency for our changing future.

Another critical issue with PC generation is criteria and other emissions. Application of advanced emissions control technologies to PC units can result in extremely low emissions, and emissions control technology continues to improve, including the potential for high degrees of mercury control. In general, the issue of PC emissions is not a question of technology capability but the breadth of its application. This may not hold for specific local situations.

Using detail design study capital costs, EPRI economic TAG guidelines and assumptions and coal at $1.50 per million Btu, the estimated cost of electricity (COE) for a subcritical PC is about 4.8 ¢/kW_e-h, consistent with recent EPRI estimates [1]. The COE decreases slightly (~0.1 ¢/kW_e-h) from subcritical to ultra-supercritical generation. For supercritical generation almost 1 ¢/kW_e-h, or about 20%, is associated with achieving emissions control to the high design levels assumed here. Reducing emissions by a factor of two further would add an estimated 0.2 ¢/kW_e-h increasing the COE to about 5.0 ¢/kW_e-h.

IGCC: The promise of IGCC has been high generating efficiency and extremely low emissions. There are a number of critical options associated with gasification technology and its integration into the total plant that affect efficiency and operability. Of these, the gasifier type and configuration are the most important. Table 1 summarizes the characteristics of gasifier types. Entrained-flow gasifiers, which are extremely flexible, are the basis of each of the IGCC demonstration units. Figure 1 shows the configuration of an IGCC employing full quench cooling of the gasifier exit gases. This configuration will produce about 35-36 % generating efficiency. Figure 2 illustrates the addition of a radiant syngas cooler to raise steam for the steam turbine, which increases the electricity output and raises the generating efficiency to 38-39 %. Adding convective syngas coolers to recover additional heat as steam is also shown in Figure 2. It can increase the generating efficiency to the 39-40 % range. Existing IGCC demonstration units, which employ different practical combinations of these options, operate at generating efficiencies from 35.5 % (Polk) to 40.5 % (HHV) (Puertolanno Spain). Since IGCC is not yet mature, there is still potential for efficiency gain. However, I do not expect to see commercial IGCC generating efficiency exceeding that of ultra-supercritical PC in the intermediate time frame. The design/engineering firms and the power industry need to gain experience with IGCC to develop better designs and achieve improved, more reliable operation.

Current coal-based IGCC units are permitted for and are operating at the same criteria emissions levels as the best PC units. An IGCC plant with radiant and convective syngas coolers using Illinois #6 coal, operating at 38% efficiency, and achieving high levels of criteria emissions control produces electricity for about 5.1 ¢/kW_e-h or about 0.3 ¢/kW_e-h higher than a supercritical PC [1, 2]. IGCC would not be the choice based on COE alone, independent of gasifier availability concerns. Requiring high levels of mercury removal, reducing criteria pollutants by one half from the very low levels that we are already considering and including the cost of emissions credits and offsets increases the COE for the PC, narrowing the gap, but does not suggest a shift in technology choice based on COE. However, IGCC has the potential for order-of-magnitude criteria emissions reductions, 99.5+ % levels of mercury and other toxic metals removal, much lower water consumption, and highly stabilized solid waste production. These may become a larger factor in the future. To achieve these order-of-magnitude criteria emissions reductions is expected to increase IGCC COE, but this increase is not expected to be large. Companies considering construction of a new coal-based generating facility need to bring all these considerations into their forward pricing scenarios to help frame the decision of which technology to build.

CO_2 Capture: If it becomes commercial practice, CO_2 capture will add significantly to the COE, independent of which approach is taken. CO_2 capture could also change the choice of technology in favor of IGCC, although it is too early in technology development to declare this a foregone conclusion. History teaches us that one single technology is almost never the winner in every situation. The options are:

- Capture the CO_2 from PC unit flue gas. In this case, the CO_2 is at a low concentration and very low partial pressure because of the large amount of nitrogen from the combustion air. To capture and recover the CO_2 using today's amine (MEA) technology requires a lot of energy. Energy is also required to compress the CO_2 to a supercritical liquid. This large energy consumption reduces plant electricity output by almost 25% and reduces generating efficiency by about 9 percentage points. The added capital and the efficiency reduction increase the COE by about 60% or about 3.0 ¢/kW$_e$-h to about 7.7 ¢/kW$_e$-h. In this situation a 50% reduction in the CO_2 capture and recovery energy would have a significant impact on PC capture economics. Focused research on this issue is clearly warranted.

- <u>Combust coal with oxygen(Oxy-fuel combustion)</u> to reduce the amount of nitrogen in the flue gas. This allows the flue gas to be compressed directly liquefying the CO_2 without a costly separation step first, significantly reducing the energy consumption. The technology required the addition of an air separation unit which consumes significant energy and thus would not be used except for CO_2 capture. This technology is in early development stage, is advancing well, and at this point appears to hold significant potential for both new-build capture plants and for the retrofitting existing PC plants. The estimated COE for oxy-fuel combustion is about 7.0 ¢/kW$_e$-h (includes capture and compression to supercritical liquid, but not transport of sequestration) or about 0.7 ¢/kW$_e$-h less than for air-blown PC combustion with capture. The technology requires further development and demonstration along with detailed design studies to allow effective evaluation of its cost and commercial potential.
- <u>Use IGCC, shift the syngas to hydrogen, and capture the CO_2 before combustion</u> in the gas turbine. IGCC should give the lowest COE increase for CO_2 capture because the CO_2 is at high concentration and high partial pressure, and this is what is observed. The needed technology is all commercial, although it has never been fully integrated on the scale that it will need to be applied here. The estimated COE is 6.5 ¢/kW$_e$-h [1] which is a 1.4 ¢/kW$_e$-h increase over non-capture IGCC and is about about 1.2 ¢/kW$_e$-h less than supercritical PC with capture. Oxy-fuel combustion falls in between them

<u>Lower Rank Coals</u>: As Figure 3 shows, moving from bituminous coal to sub-bituminous coal and to lignite results in an increase in the capital cost for a PC plant and a decrease the generating efficiency (increased heat rate). However, for IGCC, these trends are much larger, such that currently demonstrated IGCC technologies become more substantially disadvantaged relative to PC for subbituminous coals and lignite. Note that over half of the U.S. recoverable coal reserve is either subbituminous coal or lignite. Thus, there is a substantial need for improved IGCC technology performance on lignite, other low rank coals, and biomass. Options include, but are not limited to, improved dry-feed injection into the gasifier, coal drying, fluid transport reactors and other gasifier configurations. Development should be at the PDU scale before moving to demonstration.

