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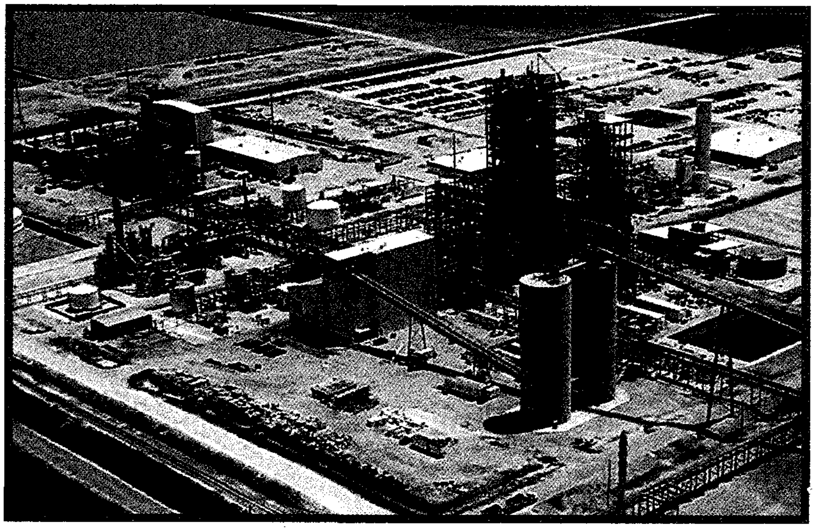
Fifth Annual Clean Coal Technology Conference

PROCEEDINGS

Powering the Next Millennium



Hyatt Regency Westshore
January 7-10, 1997, Tampa, Florida

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THE CENTER FOR ENERGY & ECONOMIC DEVELOPMENT

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Fifth Annual Clean Coal Technology Conference

Proceedings

January 7-10, 1997
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MASTER

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Powering the Next Millennium

The Fifth Annual Clean Coal Technology Conference will focus on presenting strategies and approaches that will enable clean coal technologies to resolve the competing, interrelated demands for power, economic viability, and environmental constraints associated with the use of coal in the post-2000 era. The program will address the dynamic changes that will result from utility competition and industry restructuring, and to the evolution of markets abroad. Current projections for electricity highlight the preferential role that electric power will have in accomplishing the long-range goals of most nations. Increased demands can be met by utilizing coal in technologies that achieve environmental goals while keeping the cost-per-unit of energy competitive. Results from projects in the DOE Clean Coal Technology Demonstration Program confirm that technology is the pathway to achieving these goals.

The industry/government partnership, cemented over the past 10 years, is focussed on moving the clean coal technologies into the domestic and international marketplaces. The Fifth Annual Clean Coal Technology Conference will provide a forum to discuss these benchmark issues and the essential role and need for these technologies in the post-2000 era.

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Opening Plenary Session

Powering the Next Millennium: Challenges in Meeting the Goal

Welcome Address

CLEAN COAL TECHNOLOGY CONFERENCE
WELCOME REMARKS/POLK PLANT

Chuck Black
Vice President, Energy Supply
Tampa, Florida

Good morning. On behalf of Tampa Electric and TECO Energy, I'd like to welcome all of you to Tampa.

We are proud and delighted that the U.S. Department of Energy has chosen our city for its Fifth Annual Clean Coal Technology Conference.

It's quite fitting that the theme of this conference is "Powering the Next Millennium" and that the Department of Energy chose Tampa as the site for this year's Clean Coal Technology Conference.

We are proud to have the DOE as our partner in our Polk Power Station as we move forward to put innovative technologies to work.

The Polk Power Station, which you'll have a chance to tour as part of this conference, is an example of the public and private sectors working together to provide for the long-term energy needs of our customers and to balance that with our need for a clean environment.

We thank the community and the Department of Energy for their partnership and support in this first-of-its-kind venture.

We especially want to thank Secretary of Energy Hazel O'Leary, not only for her Department's support but also for her participation in the Clean Coal Technology Conference. Here this week, we are all looking forward to her remarks.

I would like to tell you a little about your host utility, Tampa Electric Company, since you'll be seeing at least two of our facilities during this conference.

At Tampa Electric, we serve a sizable portion of the dynamic West Central Florida region, the largest metro market in Florida and second-largest in the Southeast.

Our retail service area encompasses Hillsborough County, plus portions of Pasco, Polk and Pinellas counties.

All together, we cover nearly 2,000 square miles, serving more than 450,000 residential Customers and more than 55,000 commercial and industrial Customers, for a total population of about one million.

We've been providing energy services to West Central Florida since 1899.

Today, as we look forward to celebrating 100 years of serving our community, we're a $3-billion company, with almost 3,000 employees.

I hope you enjoy your stay in Tampa and its many attractions.

As I mentioned, you'll have a chance to tour the new Polk Power Station, but we have another plant that also serves as an attraction in this area.

It's our largest generating facility, Big Bend Station, in South Hillsborough County.

The endangered West Indian manatee has made Big Bend's discharge canal its winter home for the past several years, and 10 years ago, we took steps to protect these gentle giants by creating a manatee sanctuary.

Since that time, nearly three-quarters of a million people from all 50 states and around the world have come to Tampa Electric's Big Bend Manatee Viewing Center to see these marine mammals up close.

I hope you have an opportunity to visit the Manatee Viewing Center while you're here for the conference – it's open daily to the public from 10 a.m. to 5 p.m. and there's no admission charge.

Of course, this conference is the main attraction while you're with us in Florida, and I know we can expect an excellent program over the next several days.

Thank you, and now, I'd like to introduce Jerry Anderson, the president and chief operating officer of TECO Energy, who is our keynote speaker for this morning.

--END--

Keynote Address

KEYNOTE ADDRESS
Vision and Challenge to Ensure that CCTs Contribute in the Next Millennium

Jerry Anderson
President and Chief Operating Officer
TECO Energy

5TH ANNUAL CLEAN COAL TECHNOLOGY CONFERENCE
TAMPA, FLORIDA
JANUARY 8, 1997

Thank you, Chuck, and good morning everyone.

On behalf of our sponsors, and your host utility, I'd like to welcome you all to Tampa and the Fifth Annual Clean Coal Technology Conference.

Tampa Electric is extremely proud to serve as host for this prestigious international conference on "clean-coal technologies that will power the next millennium."

The focus of this conference is the presentation of innovative strategies for the 21st Century that will meet the demands for electric power, economic viability and environmental awareness – all connected with the use of coal.

It promises to be an exciting and informative conference.

Now, let me tell you a little about your host city. Tampa is the business and financial hub of West Central Florida and one of the fastest-growing urban areas in the country.

The Tampa-St. Petersburg metro area is the largest in Florida, with more than two million people.

In fact, it's the second largest in the Southeast behind only Atlanta, and 19th in size in the country.

Many high-tech and high-quality companies agree this is a prime location for business, and have established substantial operations here.

Companies such as Time, Salomon Brothers, Citibank, Disney, Capital One and Beneficial.

There's also a business and construction boom going on in downtown Tampa, particularly along our waterfront.

Our Florida Aquarium celebrates its second anniversary next month, having drawn well over a million visitors since its opening in 1995.

A few blocks away, hockey fans and concert-goers are flocking to the Ice Palace, our new 21,000-seat downtown arena.

Another one of our community's major assets, particularly as a business resource, is the University of South Florida.

A major public university that's leading our state into the 21st Century, USF has also been on the cutting edge of research, innovation and developing new technologies.

Citing just one example, the university's College of Engineering has been actively engaged in the Nineties with Florida's key utilities, including Tampa Electric Company, in researching solar power and electric vehicles.

And, Tampa Electric has worked closely with USF in researching and demonstrating advanced electric technologies at our Electric Technology Resource Center, located on the university's main campus in Tampa.

I hope you have a chance while you're here to see some of the places I've mentioned and more of our beautiful Tampa Bay area, and why we're proud to call it home.

Tampa Electric Company has served the energy needs of this growing and dynamic Tampa Bay market since 1899.

Today, the utility has more than half-a-million customers and close to 3,000 employees.

Tampa Electric's parent company, TECO Energy, is also headquartered here in Tampa. It is one of Florida's largest utility holding companies.

TECO Energy's stock is publicly traded on the New York Stock Exchange and is owned by more than 33,000 shareholders.

Besides Tampa Electric, TECO Energy's family of energy-related companies are involved in water transportation, coal mining, natural gas production, home automation and energy management, engineering and energy services, and wholesale power generation. We have facilities and offices in several states, and in Central America.

Our family of diversified companies experienced rapid growth in 1996.

Last month, we acquired a Tampa-based engineering and energy services company, which provides a wide range of services to commercial customers throughout Florida and in California.

And, in November, TECO Energy agreed to merge with Lykes Energy, the Tampa-based parent of Peoples Gas System, Florida's largest natural gas distribution company.

We expect to complete the merger by the middle of this year. And when we do, we will add Peoples' 1,100 employees, 200,000-plus customers and $300-million in revenues to our diversified business base.

Now, to the subject of this conference, how clean-coal technologies will power the next millennium.

During the conference, you'll have the opportunity to see first-hand how Tampa Electric and the Department of Energy are meeting that 21st Century challenge at the Polk Power Station.

This 250-megawatt, power generating facility, located about 40 minutes east of Tampa in southwestern Polk County, demonstrates the value of public-private partnerships – like ours between the DOE and Tampa Electric.

We are extremely pleased and appreciative to have the DOE as partners in this project, and for bringing this fifth annual clean-coal conference to Tampa.

The DOE has played a key role in the success of the project by co-funding its innovative technology – providing $140 million through its Clean Coal Technology Program to demonstrate this first-of-its-kind technology application.

DOE's partnership and commitment is enabling us to apply these advanced power generation technologies commercially for the first time.

And, we look forward to hearing the DOE perspective on the Polk project and the future of clean-coal technologies from DOE Secretary Hazel O'Leary on Friday, when she helps us formally dedicate the Polk Power Station.

The Polk project also is the product of another successful public-private partnership that broke new ground in the selection of a site for this new power plant.

In fact, it's the first U.S. power plant ever located through community input.

Seven years ago, we gave the people in this community a real voice in where we would build our next power plant.

We relied upon the recommendations of a citizens power plant siting task force to determine the best location for this facility.

Meeting and working in the sunshine, an independent coalition of educators, business and community leaders and environmentalists evaluated 35 potential power plant sites in six West Central Florida counties. They did that over a year's time, before recommending three inland Polk County locations.

Tampa Electric followed the task force's recommendation even though the site that group selected did not meet traditional economic evaluations.

The site we selected DID, however, have the least impact on the environment and the surrounding community.

I expect it is also the lowest overall cost because of the relative ease and speed of its permitting process.

For this innovative work, the Siting Task Force and Tampa Electric garnered a number of environmental awards, including the 1991 Florida Audubon Society Corporate Award, the 1993 Timer Powers Conflict Resolution Award from the state of Florida and the 1993 Ecological Society of America corporate award.

We also received praise from government leaders, utility regulators and the news media for putting this critical choice in the hands of the public.

The Polk Power Station operating today is one of the cleanest, most efficient and economical coal-fired plants in the U.S.

The plant went on line this fall on schedule and on budget, just two years after tthe start of construction.

At Tampa Electric, we are very proud of having been able to bring this $500-million project into our utility rate base with NO increase in prices to our customers.

Last year, the Florida Public Service Commission approved an innovative proposal, which will freeze Tampa Electric's base rates through 1999.

And, the plant actually reduces the average cost of electricity because of its high thermal efficiency and use of low-cost coal.