A variation on PC combustion is fluid-bed combustion in which coal is burned with air in a fluid bed, typically a circulating fluid bed (CFB)[2, 3] CFBs are best suited to low-cost waste fuels and low-rank coals. Crushed coal and limestone are fed into the bed, where the limestone undergoes calcination to produce lime (CaO) which captures sulfur. The steam cycle and generating efficiencies are similar to PC. The primary advantage of CFB technology is its capability to capture SO_2 in the bed, and its flexibility to a wide range of coal properties, including low-rank coals, high-ash coals and low-volatile coals. The technology is fully commercial, and several large new lignite-burning CFB units have been constructed recently. CFBs are well suited to co-firing biomass [4].

When CO_2 capture is considered, the differences among IGCC, oxy-fuel PC and air-blown PC become significantly less than discussed above for bituminous coal.. In this situation all three of the technologies with CO_2 capture must be considered to be in the early stages of development, and it is simply too early to select one of these technologies as the winner vs. the others

Key Findings:

- PC technology, although mature, still offers opportunities for improved efficiency and thus reduced coal consumption and CO_2 emission per unit of electricity generated. Higher efficiency generation is important without CO_2 capture but also makes CO_2 capture less costly. An expanded program to develop and apply new materials for more severe steam cycle operation is warranted.
- PC emissions control technology has become very effective in reducing criteria emissions, but it continues to expand its capabilities. The limit of the technology has not yet been reached although increases in extent of required removal and addition of new requirements continue to increase the PC COE.
- IGCC is commercially demonstrated technology that is not yet mature in the power generation arena, although it is mature in the refinery arena. With coal its main challenges are gasifier availability and COE. It has the potential of a much smaller environmental footprint than PC technology and of markedly lower air emissions. In the near term, these advantages do not drive a change in generating technology.
- Current commercial IGCC technology is not well suited for lower rank coals, of which the U.S. has a large amount. To expand its potential scope to these coals, IGCC technology needs to undergo further targeted development.
- The technology systems required to capture CO_2 from coal-based power production are in the early stages of development. Of the three competing systems (PC with CO_2 recovery from flue gas, Oxy-fuel combustion with flue gas direct compression to liquefy CO_2, and IGCC with pre-combustion CO_2 capture) it is too early to choose winners because it is not possible to predict how technology development and commercial innovation may evolve. Further, one technology system may be well suited for bituminous coals, whereas another may apply best to low rank coals and lignite..

Citations and Notes

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3. Beer, J.M. *The Fluidized Combustion of Coal*. in *XVIth Symposium (Int'l) on Combustion*. 1976. MIT, Cambridge: The Combustion Institute, Pittsburgh.
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Table 1. Characteristics of different gasifier types

	Moving bed*	**Fluid bed****	**Entrained flow*****
Outlet temperature	Low (425-600 °C)	Moderate (900-1050 °C)	High (1250-1600 °C)
Oxygen demand	Low	Moderate	High
Ash conditions	Dry ash or slagging	Dry ash or agglomerating	Slagging
Size of coal feed	6-50 mm	6-10 mm	< 100 µm
Acceptability of fines	Limited	Good	Unlimited
Other characteristics	Methane, tars and oils present in syngas	Low carbon conversion	Pure syngas, high carbon conversion

* Lurgi is an example
** KBR transport reactor, BHEL, KRW are examples
*** GE, E-Gas, Shell are examples