For Tampa Electric, the Polk Power Station means a clean, economic and efficient source of power – 10-12 percent more efficient than conventional, coal-fired units, and the first unit on Tampa Electric's system to dispatch.

At the same time, we've taken several steps to protect, preserve, and in fact, enhance, the area's environment.

The Polk project was the first utility power plant ever built on old phosphate mining land.

We started our environmental efforts by reclaiming the property, planting some 200 acres of trees and creating 600 acres of lakes.

We've minimized the plant's impact on its immediate surroundings by establishing a protected 1,500-acre recreational preserve, which includes wetlands, uplands and five fishing lakes that will be managed by the Florida Game and Fresh Water Fish Commission.

This expansive natural habitat also provides space for nesting bird islands and osprey platforms.

So, at the Polk Power Station, we're balancing the need for a healthy, diverse environment, with the need for a reliable, efficient energy supply.

The plant's clean-coal technology meets the latter need by fully integrating two leading technologies: combined-cycle turbine, which is the most efficient commercially available method of producing electricity, and coal gasification, which converts coal into a clean-burning synthetic gas.

This project differs from other integrated-gasification, combined-cycle, or IGCC, plants, because it will be completely integrated – from coal gas production to turbine generator operation.

For example, Tampa Electric owns and operates the 150-ton-per-hour air separation unit.

Pure oxygen is required for the operation of the coal gasifier to produce the synthetic gas, which is burned in the combustion turbine.

The high-pressure nitrogen product from the unit is piped to the combustion turbine, generating additional electricity, lowering the combustion temperature and thereby reducing the formation of nitrogen oxides.

By integrating the plant, we'll enhance the high-efficiency of the facility's combined-cycle with the low cost of coal for its fuel.

This plant represents the most advanced electric technology from the power generation side. Now, I'd like to share with you how Tampa Electric is applying advanced electric technologies at the point of end use.

It's happening today at our utility's Electric Technology Resource Center.

The ETRC, located adjacent to the main entrance of the University of South Florida, is Florida's first full-service demonstration facility for electric technologies.

The ETRC is an interactive demonstration facility that allows Tampa Electric's business customers – restaurants, retailers, manufacturers – to come in and try out the newest technologies before they invest and change their methods of operation.

The ETRC features three demonstration areas: One for advanced electric technology, one for commercial foodservice and a lighting display center.

Since it opened just over a year ago, the ETRC has held over 1,000 seminars and events for manufacturers, vendors and business customers; welcomed more than 4,000 visitors; and partnered with more than 100 electric technology equipment makers.

There will be a tour of the ETRC for conference delegates this afternoon, and I hope you'll take the opportunity to visit this showplace for exciting new electric technologies.

Tampa Electric expects that these technologies will increase our customers' competitiveness, improve their productivity and strengthen our area's economy.

And, that's especially important for electric utilities as the industry changes into a more competitive marketplace.

All of us with an interest in coal as a source of energy, should also recognize that this changing political and business environment could affect utilities' use of coal in the 21st Century.

Certainly, any legislative or regulatory change in the way utilities do business has the potential for a major impact on the coal industry.

In the United States, coal will remain the major primary fuel source for the foreseeable future.

What is not clear is the share of new source electric generation that will be coal fired.

Part of this uncertainty is caused by changing environmental regulation.

These environmental concerns are successfully being addressed by the clean-coal program through projects such as our Polk IGCC plant.

However, global competitive pressures are forcing changes in the electric utility business. You will be hearing about those changes at this conference.

In general, I believe increased competition should result in greater utilization of existing coal-fired plants because of their low incremental cost.

The probable near-term effect on the coal industry is positive, with an increase in demand. It is more difficult to estimate the long-term effect.

Changes in the regulatory environment will make it more difficult for utilities to make large, long-term capital commitments.

This uncertainty about the future is the negative that faces the coal industry and the advancement of clean-coal technologies for the longer term.

The initial investment in a clean-coal gasification plant is three times the investment in a natural gas or light oil-fired plant.

Even though that higher initial cost is more than paid off over the life of the plant, it is still a difficult investment decision.

Let me quickly add that I believe we have found the successful formula here in Florida.

As you have heard, we serve a growing community that is environmentally aware.

We have no easy inexpensive sources of energy here, and we simply must provide affordable energy that makes our businesses competitive in a world market.

The coupling of our nation's abundant coal resources with the technology you will see here has allowed us to meet all of these challenges.

Yes, it took thought and care and planning. But with the help of many of you and with the support of the Department of Energy, we have achieved our goal:

- A new source of electric energy, competitively priced – clean, reliable and ready to fuel our future growth.

I know you will benefit from the insights you gain at this conference.

I hope you like what you see here in Florida, and that you enjoy your stay in Tampa.

– END –

Plenary Session:
Introduction of the Session

INTERNATIONAL MARKETS FOR CCTs

Mr. John P. Ferriter, Deputy Executive Director
International Energy Agency
Paris, France

INTRODUCTION

The Role of the IEA

Let me start with a few remarks about the International Energy Agency.

The IEA was created in 1974, in response to the first oil shock to ensure its Members' collective energy security. At that time, the essence of energy security was seen as an uninterrupted oil supply.

Attention focused on developing emergency preparedness measures to respond to a major disruption in the international flow of crude oil, and on promoting long-term cooperation and research and development activities among Members to reduce their dependence on imported oil.

While these activities continue today as fundamental elements of the Agency's work, events of the last several years, in particular the end of the Cold War, have dramatically altered the world political and economic scene, and thus changed the basic environment in which world energy markets function:

- The economic restructuring under way in former communist countries, coupled with the expected continuation of strong incremental energy demand in non-OECD Asia and elsewhere in the developing world, will have significant effects upon both the supply and demand sides of international energy markets - these are now becoming truly "global".

- The resulting world energy balance is shifting, with the OECD now accounting for only half of global energy consumption.

- Energy markets generally have evolved, with deregulation and liberalisation resulting in their being driven more by market forces than through government intervention, although government involvement is clearly still required in certain instances.

- Environmental effects associated with the energy sector, from production through to consumption, have become increasingly vexing and compel innovative approaches to energy policy.

Importance of Coal

The response by energy policy makers to these challenges must draw on coal for a major contribution.

- Coal is one of the world's most important and abundant fossil fuels; its share of many countries' energy mix and the wide distribution of reserves around the world enhance diversity, and thus increase energy security.

- There is major scope for improving the efficiency with which coal is used and for mitigating the pollution and other emissions that its production and use can cause.

- Coal is low-cost compared with oil or gas, perhaps between a quarter and one-half the price for the same primary energy content. Many countries have economically viable domestic resources of coal to support economic development.

What is the IEA doing in the area of Clean Coal Technology?

The IEA Secretariat conducts a wide range of policy research, at the direction of its Members, on energy technology, energy-environment, and energy diversification issues. Much of this is concerned with advising governments on the market conditions required for optimising decisions on economic and energy-environment issues.

Important work of relevance to clean coal technology is also conducted by groups of our Member Countries, which come together to carry out work in areas of particular interest to them. These are known as Implementing Agreements. The oldest of these, IEA Coal Research - The Clean Coal Centre, publishes a wide range of studies, from basic coal science through exploration and production, to coal beneficiation, transport and use. The environmental dimension of each part of the coal chain is ever more important in the decision making process, and is therefore increasingly represented in IEA Coal Research publications.

Other Implementing Agreements on coal include:

- The Coal Combustion Sciences Agreement which is concerned with the basic science of coal combustion, including the development and application of analytical techniques for the analysis of coal combustion processes.

- The Fossil Fuel Multiphase-Flow Sciences Agreement, which coordinates the exchange of information and complementary research tasks in a wide range of research programmes to improve understanding of the behaviour and properties of multiphase phenonema associated with obtaining energy from coal, oil and gas.

- The Fluidised Bed Conversion Programme, which is sharing information about, and collaboratively researching, the physical and chemical processes which occur during fluidised bed conversion, in atmospheric and pressurised fluidised combustion beds, both bubbling and circulating.

Some recent highlights of our work show the approach we are taking in support of the clean coal technologies.

In early December, I led an IEA team at a conference on energy efficiency in Beijing, which we organised with the State Planning Commission. A major part of the conference was devoted to coal development, and coal utilisation in China. Papers presented by the IEA side sought to promote the clean and efficient production and use of coal.

Similarly, in October last year, we organised a joint workshop with the World Bank on the financing of clean coal technologies. The seminar brought together policy makers, financial institutions, equipment manufacturers, and research organisations.

In 1995, the US Department of Energy and other bodies sponsored an IEA Conference on *The Strategic Value of Fossil Fuels: Challenges and Responses*.

We will shortly publish a major study on electricity in Asia, the *Asian Electricity Study*, which examines the electricity sectors in Indonesia, the Philippines, and Thailand. A chapter of the report is devoted to issues of power plant finance.

We have also published a number of reports covering coal issues generally. These include a report on the *Energy Policies of the Russian Federation* (1995), the *Energy Policies of South Africa* (1996), both with coal chapters. Each year we publish *Coal Information*, a major compilation of coal statistics with extensive commentary on coal production, demand and trade. The Coal Information series also provides current information on coal-fired power stations under construction and in planning throughout the world, including those using advanced power generation technology.

As a final example from many activities related to your conference, we have formal recognition at the on-going negotiations on climate change. We are at present developing advice for consideration at the Conference of the Parties (known as COP-3) to be held at the end of this year, and which could have a major bearing on the future of coal.

Role of the IEA Coal Industry Advisory Board

The IEA has a specialist industry source of advice on coal - the Coal Industry Advisory Board. The CIAB currently has 45 Members, representing coal industry interests from 16 countries. Members are corporate leaders from coal production, transport and utilisation companies.

Membership is not limited to OECD Member Countries. In 1995, the CIAB gained two new Members from South Africa, from Eskom and Ingwe. This year I hope we might make progress in gaining Members from China, the world's largest producer of coal and a key player in international coal trade.

The CIAB is vitally concerned with promoting the use of clean coal technologies. The Board has produced a series of three reports published by the IEA* on clean coal technologies, examining industry attitudes to the take-up of both gasification/combined cycle, and advanced steam cycle technologies.

The CIAB studies confirm that there is a wide range of state-of-the-art coal-fired technologies suitable for different conditions in both developed and developing countries. These range from large scale supercritical steam-cycle power generation, through smaller scale fluidised bed plants for power generation and industrial heat, to IGCC technology which is under demonstration for very clean power generation.

Progress in installing such technologies is still slower than had been hoped and expected. Nevertheless, supercritical steam cycle plants are successfully established in Japan, Germany, and Denmark, and there is no shortage of industrial scale and demonstration plants for many of the other technologies.

The CIAB has been studying reasons for this slower progress and is now examining what may be done to accelerate the adoption of advanced coal-fired technology in different regions. The IEA expects to publish a new report from the CIAB, looking at the regional factors influencing the take-up of clean coal technologies, during 1997.

Context for discussing Clean Coal Technologies

The IEA's *World Energy Outlook* (1996) shows the secure future for coal.

We take two cases, which we call the Capacity Constraints case and the Energy Savings case. In the Capacity Constraints case trends in past behaviour are assumed to continue to dominate future energy consumption patterns. In the energy savings case energy consumers choose to use available energy efficient technology to an extent greater than has been seen in the past.

Three major conclusions can be drawn from the projections:

- First, world primary energy demand is expected to continue to grown steadily, as it has grown over the last two decades.

- Second, fossil based fuels will account for almost 90% of total primary energy demand in 2010.

- Third, a structural shift in the shares of different regions in world energy demand is likely to occur - the OECD share of world energy demand will fall in favour of the rest of the world, where the share of world primary energy demand is expected to rise from 28% now, to almost 40% in 2010.