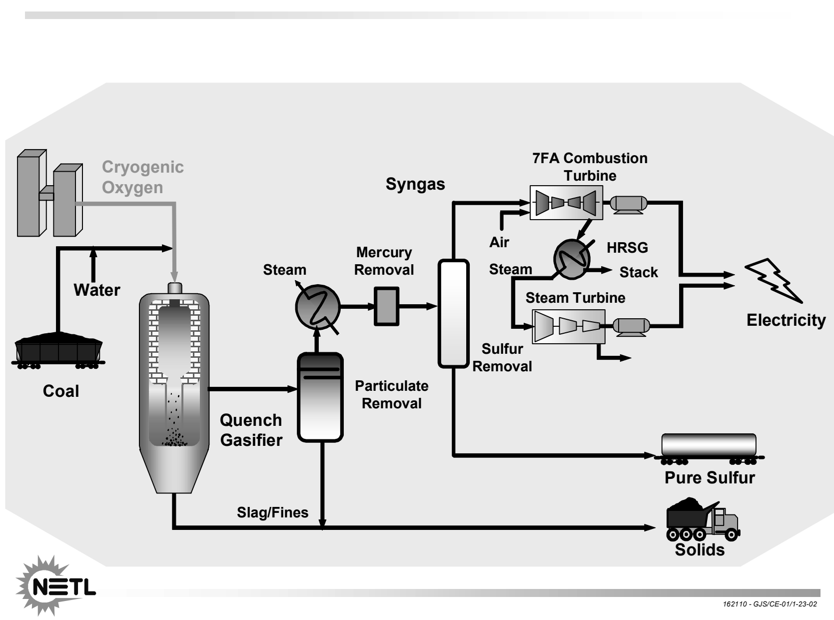

Figure 1. IGCC Plant with Entrained Flow (GE) Full Quench Gasifier

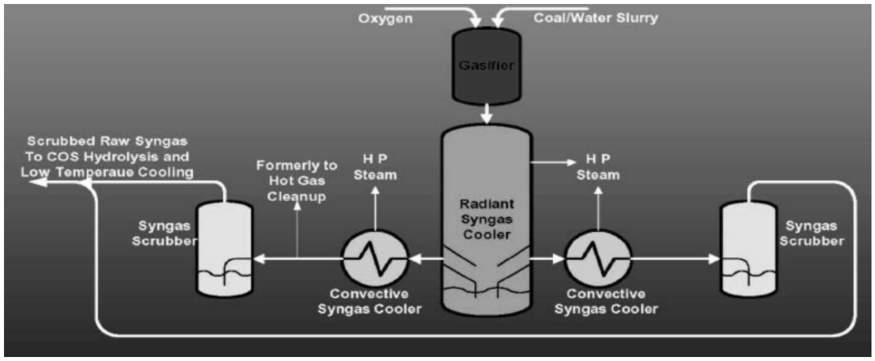

Figure 2. Heat Recovery Options for Entrained-Flow Gasifier

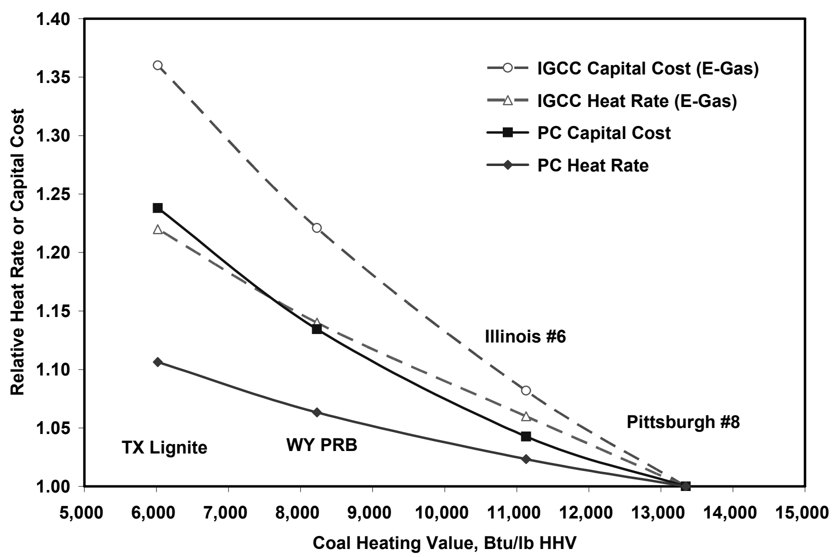

Figure 3 Effect of Coal Type (Rank) on Capital Cost and Heat Rate for PC and IGCC

MR. HALL. I thank you and I found it very interesting and have some questions for you about it. Mr. Cresci.

MR. CRESCI. Thank you, Mr. Chairman. Good afternoon to you and the members of the subcommittee. I am Joe Cresci, Chairman of the Environmental Power Corporation. Thank you for inviting us to be here today.

You have already heard a good deal today about the importance of renewable energy and the value of the various programs that support and encourage renewables. Therefore, I will focus today on our subsidiary, known as Microgy, which is a renewable energy source that most people know much less about than some of the others. Microgy develops biogas systems which are very efficient at extracting methane-rich biogas from a combination of livestock manure and other organic and food industry wastes. Inside Environmental Power, we refer to our biogas as RNG, renewable natural gas. Our RNG is used to produce green electric power, thermal energy, or it can be refined to pipeline grade methane.

To date, we have completed or announced projects in Wisconsin, California, Texas, and Nebraska. Microgy, along with our Danish licensor, have significantly improved conventional anaerobic digestion technology, thereby enabling us to generate RNG at volumes and cost, which are commercially attractive. Though the SEC rules in competitive considerations do not permit us to discuss a lot about cost and pricing matters, I can say that we believe our renewable natural gas can be delivered to the pipeline at competitive prices with those projected for imported LNG. At the same time, our technology and manure handling process have also significantly reduced greenhouse emissions, improved water quality, and dramatically reduced odors around animal operations. Take notice of the samples of the post-digestive material coming from one of our Wisconsin projects and I think you will be surprised by it.

Our newest and largest projects to date are in Texas and we will produce pipeline grade RNG. One is a 10,000 cow system in construction is at Huckabay Ridge in Stephenville and another soon to enter construction at the Mission Dairy in Hereford, Texas. These represent a major technology upgrade and a significant financial step forward for us, moving our systems from small local operations to systems capable of providing RNG at volumes equivalent to a good natural gas well. Ours, however, is a gas well that needs no depletion allowance as long as we have cows and other waste being generated. At the Mission Dairy project, there are 24,000 cows permitted for the site. In addition, there are tens of thousands of animals within a 10-mile radius of that site, including both dairy and feedlot cattle. Each 10,000 cows represents another potential well site, so to speak.

With regard to the scale of the market as a whole, we estimate that there are more than 150 Huckabay size projects, including more than 1,000 individual tanks which would produce in excess of 81 trillion cubic feet of renewable natural gas annually. If you add the meat processors, swine farmers, and others, we could add the equivalent of 400 to 500 natural gas wells that produce a renewable natural gas with no depletion.

Let me conclude with comments on ethanol in our technology. Ethanol and our system are complementary technologies, not competitors. One of our EPC digesters in Wisconsin is already partially fueled by by-products of the ethanol production process. This increases both the efficiency in the production of ethanol and reduces the ethanol production waste. EPC digesters, more importantly, can supply ethanol producers with RNG on site, thereby reducing reliance on conventional natural gas and on imports of LNG and in some situations, even the infrastructure needed for natural gas transport.

Natural gas now costs about $7 a million BTUs and it takes approximately 33,000 BTUs of natural gas to manufacture one gallon of ethanol, costing, at today's market, about 23 cents for every gallon of ethanol they make. By providing readily available RNG for ethanol producers, we can offer a crucial element that will facilitate expansion of ethanol production.

What are our challenges? The lack of commercial credit and limitations on our own capital financing capabilities mean that the development of our biogas technology will be significantly slowed if the public portion of the public/private partnership, such as Title XVII of the Energy Policy Act of 2005, is unavailable to bridge the gap. Further, our production of RNG is not included in any of the numerous incentive programs available to all other alternative energy producers.

As I wrap up, Mr. Chairman, let me say that this committee structured the loan guarantee program in Title XVII very well. Unfortunately, what we last heard was that the guidelines are still at OMB, and the Department of Energy has informed us that renewable natural gas from manure and food waste is currently not a high priority for them. We at EPC are advancing with the support of accommodative equity markets by picking the low hanging fruit in this business. Our RNG initiatives could move forward much more quickly with a private/public partnership, with participation at simple parity, and incentive programs that are available to other renewable energy producers. RNG development would benefit from a level playing field and from the implementation of Title XVII.