In general terms, the outlook for coal in the world energy scene is for strong competition with gas, weakening demand for some coal uses, but continuing demand for baseload power generation.

Demand for solid fuels - principally coal - is expected to rise steadily in the outlook period to 2010 (at an average annual rate of 1.7% - 2.2%). Overall, the share of solid fuels in the primary fuel mix is likely to remain stable, but there will be significant changes in the pattern of world solid fuels consumption:

- Countries such as China and India, are very coal intensive. Growth in coal demand in the non-OECD countries could be as high as 3.8% per annum, and use in power generation could be as high as 6% per annum.

- In the OECD countries, coal is expected to be increasingly a fuel for power generation. In 1993, the OECD was the largest fuel consuming region. By 2010, however, the OECD could account for only just over one-third of world solid fuel consumption. The Rest of the World could consume more than on-half of world solid fuel.

The messages from our projections for your conference are:

- Coal has, and will retain, a central role in meeting the world's future energy needs.

- The growth area of coal use is in power generation.

- In OECD countries, coal's share in the electricity output mix will be maintained, but coal demand for other uses will fall.

- In the Rest of the World, coal will lose share in final energy consumption, but use in power generation will grow at over 6 percent per annum. The region where attention needs to be focused is Asia.

Technology Choices

Which Coal Technologies will be Chosen?

These messages are good news for coal producers, and seemingly so for coal technology developers and manufacturers. I mentioned earlier that the CIAB has expressed concern about the slower-than-expected take-up of the clean coal technologies. Let me review the evidence for this.

In the OECD countries, tighter emission standards are encouraging interest in clean coal technologies. But there is little prospect for growth in coal use in these countries taken as a whole.

Where growth prospects are greatest, in the Asia-Pacific region, Independent Power Producers are the key to power generation investment in the Asian region. The choices they make on technology will be decisive in determining if clean coal technologies are used.

The CIAB has conducted a survey of Independent Power Producers (IPPs) in several regions, as part of the regional study I mentioned earlier. Sixteen companies involved in independent power generating project development and/or construction were surveyed. Several of the surveyed companies also represented technology supply or engineering/construction firms.

The survey found that at present, IPPs will choose mainly sub-critical pulverised-coal technology (that is, conventional coal-fired power generation technology), and in some cases Atmospheric Fluidised Bed (AFBC) technology. This technology can be clean and economic. Sulphur dioxide, NOx and particulates can be reduced to acceptable levels, and provide low-cost electricity. At present, environmental standards, especially in developing economies, do not require environmental performance beyond the range of conventional plant with add-on pollution control.

Local and regional environmental problems from sulphur dioxide, NOx and particulates can be addressed by available technology, and there is a generally accepted policy framework for governments to adopt to ensure that emissions are controlled in an economically efficient manner.

As an aside, Flue Gas Desulphurisation at the power station would generally be regarded as the technology of choice for reducing sulphur dioxide emissions. This is not always the case. In China, for example, coal use is 70% in direct applications, and only 30% in power generation. During the IEA's recent conference on energy efficiency in China, which I mentioned earlier, coal preparation was described as the highest priority in clean coal technology for China because it would reduce emissions from direct use of coal.

However, on a global level, CO_2 emissions from power generation are becoming increasingly the focus of attention for energy policy makers. The higher levels of conversion efficiency which can be achieved by advanced steam cycle and gasification/combined cycle technologies, are desirable on global environmental grounds.

When asked what their expectations were for 2005, the IPPs responded that they would expect more supercritical steam cycle plants, and Pressurised Fluidised Bed Combustion (PFBC) in specialist uses, but Integrated Gasification Combined Cycle (IGCC) technology would not be in widespread use for coal before 2010.

The factors influencing these views were given as:

- Reliability, technology cost and financing constraints are the most important factors influencing the choice of technology.

- Government regulation, maintainability, technology risk and lender attitudes came a close second.

- Environment was not seen as a major determining factor. But environmental considerations would be important if contained in the category of government regulation, listed as important.

- Need for skilled operators came low on the list of factors, as IPPs felt it is not difficult to find and train them.

What are the problem areas?

The survey revealed that the advanced steam cycle technologies are considered to be commercially proven, but to be more costly and riskier, especially when built in non-OECD countries.

There are more than 350 supercritical units operating world-wide. Their early technical problems have been overcome and improvements incorporated in areas such as metallurgy, equipment design and water treatment. The reliability of these plants is now considered as good as for sub-critical plants. Nonetheless, the IPPs surveyed were cautious in selecting this form of clean coal technology.

IGCC was considered to be too costly to compete without some form of support.

Accelerating the Take-up of Clean Coal Technologies

What can be done?

In looking at what might be done to accelerate the use of the advanced clean coal power generation technologies, three points are clear:

- The regions where rapid growth in coal-fired power generation is occurring, are viewed by developers as having a different investment environment from the OECD countries. In short, there are more risks involved and, possibly, conventional risks are higher.

- Policies to encourage the take-up of advanced clean coal technologies need to be narrowly targeted, since the problems are different for the different parts of the world and for different technologies. Policies may need to be designed to suit particular regions and particular technologies.

- Governments should not be left to cope with the task. It is in the long-term interests of the coal industry to be actively involved.

General Prescription

There is a general prescription for encouraging the take-up of clean coal technologies in power generation:

- Electricity costs from plants *with* pollution control cannot be expected to drop dramatically, or drop below those *without* pollution control, unless completely new technologies are developed. These may be possible, but they are not on the horizon today.

- Consequently, clean coal technologies will be chosen when environmental regulations require them.

- Environmental regulations will be applied when environmental costs to society are recognised.

IEA Coal Research published a report in 1995, *Air Pollution Control Costs for Coal-fired Power Stations*, which quantified the cost of air pollution control costs for coal-fired power stations. They found that for new installations, the costs of sulphur dioxide and NOx control account for about 15% to 20% of the cost of electricity, depending on emission limits, the technology chosen and other technical and economic factors. Particulate control adds 3% to 4% to the cost of electricity.

It is unavoidable that as more stringent emissions controls are imposed, the cost of electricity also rises. For currently available technologies, the price rises steeply as different technologies are used to attain the next higher level of performance.

We know from the experience with control of sulphur dioxide, NOx, and particulates, that once Governments decide on minimum standards of performance, the market will choose the most cost-effective way of meeting the standards. It is important to a cost-effective outcome that Governments do not attempt to impose the particular type of technology which should be used.

At the moment, there is no generally agreed standard which might encourage higher levels of conversion efficiency in plants. Economics determines the level of efficiency considered appropriate in a particular circumstance. As I have already commented, at present power developers in the high growth Asian economies are satisfied with the level of performance that can be attained by conventional sub-critical plant. They can meet all environmental requirements with this type of technology, with add-on pollution control such as Flue Gas Desulphurisation, if necessary.

In the absence of private economic incentive to use clean coal technology, then more advanced technologies will not be chosen until Governments choose to place a higher value on environmental performance, including carbon dioxide. Of course, developers might then turn away from coal if competing fuels, particularly gas, are more economic under a stricter environmental regime.

In the past, Governments have seen their role as supporting the take-up of new technologies in many fields, through direct financial support such as support for research and development, demonstration plants, and capital subsidies. There can be little doubt that programmes along these lines have advanced the technology and economics of clean coal power generation.

But enthusiasm for such measures is waning, under pressure of budget constraints.

Where clean coal technologies are commercially competitive, the situation is fairly straight forward. Governments have a role to develop sound environmental regulations, and to strive for undistorted energy markets where fuel prices reflect costs, including environmental costs.

For the technologies which are close to commercial or not yet generally accepted as proven, the situation is more complex, possibly calling for a range of policy measures.

Generally speaking, measures usually discussed all involve a degree of market intervention. We should be certain we understand the market before interventionist measures are implemented. At least three areas of the market need to be looked at:

- Is there genuine competition between electricity producers? Producers should be obliged by market conditions or regulation to look at the relative economics of the different technologies, and not be guided, say, to give preference to one form of technology over another because it is manufactured in the same country.

- Similarly, is there genuine competition between technology suppliers?

- Have external costs of power generation been taken into account?

Once we have a sound understanding of these points, we can look at measures governments might take to promote clean coal technologies.

A variety of measures have been proposed to complement the more traditional direct financial assistance measures. In listing these measures, I am not suggesting that the IEA necessarily gives its endorsement. Measures which have been proposed include, for example,

- Promotional measures to break down perception barriers concerning the use of coal, and to disseminate information on available, commercially proven, advanced clean coal technologies.

- Certainly, coal has a poor image and countries with major national interests in coal production have a particular responsibility here.

- The CIAB takes the view that there is insufficient understanding of the current reliability and economics of supercritical power generation technology, and has sought to address this by undertaking an analysis (still underway) of costs and other issues relevant in comparing sub-critical, supercritical and ultra-supercritical pulverised coal plants in non-OECD countries.

- Sharing the risk: This might take the form of Governments providing assurances against reduce technology risks. These measures would not be designed to direct a developer to a particular technology, but rather to ensure the developer's choice was not prejudiced.

- Developing "innovative" financing packages for new developments. This suggestion is based on the assumption that the risk-averse nature of lenders will influence technology choices.

- Activities Implemented Jointly (AIJ). AIJ has been proposed as a means by which countries might achieve reductions in global emissions of carbon dioxide, by projects and activities conducted outside their borders. The result could be a greater reduction in emissions, at lower cost, than the country might achieve within its own borders.

- In a comparison made by the CIAB, based on hypothetical 600 MW pulverised coal plants, the annual mass of carbon dioxide emissions for conventional, supercritical and ultra-supercritical plants are 5.2 million short tons, 4.8 million short tons, and 4.4 million short tons, respectively.

- This represents a reduction in emissions of 8% for supercritical, and 15% for ultra-supercritical plants, compared with conventional plant. There is scope for huge reductions in carbon dioxide emissions from Asia, through the use of these technologies.

These proposals are generally at the conceptual stage, and your conference would be making a major contribution if it could develop some ideas, either to further develop those I have listed, or as additional suggestions for promoting clean coal technologies.

The measures I have described should not necessarily replace all the more direct forms of encouragement I mentioned. Research and development, promotion of technology development and deployment, and technology cooperation are all proper roles for government in relation to coal technology. The decline in expenditure in these areas is to be regretted.

Nonetheless, industry has an important role in ensuring the future of coal. The coal industry needs to look to its own long-term interest, and companies along the length of the coal chain - from production to utilisation - should see that their interests are bound up in the future of the clean coal technologies.

At the end of this year, at the third Conference of the Parties on climate change, to be held in Japan, there is a very real prospect that legally binding targets on Greenhouse Gas emissions will be agreed. Such a proposal was put forward by the US Government at the second conference, held last year. If this is the outcome, then clean coal technologies will play a vital role in helping coal-fired power generation meet the new standards expected, in those countries which are party to any agreement emerging.

It would be short-sighted to think that any agreement at COP-3 would not eventually impact on those countries not immediately involved in the climate negotiations. It would also be short-sighted to imagine that failure to agree at COP-3 will signal an end to the debate on energy-climate issues.

Today we might usefully focus on how the clean coal technologies can provide a constructive, and economic, response to maintain coal's prominent position in the world energy scene.

Thank you.

* *Industry Attitudes to Combined Cycle Clean Coal Technologies* **(IEA OECD, 1994)**
Industry Attitudes to Steam Cycle Clean Coal Technologies **(IEA OECD, 1995)**
Factors Affecting the Take-Up of Clean Coal Technologies **(IEA OECD, 1996)**

Draft Outline of Clean Coal Conference Remarks
by
Kenneth Gordon

Senior Vice President, National Economic Research Associates

Tampa, Florida
January 8, 1997

Title: The Role of Clean Coal Technologies in the Evolving Domestic Electricity Market

I. Introduction

-substantial changes taking place in the electricity industry: worldwide phenomenon

-FERC and the state commissions, especially in a few states, driving the change

-fundamental changes are taking place, go beyond simple policy preferences
-technological change, especially as it affects optimal generation scale
-lowered transaction costs, ability to organize more "complex" markets
-experience in other industries, electric experience abroad as an indicator
-ability of markets to handle formerly vertically integrated arrangements
- "what is the firm" is a changing concept: not unlike other industries

II. What Will the Future Electric Industry Look Like?

-Early regulatory determinations of structure:
-the separation of retailing functions and generation activities from transportation
-transportation = transmission and distribution; continuing regulation via PBR

-Other aspects of structural evolution less clear: the inherent uncertainty of markets

-The point of relying on markets is that we don't know the best outcomes in advance

-Forecasts today of five or ten years in the future are almost certainly off the mark

-with that caveat/disclaimer, turn to what is happeing and may unfold

III. The Industry as it has been Until Recently

- vertical integration, franchise monopoly or the equivalent: this is ending

- thoroughgoing regulation at state and federal levels; monopoly the norm: ending also

- (exception- has been movement toward a competitive wholesale market)

- Traditional regulation (briefly), resource planning, impact of environmental constraints
    - application of specific technologies (include. clean coal) in this framework

- The rise of integrated resource planning (IRP); state and federal policy
    - evaluation of successes and failures
    - regulatory freedom to pursue specific goals: a "benefit" of monopoly
    - the pursuit of economic rents; rent capture for the policymaker
    - Ability to set prices and price structures administratively; w/o reference to cost
    - Extended ability to apply specific technologies in an IRP setting
        - clean coal

- The Critical Shift:

- The substitutution of markets for central planning; inconsistency with traditional practice

- Reduced control by firms and regulators. Shift of power to customers

IV. The critical factors: price, and cost

- link to wholesale
- excess capacity
- alternatives for large customers
- the economic development imperative
- environmental concerns, an uncertain factor

V. The movement to allow customer choice in the states
- California
- the northeast; esp. Massachusetts, R.I. and N.H.
- others such as Texas, Wisc.
- only a few states not at least studying the problem

VI. The federal government
-EPAct
-FERC
    Order 888, 889
- Congress ??
- the end of PURPA and PUHCA? rationales and inconsistency with competition
- antitrust issues ??

VII. Elements of the process , rationales , implications and new requirements

THE END GAME

1. Choice; for all customers

-not simply cost shifting or passing the buck

2. All customers share benefits
   - idealized goal, or realizable end point?
   - link to today's rate structure: an opportunity or a limitation?
   - market driven, cost driven prices and price structures

3. Preparing for the future: more cost based rate structures today
   - must also allow flexibility and opportunities for rebundling services (competitively)
   - must allow for subsequent repricing of bundled services (competitively)

4. Functional separation of electric companies into generation, transmission & distribution
   - monopoly sector: regulate
   - competitive sector: rely on competition and perhaps traditional anti-trust

5. Independent System Operator
   - broad responsibility for regional transmission reliability
   - independent (?) from electric companies (traditional?, future?)
   - equal access and non-discriminatory terms and conditions for all users

6. Short term pool or power exchange
   - a basis for markets to develop around
   - link to or identical to the ISO??
   - why should there be two entities at this level?
   - issue: allowing markets to evolve their own institutional structures

7. Universal Service
   - low income, etc., issues

8. Environmental
   - traditional regulatory involvement (PUCs) versus independent environmental regulation

   - the end of IRP? Essential distinctions

9. Full competition in generation and retail marketing

10. PBR and price cap regulation: The end of rate of return

THE TRANSITION PROCESS

11. Stranded costs and policies
    - historic and sunk costs
    - utility, IPP "uneconomic" costs
    - future "uneconomic" costs

12. New foundations for old policies
- separation of electricity policy goals from other goals: a new coordination
- environmental goals
- social and low income goals
- tie to clean coal and similar technology- specific goals
- explicit mechanisms and goals

VIII. Conclusion

- breaking free from traditional thinking
- redefining approaches to our goals
- remebering: it is the ultimate, not the instrumental goals that really count

Environmental Issues Affecting Clean Coal Technology Deployment

Michael J. Miller
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I. INTRODUCTION

I appreciate the opportunity to "set the stage" at this important conference on the topic of environmental issues affecting deployment of Clean Coal Technologies (CCTs). As you all know, environment was the driving force behind the DOE CCT program. At the time the program was initiated, the primary environmental issue for which CCTs were being demonstrated was acid rain compliance. Since then, the environmental drivers in the US affecting electric generation have become even more complex, competition/restructuring/deregulation/re-regulation (whatever nomenclature you want to use) has also been added to the mix, and natural gas availability (and its competitive price) has had a major effect on coal markets. On the international front, the role of environment is somewhat different in its impact on the selection of power generation technologies. This difference is particularly noticeable in the developing economies where coal is increasingly the fuel of choice.

In this overview presentation today, I will outline what I consider to be the key environmental issues affecting CCT deployment both in the US and internationally. Since the international issues are difficult to characterize given different environmental drivers in various countries and regions, the primary focus of my remarks will be on US deployment. However, I will attempt to make some general remarks, particularly regarding the environmental issues in developing vs. developed countries and how these issues may affect CCT deployment.

Further, how environment affects deployment depends on which particular type of clean coal technology one is addressing. I do not intend to mention many specific technologies other than to use them for the purposes of example. I will generally categorize CCTs into 4 groups since environment is likely to affect deployment for each category somewhat differently. These four categories are:

- Precombustion technologies such as coal cleaning
- Combustion technologies such as low NOx burners
- Postcombustion technologies such as FGD systems and postcombustion NOx control
- New generation technologies such as gasification and fluidized bed combustion

II. KEY ENVIRONMENTAL ISSUES

I will mention 8 environmental issues that I feel will, over the next 5 to 10 years affect deployment of Clean Coal Technologies. Not all are as important as the others in terms of their affect on CCT deployment; therefore, I will focus my attention primarily on issues related to air emissions and mention only in passing issues related to waste (by-products is the term I will use) and water.

1. NOx and SO_2 Controls

Let me start with NOx and SO_2 controls. There are 3 regulatory initiatives affecting NOx and SO_2 reductions from electric utility boilers (and other large combustion sources as well) in the US. These include the ambient standards for ozone, ambient standards for fine particulates and the acid rain provisions of the 1990 Clean Air Act Amendments.

Acid Rain

The passage of the 1990 Clean Air Act Amendments focused heavily on reductions of SO_2 and NOx to reduce the precursors of acid rain (Title IV). The USEPA is still in the process of implementing this program. Phase I of the program is complete. EPA just recently announced NOx limits for the Group II boilers (cyclones, cell and wet bottom boilers) and the Phase II boilers (the other tangential- and wall-fired boilers not covered in Phase I). These new, proposed limits are quite stringent and, if implemented will likely entail retrofit of technologies that were demonstrated during the DOE Clean Coal Technology program, as well as others independently demonstrated by utilities, often in collaboration with EPRI.

For example, boilers with cell burners will likely have to meet an emission limit of 0.68 # NOx/ MBtu under the latest EPA proposed standard. The DOE CCT program demonstrated a low NOx burner for this class of boilers and assessed the levels of NOx reduction this technology could achieve. While it is still unclear if this will be the final limit, the technology demonstrated under the CCT program will likely be used to meet this proposed limit with some caution for accelerated corrosion. The market here is 36 boilers with a capacity of 24 GW.

As the other parts of the Phase II program are implemented, it is likely that other CCTs will be employed as well. For example, EPA's proposed NOx limits for the Phase II tangentially-fired boilers is 0.40 # NOx/MBtu which will be a challenge to meet in all cases. Approximately 300 boilers are affected and it is likely that technologies comparable to the most sophisticated of the set of LNBs evaluated under a Round 2 project (LNCFS-3) will be applied.

Most utilities complied with the SO_2 requirements in Phase I through fuel switching rather than use of FGD systems. Phase II will require additional SO_2 reductions such that the 10 million ton goal required of the Clean Air Act will be met. It is likely that FGD will play a somewhat larger role than in Phase I--how much larger will depend on other regulatory pushes to be discussed later. To the extent that FGD will be used, it is likely that systems demonstrated under the CCT program, such as the high velocity, single reactor vessel Pure Air scrubber or jet bubbling reactor (CT-121) will be deployed. Depending on the date by which a utility must comply, given any allowances it has banked, it may use even newer emerging technologies that enhance the processes demonstrated under the CCT program.

Internationally, there may now be less of an emphasis on ultra-high SO_2 and NOx reductions. In the developed countries of Europe, retrofits for NOx and SO_2 have already been accomplished using the best systems available in the late 1980s. In developing countries, environmental standards are usually dictated by lending institutions or newly formed environmental regulatory agencies. Typically, NOx emissions are met through use of low NOx combustion systems while utilities and new project developers look for the lowest cost SO_2 controls possible. These can be wet scrubbers, but often are spray dryers, alone or in combination with cleaned or naturally occurring low-sulfur coal. Of course, coal cleaning is a CCT, especially advanced technologies such as Care Free™ coal.

Attainment of Ozone Standards (Title I)

Title I of the Clean Air Act also established deadlines for compliance with the ambient air quality standards for ozone. This problem is most acute in the eastern US. The primary contributors to ozone formation are NOx and volatile organic compounds (VOCs). Electric utilities contribute about 1/3 of the NOx emissions with the remainder from mobile sources and other combustion sources. The USEPA has just proposed a new (and more stringent) ozone ambient air quality standard which adds more complexity to this situation. A process is now underway (referred to as the Ozone Transport Assessment Group or OTAG) to determine the degree to which NOx must be reduced and from what sources to meet the current ozone ambient standard.

While OTAG plans to issue its final report in the Spring, it is anticipated that further stationary source NOx reductions may be required beyond what is necessary for Title IV compliance. Depending on the outcome of the OTAG process, EPA's own actions, and the final ozone ambient standard, it is possible that postcombustion NOx systems (selective and non-selective catalytic reduction --SCR/SNCR) will be required on some coal-fired boilers. SCR was also part of the CCT program which developed important information regarding its applicability and limitations, in particular, when burning high to medium to high sulfur coals. Simultaneously, EPRI and several of its member utilities demonstrated the applicability and limits of SNCR to a number of new sources, such as cyclone boilers and wet bottom units.

Fine Particulate Standard

The USEPA also recently proposed a revised particulate ambient air quality standard with the focus on fine particulates (<2.5 microns in diameter). While the exact composition of fine particulates is still not clear, the focus for controls is likely to be NOx and SO_2. Again, depending on the outcome of this debate, further combustion and postcombustion NOx controls and additional FGD may be required beyond that of the Title IV acid rain provisions of the Act.

Because of the relationship between these 3 regulatory inititatives and the fact they could be imposed in a piecemeal fashion, EPA has proposed a Clean Air Power Initiative (CAPI) which would combine these into one rulemaking effort. Without going into the details, the general proposal is for a 50% reduction in SO_2 beyond Title IV Clean Air Act Amendment requirements plus OTAG-wide NOx overage emissions limits of 0.15 to 0.20 #/MBtu with allowances and trading.