I thank this committee for their time and attention, and I would welcome you to visit facilities around the country, particularly in Texas, where this fall we plan to start delivering RNG to the pipeline. I would be pleased to take your questions. But first, I would request of this committee that we might submit minor revisions to our written testimony, which has already been filed. It was prepared on very short notice, and we have a few little things we would like to clean up, if you don't mind.

[The prepared statement of Joe Cresci follows:]

PREPARED STATEMENT OF JOE CRESCI, CHAIRMAN, ENVIRONMENTAL POWER CORPORATION

The focus of my comments is on one of our subsidiaries, Microgy, Inc., headquartered in Golden, Colorado. We have significantly improved conventional anaerobic digestion technology, enabling us to generate more methane-rich biogas than earlier technologies, thus making agricultural waste-to-energy projects more feasible. In our own company, we have begun to refer to our biogas as RNG---Renewable Natural Gas.

Though SEC regulations and competitive considerations do not permit me to discuss pricing issues, I am allowed to say that we believe our RNG can be competitively priced as compared to projected prices for imported LNG. At the same time, our technology and manure handling process also significantly reduces greenhouse emissions, improves water quality, and dramatically reduces odors around animal operations.

EPC's future has a place in the fuels world as well. There is potential for LNG production as a conventional fuel substitute. But perhaps one of the most important areas of potential expansion for EPC, and I know it is an important area for this committee, is that our EPC digesters can be fueled with the byproducts of ethanol production, increasing both efficiency in the production of ethanol and reducing the wastes.

Ethanol and anaerobic digestion are complementary technologies, not competitors. Ethanol is a liquid fuel source, appropriate for gasoline blending and targeted at the automotive market. Biogas, on the other hand, is more appropriate for onsite use in heating, electricity generation, and industrial processes, or as a source of RNG for delivery via conventional natural gas pipelines.

Our challenges? The lack of commercial credit and the limitations on our capital financing capability, means that the development of this biogas technology will be significantly slowed if the public portion of the public/private partnership is unavailable to "bridge the gap" until competitively priced commercial financing becomes available.

We continue to be hopeful that the Title XVII loan guarantees of the Energy Policy Act of 2006 would help expedite this exciting partnership with our livestock and food processing partners and with our future ethanol operators.

With some help with the "D" in "R&D" to more rapidly expand this efficient technology," we could move even more quickly through the first integration of our multi digester systems, which can be used for on-site, dependable systems for agricultural and ethanol operations, for sale of renewable gas into the existing pipeline system, and for future expansion to LNG applications.

Good Morning, Mr. Chairman. I am Joe Cresci, the Chairman of the Board of Environmental Power Corporation. EPC was founded in 1982. We are headquartered in Portsmouth, New Hampshire. Environmental Power has developed generating facilities powered by nonconventional fuels and renewable energy sources, including hydro-electric and waste coal-fired generation.

The focus of my comments this morning is our subsidiary, Microgy, Inc., headquartered in Golden, Colorado. Microgy develops biogas systems, which are very efficient at extracting methane-rich biogas from a combination of livestock manure and other organic and food industry wastes. Inside Environmental Power, we refer to our biogas as RNG – Renewable Natural Gas. Our RNG is used to produce "green" electric power, thermal energy, or refined to pipeline-grade methane. Microgy's biogas production system processes waste from livestock manure mixed with other organic wastes ranging from ethanol production by-products to multiple varieties of waste from the food industry. We have completed or announced anticipated installations for projects in Wisconsin, California, Texas, and Nebraska.

Microgy, along with our Danish licensor, has significantly improved conventional anaerobic digestion technology, enabling us to generate RNG at volumes and costs that is commercially attractive.

Although SEC regulations and competitive considerations do not permit me to discuss cost and pricing matters in detail, I can say that we believe our RNG will be competitively priced compared to projected prices for LNG imports. At the same time, our technology and manure handling processes also significantly reduce greenhouse emissions, improve water quality, and dramatically reduce odors around animal operations.

Microgy's system operates in the thermophilic temperature range, which provides faster, more complete digestion and accelerates composting, dramatically reducing BOD (biological oxygen demand) and virtually eliminating pathogens, while also providing more energy and a better by-product material. The residual product resulting from this process, of which I've brought a sample for you today, makes an animal bedding material, which is preferred by our customers because it doesn't carry the potential bacteria and pathogens of other products. As you'll note it looks a bit like peat moss, with only a slight earthy odor and a soft texture.

Our steel tanks, which resemble farm silos, and our piping are built to last, as are the high-tech monitoring and control systems. We build, own, and operate our energy systems so farmers can farm, while we produce continuous energy output, 24 hours a day, 7 days a week.

Why is Microgy's system so efficient? We have the exclusive, perpetual U.S. license to a European technology that has operated for over 15 years in small applications and is now being adapted by Microgy for the traditionally larger U.S. farms with a broader diversity of manure quality. We believe that, until now, there has been no commercial precedent to our systems in scale and efficiency. We can produce pipeline-quality RNG and other "mainstream" energy outputs that are marketable in conventional energy markets.

At the same time, our operations provide significant greenhouse gas reduction. Our digesters capture the methane which is a 21 times more powerful greenhouse gas than CO2, which would otherwise be given off by the breakdown of manure, equaling an approximately 95% reduction in net greenhouse emissions to the atmosphere. We believe that our large multi-digester projects could generate 30-60,000 tons of CO2 equivalent emission offsets annually.

Our systems provide a number of other environmental benefits. They substantially diminish odor from waste at animal feeding operations. Manure run-off on farms is currently one of the leading water pollution challenges. Our process accelerates the natural, existing composting rate. Since we handle the waste anyway, we can more easily direct it to organic fertilizer/compost markets or divert it for appropriate alternative disposal. Our high temperatures remove pathogens such as e'coli O157:H7 and our scrubbers remove toxic gases such as hydrogen sulfide.

Our initial projects, funded with EPC capital, have demonstrated the effectiveness of our technology, and the models are scaled to provide significant cost and productivity enhancements.