2. Air Toxics (Hazardous Air Pollutants)

This issue was also addressed as part of the 1990 Clean Air Act Amendments (Title III). Without going into all the details behind this issue, let me just say that EPA has issued a draft report and concluded that the risks associated with air toxics are low but it is not clear whether regulation of existing sources will be required. The focus for potential controls of coal-fired boilers appears to be on mercury emissions. If this is the case, no current technology exists to control mercury from coal-fired boilers to any great degree other than FGD systems, and then only if the mercury is primarily in its oxidized form. Tests on advanced generation technology (e.g., IGCC) showed emissions of most toxics, including mercury, to be similar to conventional coal plants with FGD systems and particulate controls.

Thus, air toxics would not appear to be a significant driver of CCT deployment in the US. Internationally, air toxics has not emerged as a major issue except in a few developed countries.

3. Global Climate/Greenhouse Gases

Global climate is probably the most important environmental issue affecting the future deployment of CCTs, particularly those involving new, more efficient cycles. It now appears that some mandatory programs with specific deadlines may be agreed to for the developed countries at the next Conference of the Parties this year in Japan. If there is any hope of stabilizing the increase in CO_2 emissions, electric generation technologies which produce less CO_2 per unit of electricity output or ton of coal burned will be a must. CCTs such as IGCC or advanced PFBC cycles are two examples. Further, improvements in combustion efficiency of pulverized coal plants can also help reduce CO_2 emissions increases. Obviously, natural gas has a distinct advantage here as will be pointed out by several speakers at this conference.

The growing economies in the developing world are expanding their electric generation capacity rapidly (e.g., 2000 MW/month in Asia). To date, most of this generation demand is being met by conventional pulverized coal plants, not even those with with the highest efficiency cycles such as supercritical boilers. Obviously, natural gas is, and will also continue to play a role in future generation world-wide where it is available. However, given the remaining reserves of coal worldwide and its cost advantages, coal is likely to be used extensively as most projections have shown.

Depending on the outcome of the greenhouse gas debate, the future of CCTs could either be very gloomy or quite promising. The gloomy forecast is that CO_2 restrictions are so onerous that coal cannot compete if these restrictions are to be met. On the other hand, high efficiency, generation-based CCTs could emerge as the key ingredient in meeting much more modest goals. In my opinion, this issue is probably the most critical for the generation-based CCTs in terms of future deployment.

4. Solid By-Products and Water

When we discuss environmental issues affecting CCT deployment, we tend to focus on air issues. Admittedly, these typically are the biggest economic drivers for siting new coal-based generation and retrofitting existing coal plants. However, technologies which use less water, discharge fewer solid and liquid by-products and produce salable by-products should have an advantage in the future. For example, at EPRI we are seeing an increased interest in funding R&D related to finding new uses for fly ash. Rather than incur a disposal cost ranging from $5 to $40 per ton, ash sales can generate revenues of similar magnitude. Thus, a liability is turned into an asset. In a competitive industry, this means money and the opportunity to sell more "clean" electricity. This same conclusion applies to FGD systems that produce a salable gypsum. Further, water is becoming a more limited resource and CCTs that have higher cycle efficiencies and produce less lower volume discharges will also be favored.

5. Competition/Industry Restructuring

While not an environmental issue per se, the rapid restructuring of the electric utility industry, particularly in the US, has environmental issues intertwined within it. For example, it has been argued that, in a deregulated market, midwestern power plants that rely heavily on coal (and have relatively lower cost electricity) will increase their capacity factors at the expense of higher cost plants in the eastern US. In turn, these midwest plants will generate increasing amounts of NOx which may be transported eastward, thus making it even more difficult for these regions to attain the ozone ambient standards. As mentioned above, the OTAG process is examining the role of transported pollutants. Depending on the outcome of these studies and the pace of restructuring, deployment of low NOx technologies (SCR, SNCR and advanced burner designs) on coal plants could be rather extensive.

Gas seems to be the fuel of choice now for new generation. However, speculation abounds on the length of the gas bubble. Renewables are still expensive. Thus, when the time comes for new coal capacity to be built, competitive companies will be looking for CCTs that offer significant environmental and cost advantages. As the industry increasingly comes to grips with its new business environment, I believe there will also be those who will be willing to select CCTs which offer significant cost and environmental benefits to gain competitive edge.

6. Public Image/Toxics Release Inventory

Coal has always been viewed as "dirty." The USEPA is also now planing to require all oil- and coal-fired power plants to report emissions from a list of over 600 chemicals as part of the Toxics Release Inventory (TRI). Given the number of chemicals which must be reported and the large amount of coal burned, the reported quantities for even "clean coal plants" could be large which will place many coal burning utilities high on the lists of "polluters" and do nothing to enhance the image of coal as a clean fuel. What impact this issue may have on CCT deployment is unclear at this point. But combined with the NIMBY issue, siting for new coal-based power plants could be difficult both in the US and many other parts of the world. There also appears to be a growing interest in "green marketing" of clean energy which again puts coal-based generation at a disadvantage. CCTs which greatly minimize air, solid and water emissions could find some favor even if their economics are very close to standard, but more polluting designs. The degree to which such a market could emerge is not clear.

7. Growing Population/Demand for Resources

As developing economies expand and population continues on its exponential growth curve, the environmental implications are enormous. Demand for energy resources, water, and food will continue to grow. Coal obviously must play a role in supplying energy needs and CCTs will be critical in that capacity. This issue is one issue that I will let you debate as part of this conference as it is politically and economically very contentious. The global climate issue and this much broader one can potentially be the two largest issues affecting CCT deployment in the early parts of the next century.

8. Role of Electrotechnologies

This is one issue which is not necesarily considered when it comes to environmental issues affecting clean coal technology deployment. From the introduction of the electric car, to the silicon resolution, to infrared drying, to efficient lighting, to electric arc furnaces, electricity is likely to gain increasing use in our everyday lives. Studies have shown that not only are there cost advantages in the use of electro-technologies, but environmental advantages as well.

III. SUMMARY

Environmental issues are what initiated the DOE CCT program and will continue to be a major factor in CCT deployment. Environmental issues could either be a boon or a bust to CCT deployment depending on the degree and pace of environmental regulation in the US. Deregulation/restructuring of the electric utility industry will also have an effect on deployment but to what degree it is not clear. It is likely that retrofit CCTs for NOx in particular will have a significant market given existing and proposed emissions limits. Opportunities for advanced SO_2

technologies (such as Chiyoda, SHU and the Pure Air process which were demonstrated in the DOE CCT program) will also depend on some of these emerging regulatory scenarios. Advanced generation CCTs with their inherent environmental advantages are now too expensive and the market for new generation is now primarily gas.

Internationally, how environmental issues will affect deployment is less clear. I am not aware of any other environmental issues affecting deployment outside the US that I have not discussed in the context of the US. It now appears that lending institutions such as the World Bank are becoming the international EPA in terms of SO_2, NOx and particulate standards for a new coal-based generation. Global climate is the issue which is the most international in scope and certainly is the key one in terms of how CCT deployment will be driven in the future.

Thank you for this opportunity to share my thoughts with you. I am not sure I raised any environmental issues which are new to anyone in this audience. My charge was to set the stage and to make sure all issues are on the table now so their implications can be debated as the conference proceeds.

Luncheon Address

Issue 4: CCT Deployment: From Today Into The Next Millennium

CLEAN COAL TECHNOLOGY DEPLOYMENT: FROM TODAY INTO THE NEXT MILLENIUM

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I. INTRODUCTION

The Department of Energy's clean coal technology (CCT) program succeeded in developing more efficient, cleaner, coal-fired electricity options. The Department and its private partners succeeded in the demonstration of CCT--a major feat that required more than a decade of commitment between them. As with many large-scale capital developments and changes, the market can shift dramatically over the course of the development process.

The CCT program was undertaken in an era of unstable oil and gas prices, concern over acid rain, and guaranteed markets for power suppliers. Regulations, fuel prices, emergence of competing technologies, and institutional factors are all affecting the outlook for CCT deployment.

I've been asked by the organizers to identify the barriers to CCT deployment and to challenge the speakers in Panel 4 to consider how these barriers might be overcome. Below, I discuss the major barriers, and then introduce some possible means to surmount the barriers.

II. BARRIERS

The growth in the market share for clean coal technologies will be driven by institutional/regulatory structure, environmental issues, and costs (both capital and fuel).

The demand for new capacity is addressed by another panel. Bechtel's capacity addition forecasts show that 95 percent of new coal-fired capacity will be built in two of our four geographic regions--1. Europe, Africa, Middle East and East Asia and 2. Asia Pacific (Table 1). The largest markets for coal-fired capacity within these regions will be India, China, and Indonesia, with markets also in Eastern Europe, and South Africa. Only one-third of world capacity additions will be coal-fired. Natural-gas-fired capacity is expected to be the technology of choice in North and South America, as well as much of Western Europe and the Middle East.

Institutional Barriers

Deregulation

Let's examine the institutional/regulatory issues in the US, where we've made the large investment in developing clean coal technologies, in the expectation that they would meet a significant need in the US.

Today, the market for new capacity additions in the US is not large. The major political factor influencing the US electricity market is deregulation. Uncertainty over the impact of deregulation on utilities is causing them to postpone many capacity additions. In addition, deregulation affects the independent power producers, while they await the impact of deregulation on issues such as future cost recovery.

Deregulation of the US market will lead to a big market shake-up during the next five to seven years. A larger number of players have entered the market in the past few years and more are likely to follow, leading to increased competition in the near-term. It will be a buyers' market--increased competition disfavors longer-term purchase agreements. Under such market instability, suppliers won't commit to building large coal-fired power plants (>400 MWe). Even if a supplier wishes to build one, without an assured long-term market, the supplier is unlikely to get external financing. The market outlook will certainly be too risky to use equity financing. The independent power producers have already exploited most of the desirable sites for coal-fired power plants (e.g., next to a large industrial user). Easily installed capacity in modest sizes (i.e., gas turbines) will be the technology of choice in early phases of deregulation.

In the later stages of deregulation, competition could result in large generators' (i.e., utility) mergers, and a shake-out of IPPs, meaning there would be fewer suppliers in the market. However, technology choice might also begin to affect the market, i.e., centralization versus decentralization. For example, continued progress in "mini" turbines, fuel cells, and alike, could allow businesses, housing complexes, and even homes to have a power plant in their basement, which might be a very attractive choice if the power quality problems (expected to occur with deregulation) don't get solved.

Deregulation is spreading. In Western Europe, the United Kingdom is privatizing their power market, and new players (such as North Sea oil and gas producers) are entering the market (although new, coal-fired power plants are still being built, as well.). The extensive deregulation occurring in the US may well spread to other OECD countries, assuming there are positive results from US deregulation.

Other Institutional Factors

In the two largest markets, India and China, institutional factors can affect capacity choices in other ways. In India, regulations are quite specific to individual states.

Building a standardized power plant in several states may be difficult, which can pose barriers to building optimized, inexpensive (i.e., standardized) CCT plants.

World Bank financing, a common source in India, can favor CCTs, by requiring that environmental factors be taken into consideration for capacity choices.

China prefers to build its own boilers and other components, which will favor cheap, simple technology, a barrier to CCT. However, outside financing and international institutions could accelerate the adoption of local regulations that would promote the use of CCT.

Growing developing country markets pose a problem to national governments as well as outside investors. Despite the rationalization of prices encouraged by development banks, there is still a tension between increasing the standard of living by providing cheap electricity versus recovering full costs in major capital investments. Perceived political risk in certain countries will also disfavor large, fixed, capital investments in one country by outside investors.