Our first U.S. installation, which established the commercial scale and viability of our process, is at the Five Star Dairy in Elk Mound, Wisconsin, and has been operational since June of 2005. That first anaerobic digester system is one 750,000 gallon tank processing waste from 900 milking cows. That is on the high side of a typical size dairy farm in the north-central part of the United States. That system produces approximately 775 KW of renewable energy, the equivalent of electricity for about 600 homes. The biogas produced by this installation is sold wholesale by Five Star to Dairyland Power Cooperative, which owns the generator.

The Five Star Dairy project produces about 4 to 5 times as much methane as conventional anaerobic digesters, such as the prevalent plug flow systems and the prevailing lagoon waste systems. Five Star sells biogas for Dairyland's use in renewable distributed electric generation, capturing an estimated 2,600 tons/year of greenhouse gases, and providing improved, no-cost bedding for dairy cows.

We are in the final permitting stages for a project at the Joseph Gallo Farms in Atwater, California. Two digester tanks for the manure from 3,000 milk cows are projected to generate 130 billion BTU's of energy per year, the equivalent of heating 2,200 homes. This closed-loop methane recovery from the farm itself is expected to replace 1.4 million gallons of purchased propane used in dairy and cheese-making processes. Construction of this project, too, is likely to be funded by EPC, because no credit is available, thus far. We estimate 8,000 tons of CO2 greenhouse emission offsets from the Gallo project.

Our next projects, in construction at Huckabay Ridge in Stephenville, Texas, and soon to enter construction at Mission Dairy in Hereford, Texas, represent a major technology upgrade and a major financial step out, moving our systems from small, local operations, to systems capable of providing the equivalent gas of a nice sized natural gas well. It is, however, a gas well which needs no depletion allowance, as long as we have cows and other wastes.

Huckabay Ridge at Stephenville has a plan for eight 916,000 gallon digester tanks for 10,000 milk cows. (The rule of thumb is one digester for roughly 1,000 cows.) In what we believe is a first for biogas, we will be constructing a scrubber plant (not a new technology, but a new use for integration in a biogas system) to provide pipeline quality gas that can be delivered to the nearby existing pipeline grid. A modest estimate is that we will be able to deliver 650,000 MCF of pipeline-grade gas annually, the equivalent needs for 11,000 homes or the equivalent of 12,700 gallons a day of heating oil. As previously stated, that is equivalent to a good size natural gas well. I might add there are a total of 30,000 cows near the Huckabay Ridge project.

At the Mission Dairy project recently announced in Hereford, Texas, there are 24,000 cows permitted for the site. However, there are tens of thousands of animals within a ten-mile radius of that site, including dairy and feedlot cows. Each 10,000 cows is another potential "well" site, so to speak.

We conservatively estimate that we will be able to deliver at Mission Dairy our first application of a modular design/construction program, where we perfect not only economies of scale, but the beginnings of a replicable modular system. The component producers can then produce "models," rather than "one-offs," and we can then replicate standardized core designs. The models would be envisioned to be available in modules of four tanks.

With regard to the scale of the market as a whole, we estimate there are more than 150 Huckabay Ridge-sized projects, including more than 1,000 individual tanks, which would result in 81 trillion BTU's a year, or 81 million MCF of RNG. Our modular technology would also allow the participation of smaller dairy farms, where they could be economically grouped via tank, pipes, or other transport systems to central digester sites.

Pigs are a valuable part of our process as well! Indeed, most of the systems based on our technology currently operating in Europe operate on swine farms. The potential swine market in the U.S. represents, at full utilization, potentially another 65 trillion BTU's a year of natural gas, or 65 million MCF of RNG.

EPC recently signed a letter of intent with Swift & Company, the world's second-largest processor of fresh beef and pork products, where we plan to use our technology to extract methane-rich biogas from the animal wastes, as well as meat processing wastes and certain wastewater plant residual streams that would otherwise be land filled or land applied. We will be cooperating with Swift to look at potential projects at seven other beef and pork production facilities throughout North America. We are excited about the opportunity to help Swift reduce costs and have a positive impact on the environment.

If you consider full utilization of wastes from the meat packing industry, which includes both their manure and numerous other by-products, you could potentially add another 5 trillion BTU's a year or 5 million MCF of RFG.

EPC's future has a place in the fuels world as well. There is potential for LNG production as a conventional fuel substitute. But perhaps one of the most important areas of potential expansion for EPC, and I know it is an important area for this committee, is that our EPC digesters are complementary with ethanol production, not in competition with it. Ethanol is a liquid fuel source, appropriate for gasoline blending and targeted at the automotive market. Biogas, on the other hand, is more appropriate for onsite use in heating, electricity generation and industrial processes, or as a source of RNG for delivery via conventional natural gas pipelines.

EPC digesters can supply ethanol producers with natural gas on-site, reducing reliance on imports of conventional natural gas, imports of LNG, and even the infrastructure needed for natural gas transport.

Natural gas, which you well know, is subject to wide fluctuations in price, and these fluctuations create uncertainty in industrial processes that rely on natural gas. This is no less true for the production of ethanol, as natural gas is a crucial element in the ethanol production process, and fluctuations in the price of natural gas are certainly hampering the implementation of ethanol production. Natural gas now costs $7 per mmBTU; it takes approximately 33,000 BTU's of natural gas to manufacture one gallon of ethanol, costing producers $0.23 for every gallon of ethanol they make. By providing readily available RNG for ethanol producers, EPC is offering a crucial ingredient that will facilitate the expansion of ethanol production.

Ethanol production uses corn as well as natural gas to create ethanol. The byproducts of this process, distillers grain and liquid stillage, can be used as source materials to be added to the manure for the digesters that supply the ethanol plant with RNG.

One of EPC's facilities in Wisconsin is currently co-digesting cow manure with liquid waste (stillage) from a nearby ethanol plant.

Further, if I may quote from RFA's own Ethanol Industry Outlook 2006, "Many estimate the supply of distiller's grains to reach 12-14 million metric tons by 2012 as the RFS (Renewable Fuels Standard) is fully implemented. Some believe this level of output will make it necessary to find new markets and uses for co-products." We believe that our systems can make productive use of these co-products to produce gas for the ethanol production process.

There is going to be a huge demand for a reliable, cost-effective, on-site source of renewable natural gas if the President's plan to increase ethanol production to 7.5 billion gallons by 2012 (from 4 billion gallons in 2006) is realized. To obtain an increase in production of 3.5 billion gallons of ethanol, these plants will need more natural gas. We estimate this need will essentially double the industry's demand for natural gas at the same time that domestic and world demand grows. Producing RNG on-site or proximate to ethanol plants will help abate their need for purchased natural gas and could help stabilize their pricing structure for at least the RNG portion of those energy needs.

EPC digesters use technology that has been proved successful in digesters throughout Europe and at EPC's first three projects in the United States. Unlike renewable energy methods that are exotic, but are yet to be fully tested, EPC has technology that is ready today. Our digesters already produce RNG from a diverse supply of farm and food wastes. Our technology is currently accommodating waste products from ethanol production. We believe that our evolving modular design for the digesters will enable rapid deployment at ethanol plants across the country. There are currently many ethanol plants under construction, and EPC has identified a market for 800 new digesters at these plants, bringing the total potential market for digesters to 5,600 nationwide.

Our challenges? The lack of commercial credit and the limitations on our capital financing capability, mean that the development of this biogas technology will be significantly slowed if the public portion of the public/private partnership, such as Title XVII of the Energy Policy Act of 2005 (EPACT), is unavailable to "bridge the gap." Further, our production of RNG is not included in the numerous incentive programs available to all other alternative energy producers.

I quote from EPACT, "New or significantly improved technologies" including "renewable energy systems" and "efficient end-use energy technologies" that "Avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases."

We are also looking at some of the existing Agriculture programs to expedite our work. . I must tell you, Mr. Chairman, this Committee structured the loan guarantee program in Title XVII very well. Unfortunately, when we last heard, the guidelines were still at OMB. Moreover, DOE has told us that RNG from manure and food wastes (biogas) is not currently a high priority.

Partial early guarantees, such as those this Committee did in Title XVII of EPACT, could help us "bridge the financing gap" for proving commercial viability! With some help with the "D" in "R&D" to more rapidly expand this efficient technology," we could move even more quickly through the first integration of our multi digester systems, which can be used for on-site, dependable systems for agricultural and ethanol operations, for sale of renewable gas into the existing pipeline system, and for future expansion to LNG applications.

We at EPC are advancing with the support of accommodative equity markets, by picking the low-hanging fruit. Our RNG initiatives could move forward more quickly with a private-public partnership and with participation at simple parity in incentive programs already available to all other renewable producers. RNG development would benefit from a level playing field and from implantation of Title XVII. It could enable us to extend the market place to smaller farms and more distant waste locations that may be more costly for us to serve at this time.

Environmental Power's path to commercial viability is the expanded large scale production capabilities of the technology. The construction and operation of initial projects to drive costs out of system will also provide those modularized templates for future projects. Commercial success of initial projects will demonstrate the wide range of applications; e.g. electricity, pipeline gas, inside the fence, ethanol production, LNG, and other thermal energy applications.

We are very excited about our role of providing our customers with dependable, predictable natural gas supplies, of helping establish more independence from imported natural gas supplies, of a growing potential synergy with ethanol production, and of providing sensible, affordable, environmental solutions. Our trademark: we are making **Energy That Is Beyond Renewable™**, and moving forward to generating renewable natural gas.

I thank the Committee for their time and attention, and I would welcome you to visit our facilities around the country, particularly in Texas, where this fall we plan to start delivering RNG to the pipeline.

I would be pleased to take your questions.

MR. HALL. Without objection that will be done, and for questions that we may have of the group, and because others who are in other committees, we will leave the record open for additional questions from members of the committee. And if you could, try to get those back to us in maybe 10 days or 2 weeks. Thank you. Go ahead now, Mr. Cresci. You have completed?

MR. CRESCI. I have completed. Thank you very much for the opportunity to present.

MR. HALL. Okay. Mr. Novak, you gave us a lot of good facts, figures, stories, techniques, and things like that. I think you heard Mr. Yoder. Were you here this morning when Mr. Yoder testified about the fact that their city, a little city, I don't know how big the city is in Alaska, is going to discuss plans to install a small nuclear unit for electricity generation to replace diesel generators. In your comparative cost, your estimate for nuclear remains the same even though many in the industry expect that their plants are going to be less expensive--the newer plants getting less expensive. What are the facts on that and why is that?

MR. NOVAK. Thank you, Mr. Chairman.

MR. HALL. And where do they get that?

MR. NOVAK. I don't know if this mic--yes, it does work. We were a little bit conservative on the improvements or the reductions in cost between 2010 and 2020, and there may be additional cost reductions for nuclear out in the future, but we assume that you are going to see a lot of standardization in the first-of-the-kind plants built due to the MP2020 program that is currently underway in DOE. Those plants will contain a lot of the standard designs, and you will get cost savings there. So we may not see additional cost savings in the 10-year period following.

MR. HALL. Can you describe what you would call some promising energy storage technologies for use with the renewable sources? You want to enlarge on that?

MR. NOVAK. Yes. Some battery systems show some promise, and I have got a few listed here that I could provide for the record; a nickel metal high drive, redox globe battery systems, and some emerging lithium ion technology. But also, there are existing energy storage technologies such as compressed air and pump storage that still make a lot more sense economically than some of the battery technologies. But again, those have their own challenges with where you would put pump storage in and those are some of the environmental considerations. I would be happy to provide more information.

MR. HALL. Okay, if you would. And Mr. Cresci, I think you are aware of an ongoing debate in Texas and Oklahoma where Superfund laws, namely CERCLA and EPGRA, are being applied to animal feeding operations and with litigation that is filed by the city of Waco against some surrounding ranches there and litigation in Oklahoma. What impact could this have on your industry and how would you be affected?