Environmental Barriers

As stated earlier, the CCT program was undertaken when acid rain was a major concern, especially with respect to burning higher sulfur coals. The clean coal program successfully demonstrated virtual elimination of precursors to acid rain. Today, global warming has emerged as a major environmental driver. Carbon dioxide is seen by the public and some of the technical community as the key component in global warming. Carbon dioxide emissions has therefore become one of the biggest technical challenge to future, environmentally-benign coal consumption .

Coal-fired electricity generation releases relatively more greenhouse gases than does combined-cycle, combustion-turbine technology (CCCT). However, the efficiency increases of CCT will decrease CO_2 emissions significantly, relative to standard coal technologies, such as atmospheric fluidized bed combustors. Therefore, CCT certainly helps with the greenhouse gas problem resulting form coal consumption, but doesn't solve it as shown in Table 2.

If the international community ever agrees upon greenhouse gas emissions quotas, the quotas could encourage use of CCT relative to conventional coal capacity, but perhaps generally discourage coal use, relative to natural gas use.

The joint implementation (JI) program is off to a rather weak start. JI could, however, subsidize CCT in developing markets, where the technology of choice might have been conventional coal technology. JI could also favor more natural gas technology, however.

Repowering and retrofitting have been proposed by many as one of the solutions to revitalize the aging US power industry. However, there are other environmental considerations that affect the market for CCT. Environmental regulations in the US discourage retrofits of coal-fired power plants. For example, retrofitting a plant makes it subject to updated emissions requirements, and also requires asbestos removal, etc. These regulations/environmental factors discourage retrofitting older coal-fired capacity with new CCT.

Cost Barriers

Table 3 shows Bechtel's projections of levelized life-cycle cost per kilowatt hour for a number of electric generating technologies. The figure demonstrates that cost poses a significant barrier to CCT adaptation, even though the cost of CCT could approach that of conventional coal-fired generation on a levelized life-cycle cost basis.

Capital Costs

The capital costs of coal technologies are at least twice the capital costs of CCCT (i.e., 2.2 to 2.9 c/kwh for coal-fired capacity compared to 1.1 c/kwh for CCCT). From a front-end investment standpoint, the cost of coal-generation certainly disfavors coal-fired capacity relative to gas-fired generation. Capital investment is also the major factor in choosing capacity type if outside financing is sought.

The near-term potential to decrease the capital cost for CCT lies in system optimization (e.g., be less conservative in redundant systems while maintaining reliability). Total system optimization can be difficult to achieve until a number of CCT plants are built, however. Even then the system optimization improvements won't halve CCT capital costs. If one expands the definition of "system" from the power plant components to a more expanded system, including fuel production, delivery, combustion, and electricity transmission, there are further economies to be captured. Whether this integrated energy system based on coal can compete with integrated systems based on natural gas remains to be seen.

The longer-term potential to decrease CCT capital costs will come from new technologies, such as ceramic membrane technology to decrease the cost of oxygen production for technologies that can benefit from an enriched oxygen source, such as IGCC. Unless we invest in these developments, however, these new technologies won't be built.

O&M Costs

O&M costs (excluding fuel) are not major differentiators for the capacity choices. The further development of "smart" operating systems are likely to further decrease the costs of running electric generators. This enhancement should benefit all technologies, but CCT, which tend to be more complex, should benefit more.

Fuel Costs

Fuel costs are relatively a much larger component of the total cost of electricity from natural-gas fired plants than they are for coal. In the absence of any decrease in capital costs, natural gas costs would have to increase significantly for a sustained period to " level the playing field" (on a levelized life-cycle cost basis) between CCCT and CCT. Natural gas costs would have to increase by about 50 percent (about $1.5 per MM Btu) relative to coal to make CCT competitive with CCCT. The natural gas price increase would have to be sustained. However, long-term natural gas price expectations generally are fairly flat. Deployment of advanced natural gas processing technologies (e.g., Fischer Tropsch) could help ensure natural gas price stability at current levels. This outlook for natural gas prices makes CCCT hard to beat on a life-cycle-cost basis, except in markets with an abundance of cheap coal and/or wastes for combustion in CCT.

III. CHALLENGES TO MARKET INTRODUCTION OF CCT

The foregoing has demonstrated the significant barriers that are presented for the widespread introduction of CCT. The question then is how does one make coal more competitive with its fossil competition? How can widespread market introduction be accomplished? This can be done by looking at the differences between coal and the alternatives and developing strategies to minimize these. The challenges below are technical ones; an alternative or complementary approach is to pursue regulatory or policy changes to effect some of the institutional barriers outlined above.

Make Coal "Look" Like Other Fossil Fuels

The variability of coal makes it difficult to take full advantage of standard plant designs (which are the cheapest). Therefore, one needs remove, as much as possible, the differences among coals of equal rank. This entails beneficiation, washing, etc. Coal blending is one method already being practiced in some cases to improve plant availability and stabilize sulfur control systems.

An additional consideration is that natural gas and oil are delivered by suppliers in an integrated manner. Therefore, we need to use an integrated, systems approach to coal preparation and delivery (mining, grinding, cleaning, transport, and the method of utilization), i.e., break apart the old "silo" approach among mining firms, transportation (railroads), and utilities/IPPs. Coal-water slurries are one example of such integration. CCT's, such as IGCC and PFBC have already demonstrated the ability to use slurries to feed coal at high pressure.

Improve Coal's Environmental Performance

The most important need here is to increase the overall efficiency of coal utilization thereby decreasing the pollutant unit per kwh or per ton of coal. As stated earlier, CCT have increased efficiency, but current initiatives by DOE, included in Combustion 2000 (and other programs) will further increase the fuel efficiency for pressurized, fluidized bed combustion, IGCC, and other CCT.

Removing coal variability as proposed above also enables more of a standardized approach to CCT. CCT is fairly flexible, for example, with minor design changes it can handle coals range from 1 to 4 percent sulfur and beyond. Further fuel flexibility could improve plant standardization.

"Blending" coal with other fossil fuels can also mitigate environmental impact. Blending can be done in a dual fuel approach or in an incremental approach as noted below. The use of natural gas in the pressurized fluidized bed topping cycle is an example of blending that improves environmental performance.

Reduce Costs on a Net Present Value (NPV) Basis

For certain technologies, we could look at how the plant can be built for dual-fuel capability in one of two ways. The first approach is to build a CCCT plant leaving space to add coal handling equipment to convert to coal as fuel prices change. The second approach is to build the plant for dual-fuel capability right from the start and mix and match as fuel prices and national interests dictate. The latter approach is a variant of the solar hybrid concept (in reverse).

Another way of improving the NPV is through environmental subsidies, i.e., recognizing that the use of indigenous fuels is desirable, but that such fuels (coal) are only competitive in the current market if environmental pressures are relaxed, a policy could be developed which would give incentives for the use of state of the art CCT. Such incentives may be provided by the Global Environment Facility, or other lending agencies involved in the country under question.

Yet another way to incrementally improve the NPV of CCT is by developing a market for the CCT with low-price fossil fuels other than coal, i.e., heavy oils, petroleum coke, orimulsion, biomass, etc. This expansion of the market for CCT could speed plant optimization. A recent announcement by GE and Toshiba that they plan to partner to market IGCC technology demonstrates this approach. Under the agreement, GE and Toshiba expect to furnish the turbine-generator equipment, and to broaden their IGCC market penetration.

IV. CONCLUSION

The implementation of clean coal technologies will be difficult for a variety of reasons as we have seen. Innovation and new approaches to commercialization, standardization, and improved environmental performance are keys to more widespread use in the next millenium.

Table 1. Regional capacity additions in gigawatts (based on orders, 1997-2002)

	Total	Natural Gas	Coal-fired	Nuclear	Hydro
North America	46	39	4	-	3
Europe, Africa, and East Asia	124	87	27	6	4
Asia Pacific	165	36	95	24	10
Latin America	57	26	2	1	28

Table 2. Relative Levels of CO2 Contributed to Greenhouse Emissions

	GTCC	PCF w/ FDG	AFBC	PFBC	IGCC	APFBC
Power, MWe	500	500	500	500	500	500
Heat Rate, BTU/kW	8030	10040	10190	8320	7940	7190
Efficiency, %	42.5%	34.0%	33.5%	41.0%	43.0%	47.5%
Fuel Heat Content, MM Btu/hr	4,015	5,020	5,095	4,160	3,970	3,595
Fuel	Nat Gas	Coal*	Coal*	Coal*	Coal*	Coal*
Heat Content, Btu/lb	23,840	13,260	13,260	13,260	13,260	13,260
Fuel Feed, lb/hr	168,410	378,580	384,240	313,730	299,400	271,120
Carbon, lb/hr	126,310	279,390	283,570	231,530	220,960	200,090
Sulfur Content, lb/hr	0	7,950	8,069	6,588	6,287	5,694
Ca/S	0	1.01	2.6	1.3		1.9
Limestone required, lb/hr	0	26,690	69,750	28,470	0	35,960
CO2 from Fuel	463,140	1,024,430	1,039,760	848,940	810,190	733,660
CO2 from Limestone	0	11,740	30,690	9,640	0	8,330
Total CO2	463,140	1,036,170	1,070,450	858,580	810,190	741,990
Normalized of AFBC	43.3%	96.8%	100.0%	80.2%	75.7%	69.3%

* Based on Pittsburgh Seam Coal

Table 3. Levelized lifecycle costs for alternative electric generating technologies

400-600 MW range

	PC (steam coal)	CCCT (nat. gas)	PFBC (waste/low grade coal)	IGCC (waste/low grade coal)
Capital c/kWh	2.2	1.1	2.6	2.9
O&M c/kWh	0.6	0.4	0.6	0.9
Fuel c/kWh	1.2-2.2	2.0-3.4	0.6-1.2	0.5-1.0
- based on deliv'd $/MMBtu range:	1.50-2.50	2.50-3.80	0.60-1.20	0.60-1.20
Total lifecycle busbar cost	**4.0-5.2**	**3.5-4.9**	**3.8-4.6**	**4.3-4.8**

1400 MW range

	LNG CCCT	Nuclear ABWR
Capital c/kWh	1.6-1.2 (2x1400 MW)	4.5-4.0 (2x1400 MW)
O&M c/kWh	0.5	1.0
Fuel c/kWh	2.5-3.3	0.6
- based on deliv'd $/MMBtu range:	3.50-4.50	0.60
Total lifecycle busbar cost	**4.2-5.4**	**5.6-6.1**

Note: The cost competitiveness of these technologies will depend for a large measure on local fuel availability and pricing. Fuel is the most widely varying cost factor for all technologies except nuclear.

Panel Session 1

Issue 1: International Markets For CCTs

REGIONAL TRENDS IN THE TAKE-UP OF CLEAN COAL TECHNOLOGIES

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ABSTRACT

Using surveys of the electricity industry taken in major OECD coal producing/coal consuming regions of North America, Europe, Southern Africa, and Asia/Pacific, this paper reports on the attitudes of power plant operators and developers toward clean coal technologies, the barriers to their use and the policies and measures that might be implemented, if a country or region desired to encourage greater use of clean coal technologies.

I. INTRODUCTION

The Coal Industry Advisory Board (CIAB) serves the International Energy Agency (IEA) as an advisor on issues related to the coal and electricity industries. The CIAB is made up of representatives selected by the governments of the IEA member countries. A series of three papers on industry attitudes toward clean coal technologies for power generation and the factors affecting the take-up of these technologies have been produced by the CIAB for the IEA. As a result of the information put forth in those papers, the IEA Secretariat requested the CIAB to provide its perspective on the potential for the electric power industry to take-up advanced, energy efficient, coal-fired power generation technologies (hereafter referred to as "clean coal technologies") in the near and medium time frame. The CIAB has prepared a report, which is now under review, that presents a region by region assessment of the evolution of these energy efficient, coal-fired technologies by identifying the attitudes towards them, barriers to their take-up, and policies and measures that might be adopted to overcome these barriers. The regional assessment approach is based on the generally accepted premise that the adoption of clean coal technologies will be a function of differing technological, environmental and economic constraints from region to region. While actions on these policies and measures may involve many players, the IEA is particularly interested in CIAB's views on those actions which governments and industry might consider.