MR. CRESCI. Well, the Waco litigation, I believe, has been settled and in fact, does involve a number of the farms that are in the Erath County area, which is where the Huckabay Ridge project is located. To answer your question directly, if you were to treat hazardous waste treatment or handling as the handling of a hazardous waste, it would probably mean that all people in the process, at least as I understand the way the Superfund legislation was originally set up, would probably have to treat it in that manner, and I would think that it would drive the cost of handling waste to make any type of energy extraction from that material to be uneconomic.

I don't know of any inherently hazardous materials in animal waste and basically, we see waste, animal waste in particular, in this case as a resource, and extracting the value from it and having an economic value attached to it sufficient to allow it to be processed and handled properly, including if, in some instances, perhaps, removal from areas; in other instances, digested into compost which can be sold or moved into market places requiring fertilizers and other materials for growing in other areas. It seems to me that that more than adequately deals with the issues as I understand them in terms of over-nutrification.

MR. HALL. I know we have had an opportunity to discuss with you, your dairy cows around the county. What are the ways you can handle it? A constituent in my district, in particular, a guy named Bo Kilgren, was very interested in chicken waste. Would you enlarge on that?

MR. CRESCI. I will, indeed. Unfortunately, we can't handle chicken waste. It does not really process efficiently through anaerobic digestion. There are, I understand, some other technologies that are being talked about for chicken waste, but it certainly is a problem. We would like to have an answer to it because it seems to be a large problem. The waste that we can handle mostly are cattle waste; dairy cattle is, obviously, a very good source, but also feed cattle and also swine. Those are the ones that are most efficient for us to process.

MR. HALL. Okay. My time is up, but Mr. Boucher, when you are ready, if you have any questions.

MR. BOUCHER. Mr. Chairman, thank you very much. Mr. Novak, let me begin with you. You are making a prediction, if I read these numbers correctly, that by the year 2010 the cost of IGCC will be $47 per megawatt hour. The natural gas combined cycle cost will be $56 per megawatt hours, so IGCC will be cheaper at that point by a substantial margin than the natural gas combined cycle. My questions are this. What are the comparisons today between those prices and what assumptions are you making about the deployment of IGCC that gets to the cost of $47 per megawatt hour from whatever the number is today?

MR. NOVAK. Mr. Chairman, the numbers that I presented come from an analysis that we did for our summer seminar this past August, where we bring chief executives in and the topic was "Making Billion Dollar Decisions on New Generation Technology in a Carbon Constrained Future." So what we did was we looked at today's technology and tried to come up with estimates of the cost of electricity of today's technology that were it to be deployed would be on line in a 2010 time period. So those numbers on a cost of electricity basis are really today's technology. Pulverized coal is the lowest cost of electricity basis.

MR. BOUCHER. No, I understand. It is today's technology. I am not quarreling with that, but I mean, I am told that the more IGCC units that get deployed for electricity generation purposes, the lower the cost of the units becomes and so as you deploy more of these, you achieve a lower cost per megawatt hour than the current cost, so my questions to you are what today are the cost comparisons, if you know, between the natural gas combined cycle; it is going to be $56 in 2010, what is it today? And the IGCC, which will be $47 in 2010; what is that today? Do you know the answer to that?

MR. NOVAK. I do not.

MR. BOUCHER. Okay. Well, let me just go to the second part of it. In making your prediction that IGCC is going to get to $47, which is an attractive number. I mean, if it gets to that and it is cheaper than natural gas combined cycle, we can presume it is going to be widely used. How many units of IGCC have to be deployed between now and 2010 to get to this $47 number? What is your assumption?

MR. NOVAK. We think that $47 is the current number. If you build a 600 megawatt plant and have it on line in the 2010-2012 time period, over the lifetime of that plant it is $47 per megawatt hour, about 20 percent more than PC.

MR. BOUCHER. Dr. Katzer, you are expert in this. Do you agree with that?

MR. KATZER. Generally, yes. The difference between my numbers and the EPRI numbers are somewhat in the assumptions that we made in calculating the cost of electricity. I think we are using a little higher coal cost. I think you used $1 a million; we used $1.50, which is a little higher than it is on average today. I think those are the differences between our numbers, but our deltas, I think, are consistent. So basically, we don't have any differences. We try to look at what we call the Nth plant, where N is a small number, not well defined, but a small number: 5, 6. That gets you out in the range where you have gotten over making mistakes, and you ought to be able to do things, design and construction-wise efficiently.

MR. BOUCHER. Let me ask you this, Dr. Katzer. We included some incentives, tax credits in EPAct 2005 to encourage clean coal technology used by electric utilities. We had IGCC primarily in mind at the time that we applied those credits. I am told by electric utilities that they do make a difference in their planning and that many are looking very favorably now at IGCC based upon the availability of tax credits to help bring down the cost of deployment. In the process of preparing that legislation, we had some analysis that suggested, as you have in your testimony, that pulverized coal is more economic today than IGCC, but that that equation could change and that the more IGCC units were deployed, the more that technology is placed in the commercial market and refined and the more units that are produced, and just because of volume of production, the cost comes down.

The time would be reached after about 12 full scale units to find the 600 megawatts, at least, per unit. When you deploy 12 of these, the cost differential vanishes and you wind up with, essentially, an equal cost of IGCC and pulverized coal. Now, this is IGCC without the carbon capture component, which obviously adds another element of cost. Would you agree that that is essentially right and can you also make some kind of prediction about the point at which that number of units, whether it is 12 or some other number, that equalizes the cost of IGCC and pulverized coal is reached?

MR. KATZER. I would agree that directionally, that is how things happen. To be able to quantitatively predict how things would work out for Unit 6 out to Unit 12 or for Unit 2 to Unit 6 is really difficult. Directionally, that is the correct direction. The other piece of the equation, which is what I tried to address a little bit here, is increasing cost of emissions control on PC units. As these permit levels keep going down, the cost keeps coming up and that is narrowing the gap between IGCC and PC, so if you look out in the future a decade or so, which means you have built several plants and you have got a few more in the construction stage, you begin to see a point where they look like they are coming to parity in terms of cost of electricity generating, yes.

MR. BOUCHER. So the basic conclusion is that at some point a decade or so down the road, you do achieve parity in cost between the two?

MR. KATZER. I think that is quite likely, yes.