The CIAB solicited the views of its members as well as others with electric power industry expertise within four OECD regions of the world, North America, Europe, Southern Africa and Asia/Pacific. Because the previous CIAB studies indicated that a significant amount of the growth in electric generating capacity was projected to occur in the non-OECD countries and particularly the Asia/Pacific region, the CIAB decided to devote a special effort to assessing the attitudes towards the clean coal technologies held by those independent power producers (IPP) who would most likely construct power generation facilities in the developing countries of the Asia/Pacific region. However, the results of the IPP survey are not reported here, but can be found in a paper entitled "Increasing the Efficiency of Coal-Fired Power Generation, State of the Technology: Reality and Perceptions? prepared by Shell Coal International, London, England and SEPRIL Services, Chicago, Illinois.

The clean coal technologies assessed include:

- retrofitting of enhanced controls/repowering existing plants
- the installation of advanced, more efficient steam cycle plants as described in Industry Attitudes To Steam Cycle Clean Coal Technologies, Survey of Current Status (OECD/IEA 1995)
- the development and commercial application of combined cycle technologies as described in Industry Attitudes To Combined Cycle Clean Coal Technologies Survey of Current Status (OECD/IEA 1994)

Again, because the Asia/Pacific region is projected to experience a significant increase in the amount of electric power generating capacity and the technology that is expected to be utilized most often is conventional subcritical pulverized fuel (PF) technology, the CIAB decided to contrast the capital costs, operation and maintenance expenses, reliability of operation and environmental emission characteristics for the conventional PF technology with those of one commercially available clean coal technology, supercritical PF. These results can also be found with the IPP survey results referenced above.

As was deemed appropriate for each region the assessments include:

- consideration of the growth in the demand for electricity in the region and the corresponding generating capacity that will supply that demand segregated by fuel type and technology to the extent possible.
- consideration of the degree of take-up of the clean coal technologies before 2015.
- consideration of likely relative capital costs and the effect on the price of electricity from the clean coal technologies, compared with existing technologies (e.g. taking into account the higher rates of return on investment required to compensate for the perceived extra risk).

- consideration of any extra environmental advantages of the newer technologies. This consideration would need to consider the possibility of the development of more stringent future environmental standards within the region.
- identification of government and private-sector policies, measures and incentives that would enhance the adoption of the clean coal technologies.

This paper summarizes the results of the regional assessments.

II REGIONAL ASSESSMENTS

The attitudes of power generators, both utility and independent power producers, towards the clean coal technologies is expected to be different from region to region because attitudes are influenced by differing technological, environmental and economic constraints. The following discussion is an assessment of these differing attitudes and their implications on the take-up of the clean coal technologies in each region.

OECD North America

Regional attitudes in North America were assessed by examining Canada and the United States.

Canada

The attitudes of the Canadian utility industry towards the take-up of the clean coal technologies is taken from a report entitled "The Potential for Energy Efficient Coal-Fired Power Generation in Canada", prepared by Edmonton Power. This assessment is a compilation of responses from utilities in Canada which collectively represents almost 97% of Canada's electricity generation and all existing coal-fired generation.

Canada is extremely large geographically and, therefore, a diverse nation in many respects, not the least of all in electricity generation. Coal, natural gas and hydro power are readily abundant depending on the Province in question. Nuclear power has been developed extensively in Eastern Canada. Since 1980, new generating capacity has been installed in all parts of the country embracing all "conventional" technologies" with hydro, nuclear and subcritical PF being the dominant technologies. Only one advanced technology has been installed during this period, a 182 MW AFBC unit in Nova Scotia during 1995.

Generating capacity is forecasted to increase 2.8% by 2000 with further increases of 3.0%, 4.3% and 3.4% respectively in each 5-year block until 2015. This represents a modest annual growth rate of 0.68%, while energy consumption is expected to increase by 1.38% per year until 2015. Of the new capacity being added, 15.9% is expected to be coal-fired and 49.8% is expected to rely on natural gas. Repowering with the addition of a gas turbine and life extension with improved unit efficiency will also play major roles in fulfilling new capacity requirements.

In choosing the types of new capacity, capital and fuel costs were cited as the top two determining factors, followed by environmental considerations, plant availability, return on capital invested, construction time, and security of fuel supply. In those Provinces where deregulation is occurring, the higher risk of not recovering costs makes the reduction of investment risk through shorter planning, design and construction times a key factor. CO_2 is considered the most important environmental factor, followed by SO_2, NO_x and siting considerations.

The potential for the take-up of the clean coal technologies in Canada is relatively low with the limited addition of coal based capacity. The expressed interest is in IGCC technology to be installed after 2006. Interest in the other technologies will be dependent on their commercial maturity and economics in the same time frame.

The barriers to the clean coal technologies are increased deregulation of the electric industry with the delay of long-term decisions due to uncertainty, increasing environmental limitations and costs associated with coal-fired technologies, increasing complexity of financing arrangements and in a deregulated market, gas will be very competitive with coal.

In those locations where gas is readily available and competitively priced, it will act as a barrier to the take-up of clean coal technologies. In addition, proof of performance in the areas of environment, reliability, operability and power cost at a commercial scale in a utility environment is needed. Similarly, the capital cost and construction time of the clean coal technologies must be reduced. Proposals under consideration to control/tax greenhouse gases are seen as limiting the opportunities for coal based technologies.

Government policies to overcome these barriers should address two areas; funding a substantial portion of up-front R&D and demonstrations consistent with long-term environmental policies and favorable tax/depreciation for environmentally sound technologies requiring penetration assistance.

United States

The attitudes of electricity producers in the US towards the take-up of advanced energy efficient, coal-fired technologies is assessed in the report entitled "Regional Trends in the Evolution of Energy Efficient, Coal-Fired Power Generation Technologies in the United

States", Prepared by Peabody Holding Company, Inc. The assessment is based on published information which reports the results of surveys of electric utilities and independent power producers attitudes towards clean coal technologies. Since 1986 the US Department of Energy (DOE) has been administering a government/industry co-funded program to demonstrate clean coal technologies at a utility scale. The Clean Coal Technology (CCT) program has resulted in a US $6.9 billion effort for the first-of-a-kind or early commercial demonstration of the clean coal technologies that the CIAB has previously reported to the OECD/IEA. The attitudes reported here are influenced by the experiences learned in the CCT program.

Kilowatt hour sales in the US are expected to increase by 31% for the period 1995 to 2015. During that same period net generating capacity additions are expected to increase by 22% or 167 gigawatts (GW). New capacity additions plus replacement capacity for retired units is expected to be 252 GW. Coal-fired capacity additions are projected to increase by 5% or 15 GW. Natural gas-fired capacity will dominate with a 69% increase or 166 GW while nuclear capacity will decrease by 36% or 35 GW. The majority of the nuclear reductions are projected to occur after 2010 when most of the plants' current licenses expire. The projections do not reflect any changes that may occur as a result of the deregulation of the US electric industry.

The potential for the take-up of the clean coal technologies exists in the 252 GW of new or replacement capacity. However, this potential is influenced by a number of attitudes of the user community. The opportunities for base load units are limited before 2000 and increase to some extent between 2000 and 2005. The clean coal technologies are viewed as having higher capital and operating costs relative to subcritical PF technology. Subcritical PF appears to be the coal technology of choice despite the fact that supercritical PF is viewed as a proven, reliable technology. IGCC is viewed as somewhat proven/reliable, while PFBC is viewed as not proven. Strong interest exists in life-extension and improving performance at existing plants. In addition, deregulation is delaying, indefinitely, long-term decisions for additional generating capacity.

The barriers identified to the take-up of the clean coal technologies are many. Coal continues to a have a poor public and political image even though the clean coal technologies offer the promise of significant efficiency improvements and reduced environmental impact. Coal remains the fuel-of-choice for base load applications. Where natural gas is readily available and competitively priced, natural gas will continue as the fuel-of-choice for incremental capacity additions. Concern exists over the future regulation of CO2. Life cycle costs are less important and decisions are being driven by short-term considerations related to financial risk.

Policies and measures that could be implemented center around two areas - technology transfer and economic incentives. The attitudes of the electric utility industry indicated a lack of knowledge and perhaps an excessive degree of risk aversion concerning the commercial status, costs and reliability of the clean coal technologies and, in particular, supercritical PF. A better job needs to be done to market the clean coal technologies by providing more information on risks and costs. This program should be targeted at non-utility generators because of their future role in providing new capacity additions. Finally, without some program of cost sharing to reduce risk, the clean coal technologies are unlikely to be taken-up to any significant extent before 2005. Financial incentives that have been explored are subsidies and special tax/depreciation treatment.

OECD Europe

In Europe, the attitudes of 16 OECD member countries were solicited and the findings are contained in the report entitled "Regional Studies on Evolution of Power Generation, OECD Europe", S-K Power, Denmark. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Spain and the UK responded to the request for information and these 13 countries represent OECD Europe for purposes of this paper. In addition, information was requested for the 20 year period 1995 through 2015. However, not all respondents were willing to provide information for the 2010-2015 timeframe and those that did respond, had strong reservations about the reliability of the data. Therefore, the time frame for OECD Europe information is 1995 through 2010.

The OECD Europe electric power industry expects a fairly constant load growth over the period from 1995-2010, to the order of some 16% growth in capacity and a higher 27% growth in energy use.

As a consequence of the on-going transition of the industry from one of monopolies to a deregulated competitive market, power companies have redefined their earlier strategic/politically based objectives (technological reliability/availability, fuel flexibility and use of indigenous fuels) to economic ones like return on investment and capital cost. At the same time, environmental considerations are expected to continue to play an important role in the future choice of generating capacity.

European power companies expect oil to lose ground as an energy source in Europe over the next 15 years; while coal and nuclear should maintain the status quo; and hydropower should see a small increase. Capacity based on renewable fuels will enjoy a large increase, but even so, it will remain an incremental energy source.

Natural gas fired technologies with their relatively low capital costs and environmentally friendly image will supply most of the growth. This is remarkable because even though most European power companies agree that "Europe is becoming too dependent on imported natural gas", they still plan to select natural gas as their fuel for new capacity.

In comparison to gas, the expectation for the installation of new coal based capacity is low. Coal-fired capacity, that will be built over the next 10 years, will be supercritical PF technology. After 2005, the choice of clean coal technologies will be dependent on their state of development at that time.

The main barriers to the enhanced take-up of the clean coal technologies are economic in nature (e.g. high capital costs) and except for countries already hosting demonstrations of clean coal technologies, a skeptical view of the maturity of the PFBC and IGCC exists. Furthermore, coal has a public/political image problem.

Various proposals have been put forward by the power companies to overcome the barriers to the take-up of the clean coal technologies. As regards high capital costs, suggestions include political support of the continued development and dissemination of the clean coal technologies through subsidies, financing or funding. Preferential treatment in the market place of the electrical output from the clean coal technologies is another possible approach.

When it comes to overcoming the skepticism on the maturity of PFBC and IGCC technologies, the fact that countries hosting the technologies have a strong confidence in their virtues could indicate that a better dissemination of demonstration plant locations could constitute an effective way of proving their commercial readiness to a broader audience.