MR. BOUCHER. Okay. Let me ask this question. The EPA, as you know, has promulgated a new mercury regulation and it is a bit of a challenge for some electric utilities to comply with that; an element of cost is involved. Did you factor the cost of retrofitting pulverized coal with that or the cost of, if they are planning to use new pulverized coal, adding the mercury reduction technology into your calculations, because IGCC eliminates mercury, essentially. I think you said 99 plus percent.

MR. KATZER. Yes.

MR. BOUCHER. And so have you calculated that into your assumption that pulverized coal is a cheaper alternative than IGCC?

MR. KATZER. In the base unit cost, which is 4.8, you only capture the mercury that is captured in the process of flue gas desulphurization in a particular removal. Then we have looked down the road to increase the reduction of criteria pollutants and have added mercury removal in, and that was part of the .2 cents per kilowatt hour additional cost that I noted, so that is where we put it in. We did not factor it in as explicit technology application today because for about 10 years there will not be a requirement to explicitly remove additional mercury.

MR. BOUCHER. Okay. All right, Mr. Chairman, I appreciate your indulgence with this. Thank you very much.

MR. HALL. I thank you. I want to go back and ask Dr. Katzer about the coal. By the way, do you know John McCatta, that is an authority writer?

MR. KATZER. Yes, yes. Off-hand, at least.

MR. HALL. Okay.

MR. KATZER. I met him probably once.

MR. HALL. I heard him make a statement about 12 years ago at a speech in Dallas that there was enough coal in the mid-section of this country, if we could mine it, that would total the output of all OPEC nations combined. Could that be anywhere close to being an accurate statement?

MR. KATZER. Yes. There are a lot of assumptions in terms of exactly how you are talking about it, but the answer is in large measure, we are the Middle East of coal versus they, the Middle East of oil. It is a tremendous resource base we have, we are sitting on.

MR. HALL. On the technologies that you have capably laid out and described, are there any existing Federal or State rules that are hindering the deployment of the technologies that you set forth? And if so, it may be a hard question to answer right now, but could you give me some information in writing on that if it takes some research?

MR. KATZER. Mr. Chairman, I think I would need to do a little research on that. That piece of the equation is not one in which I have a lot of involvement.

MR. HALL. I thank you. And Dr. Murphy had questions that he wanted to ask, too, Dr. Hammond. Could you clarify the economic impact you believe cost competitive solar technology would have, and what the Government is doing to achieve this objective?

MR. HAMMOND. Yes, the economic impact of cost-competitive solar, if you look at the President's objective of having cost-competitive solar in 2015 and look at a reasonable build out of that solar technology, first of all, you might take a simple analysis and just look at the economic value of that solar energy at the total kilowatt hours that might be produced and multiply that by an average value for electricity. You would estimate an economic value of a few billion dollars for that electricity at that time, that that simplistic analysis ignores some critical aspects of solar technology that must be looked at and make solar a really attractive technology.

If you imagine the hot summer afternoons when you are clicking your air conditioning on full and likewise, our natural gas peaking plants are clicking on full, that is exactly coincident with the time when you get the maximum resource from deployed solar technology. And so the coincidence of that with the peak end load has tremendous additional benefit. It can relieve strain on the transmission and distribution infrastructure at precisely the time that it is maxed out. It would save valuable natural gas resources that are being deployed at that time. So the economic impact, while much more complicated to calculate, is multiples of just the value of the electric energy itself. And that doesn't even account for the fact that it is a zero emission, which brings substantial additional economic benefit.

What the Government is doing to achieve and capture these economic benefits, the most significant recent initiative, of course, is the Solar America Initiative. Under that guise through the Department of Energy, an additional $65 million has been allocated for Fiscal Year 2007 directly for solar technologies and that is an important program that we strongly encourage Congress to fully fund, but also to make sure that it gets deployed in a way that new revolutionary solar technologies have a chance to benefit from that, because it is those technologies that are going to really enable that cost competitive deployment.

At the State level, there are also additional important activities going on, including in our State of Pennsylvania, where the Governor and the Secretary of the Department of Environmental Protection have specifically allocated funds for new solar technology development to support Pennsylvania's aggressive solar renewable portfolio standard. So those are a glimpse at some of the activities that are going on from the Government's perspective to support it. Our key message would be that the opportunity is so significant; there is a significant opportunity for Congress to expand and accelerate that support to make sure that the United States plays a leadership role in deployment of solar technology.

MR. HALL. All right. I thank you for that. I have other questions I would like to ask of Mr. Linebarger. I am going to ask you and they are going to be in the record, and I will ask you to give us a written explanation. What do you think is the greatest significant opportunity for DG in the United States? You might answer that. I think you can do that in one sentence, can't you?

MR. LINEBARGER. I sure can, yes. The biggest significant opportunity, I think, is deploying, particularly, the energy efficient technologies related to combined heat and power and then protecting critical infrastructure would be the two things, I think.

MR. HALL. And he says the committee spends a lot of time thinking about energy security. Can you tell me what you mean when you say DE has a role in energy security?

MR. LINEBARGER. My idea there would be twofold; first, that we can use a wide range of renewable fuels, which would reduce our dependence on oil; and second, by ensuring that we have critical infrastructure ready, we protect ourselves against failures in the grid.

MR. HALL. All right, we have other questions. How can DE impact the price of electricity on the grid? I will ask you to answer that for the record. Do you have further questions?

MR. BOUCHER. No.

MR. HALL. And the reason we are asking to leave this open, where we can ask you, is the lack of availability of other members of the subcommittee that have questions they want asked. Those that are still here representing them have made notes of those, so we will be back in touch with you and I sure do thank you. You have been a good, patient panel. You have allowed us to leave to run over to the Capitol and vote. I think we voted three or four times over there. We have a committee meeting that is beginning at 1:30 that is a markup, so we have to go from here to that, but you have your job and you are a very busy man and you have been generous with your time, preparing yourself to even be solicited to give us information. We take what you say, the information you give us. We don't have to seek it from you and we write the legislation from it, or correct the legislation from it, so you are doing a real service to your country. I know Chairman Barton appreciates it, and the staff does, and we thank you very much and you are dismissed.

[Whereupon, at 1:37 p.m., the subcommittee was adjourned.]