Finally, proposals to overcome environmental (including public and political image problems) barriers entail providing more information on the virtues of coal as a fuel, e.g. the large and geographically widespread resource base and the advanced technological state of today's coal mining and coal usage facilities. Further, the implementation of closed handling systems at harbors and power plants might be beneficial to coal's image.

Southern Africa

The Southern Africa assessment presents the views of developing countries whose primary emphasis is regional development and the role that power generation plays in that development. Limited information is presented for 15 sub-Saharan Africa countries and detail information is presented for South Africa in the report entitled "Evolution of Power Generation, Southern Africa Study", prepared by the ESKOM Technology Group. During 1995, South Africa accounted for 76% of the generating capacity for the region and produced 83% of the electrical generation. As a result the regional information is to be considered quantitative at best.

The perspective from the Southern Africa region is fundamentally different than for developed OECD countries. Development is focused on local and regional issues and attempts to maximize international cooperation to ensure that development is optimized. This entails securing clean coal technologies during development with the incremental costs above conventional technology being borne by the developed countries. This approach has been referred to as "Activities Implemented Jointly" in the context of reducing environmental impacts.

The 1995 electricity supply and demand situation for the 16 sub-Saharan African countries is one of significant over supply. The region has a total of 46 GW of installed capacity and electricity production totaled 207,545 GWh which represents 52% of the potential production. Under current projections, it is unlikely that additional capacity will be required in the region before the year 2010. Excess capacity in the region may be optimally utilized via the Southern African Power Pool. However, issues such as the reliability of long transmission lines, coupled with individual national priorities could result in additional capacity being built before 2010. Any increase in capacity will, in all likelihood, be met predominately by coal in South Africa and by hydro in the other countries in the region. In addition, South Africa has introduced a demand side management program as an alternative to capacity additions.

In spite of the over supply situation and because future growth is highly uncertain, supply side options are being evaluated for future applications. Clean coal technologies are being evaluated with the objective of reducing lead time, capital and operating costs, environmental impacts and optimizing unit size and load following capability. Environmental impacts focus on local and regional impacts with a lower priority on global impacts.

Clearly the most significant barrier to the take-up of clean coal technologies in Southern Africa is the excess of generating capacity which is expected to exist until after 2010. Other potential barriers include: perceptions of unreliability and higher operating costs, limited local skills and infrastructure, competition from other fuels such as hydro, gas and possibly nuclear. Also the existing capacity is relatively new (11-15 years) and retirement and replacement with clean coal technologies has a low potential.

Realizing that capacity is not needed in Southern Africa till after 2010, options open to both governments and industry to overcome the barriers from a developing nations point of view include means to catalyze economic growth, funding of the premium for the installation of clean coal technologies by the developed nations, demonstrations in developing countries, a robust program for disseminating information on the technologies and development of human capabilities in developing countries.

OECD Asia/Pacific

The assessment of the OECD Asia/Pacific region consists of a compilation of attitudes in three countries: Australia, New Zealand and Japan.

<u>Australia/New Zealand</u>

Australia and New Zealand constitute a region of the world where government has recently promoted competition in the electric power industry. This has developed an opportunistic approach and less certainty in the type and timing of new generation plant additions. The assessment of the take-up of clean coal technologies reflects this change in the electric industry and is presented in detail in the report entitled "Regional Studies On Evolution Of Power Generation Australia and New Zealand", prepared by Sligar and Associates Pty. Ltd., New South Wales, Australia on behalf of CRA Limited.

Load growth in Australia and New Zealand is expected to average 2% per year through 2015. This low predicted growth, coupled with existing reserve margin in some areas and the developing highly competitive situation, will lead to new generation initiatives in the near future. New generation will be incremental in nature and with the deregulation of the Australian gas industry will favor gas as the fuel-of-choice. A major portion of the coal capacity has recently been retrofitted and further refits are scheduled before 2000. The retrofits consist of minor technology advances and it is unlikely that these refits will employ any clean coal technology, e.g. IGCC.

Before deregulation, the energy mix was under the control of the two countries' governments, but now the competitive market will dictate the mix of capacity additions. In this competitive environment, organizations are somewhat reluctant to release their capacity addition plans, but an estimate of minimum likely new generation has been made based on a number of sources and statements in interviews. Likely new generation in Australia is projected to total 16.6 GW by 2015 with 2.2 GW coal, 6.8 GW gas, 5.6 GW renewables, and 2 GW uncommitted. There is 1.5 GW of gas generation available in eastern Australia and 1.0 GW in western Australia which is expected to be utilized by 2000. Installation of gas-fired generation after 2000 will depend on the discovery and development of the production and transmission systems. The likely installation of a new generating plant in New Zealand by 2015 will total 1.7 GW with 0.6 GW gas, 0.4 GW renewables, and 0.7 GW of uncommitted.

Attitudes towards the clean coal technologies in Australia and New Zealand are dominated by the competitive market place and, as a result, clean coal technologies are not under active consideration in either country. However, if that situation were to change, existing and potential generators would evaluate the clean coal technologies using the following factors in their order of importance: required return on investment, environmental and political considerations, and capital costs. Under environmental factors, CO_2, then NO_x, SO_2 and others are the emissions of concern in their order of importance. Where coal technology is under consideration for new capacity, subcritical PF is the technology of choice through 2000. IGCC is projected to be introduced beginning in 2005 and it will become the preferred alternative by 2010. AFBC and PFBC are thought to have limited application.

The barriers to the take-up of the clean coal technologies in Australia and New Zealand are again a direct result of the competitive situation in the electricity industry and can be divided into competition/economic and technical issues. The competitive/economic barriers center on whether the clean coal technologies can provide an acceptable return on investment, competitive capital costs, reduced construction period, and be competitive with gas-fired generation. On the technical side, barriers such as unit size greater than 500 MW, proven reliability, and a lack of information on the technical and cost characteristics are the primary issues. In some instances, existing or new generators had a limited understanding of the attributes of the clean coal technologies.

Beyond the competitive/economic issues, the environment also has a strong influence on the take-up of new technology. The environmental anti-coal lobby is becoming a growing force that must be considered. In addition, there are low cost CO2 mitigation strategies that will be considered before coal-fired technologies.

Consideration of policies and measures to overcome the barriers to the take-up of the clean coal technologies is not a well developed concept in Australia and New Zealand because the clean coal technologies are not under active consideration. In keeping with that situation, there appears to be a limited base of knowledge about the clean coal technologies that needs to be addressed by a better dissemination of pertinent information.

Japan

The assessment for Japan is taken from yearly reports to the Ministry of International Trade and Industry (MITI) prepared by the 10 regional electric utilities. Data on regional demand and demand growth is reported and organized by fuel type. Information concerning the take-up of the clean coal technologies was provided by both major equipment suppliers and the regional utilities. This information has been compiled into a report entitled "Study on Evolution of Energy-Efficient, Coal-Fired Generating Technology (Regional Studies Asia-Pacific)", prepared by the Electric Power Development Company.

The expansion of electricity generation installed capacity will continue to be driven, at least until the beginning of the 21st century, by the concept of diversification of the fuel mix to increase the security of supply. Power generation capacity in Japan is expected to increase by 101 GW through 2010. During the period 1996 through 2005, 70.7 GW of capacity will be added with 10.1 GW hydro, 21.7 GW coal, 26.5 GW LNG plus LPG, 0.4 GW of Orimulsion, 0.1 GW of geothermal and 14.6 GW of nuclear At the same time oil and other gas capacity will decrease by 2.0 GW.

Clean coal technologies will play a major role in the coal-fired capacity being planned. Ultra supercritical steam cycle (USC) technology and PFBC will play a major role in the new coal-fired capacity additions. Candidate projects, so dubbed because all details of the installations have not been finalized, account for 4.6 GW of capacity, 4.1 GW USC and 0.5 GW of PFBC. Japan currently has 16.6 GW of supercritical and USC and 400 MW of AFBC capacity operating in the country as well as a 70 MW PFBC unit. Two additional 350 MW PFBC units are in the planning stage.

Environmental regulation in Japan is becoming more and more severe. Citizen groups are taking a more active role in shaping agreements between the local authorities and the utilities. In some situations power plants have had to install a dry flue gas desulfurization system based on scrubbing with activated char. This advanced emission control system has similar capital costs to FGD and SCR but has higher operating costs due to the activated char.

The Japanese Government has supported the take-up of the advanced flue gas desulfurization and selective catalytic reduction technologies, so far, by establishing a shorter depreciation period of 7 years as opposed to the normal 15 years. In addition, MITI often provides financial support for the demonstration of the clean coal technologies. However, recent moves to deregulate the electricity industry in Japan constitutes a new barrier to clean coal technologies in Japan. As a result, the cost factor and increased competition is causing the utilities to become more conservative in their choice of clean coal technologies and less able to accept long-term returns.

IV. CONCLUSIONS

The following discussion presents specific conclusions from the regional assessments:

OECD North America

- Growth in generating capacity in the region until 2015 is projected to be 204 GW with 21 GW of coal-fired capacity.
- The attitude towards the clean coal technologies is shaped by the following factors:
  - ➪ deregulation is delaying long-term decisions on capacity.
  - ➪ little need for base load capacity.
  - ➪ capital costs, reliability, fuel costs and environmental constraints are key criteria for selecting technology for new capacity additions.
- Barriers to the take-up of the clean coal technologies are:
  - ➪ increased availability of natural gas and relatively lower capital costs for natural-gas fired technologies.
  - ➪ high capital costs of PFBC and IGCC.
  - ➪ lack of commercially demonstrated reliability and operability.
  - ➪ lack of awareness of attributes by potential developers.
- Policies and measures that could overcome the barriers are:
  - ➪ change negative attitude of government and public towards coal.
  - ➪ provide financial and regulatory incentives, e.g. tax relief, specialized depreciation, financial support, and permitting relief for the early commercial applications (first 3 to 5 installations).
  - ➪ implement a program to inform IPP's and other developers on the virtues of the clean coal technologies.

OECD Europe

- Growth in generating capacity in the region until 2015 is projected to be 82 GW with 1 GW of coal-fired capacity.
- The attitude towards the clean coal technologies is shaped by the following factors:
  - ⇨ deregulation has redefined priorities from reliability/availability to economic.
  - ⇨ environmental limitations remain a strong consideration.
  - ⇨ natural gas appears to have advantages in some countries where it is available and competitively priced.
  - ⇨ countries with demonstration projects have a higher confidence in the clean coal technologies.
  - ⇨ supercritical PF viewed as a proven technology in some countries.
- Barriers to the take-up of the clean coal technologies are:
  - ⇨ low capital costs of natural gas-fired technologies.
  - ⇨ opportunity for the installation of base-load coal-fired capacity negligible.
  - ⇨ economic competitiveness in question.
  - ⇨ uncertainty of commercial status and reliability of PFBC and IGCC.
- Policies and measures that could overcome the barriers are:
  - ⇨ reduce capital cost through favorable financial incentives.
  - ⇨ harmonize emission limits and energy taxes.
  - ⇨ virtues of coal should be publicized.
  - ⇨ conduct pilot/demonstration projects in more countries.

Southern Africa

- Growth in generating capacity in the region until 2015 is projected to be 24 GW with 18 GW of coal-fired capacity.
- The attitude towards the clean coal technologies is shaped by the following factors:
  - ⇨ local and regional development takes precedent over technology choices.
  - ⇨ coal and hydro are the preferred choices when capacity is required.
  - ⇨ clean coal technologies are viewed favorably, but must be proven against competing options on a cost, availability and reliability basis.
- Barriers to the take-up of the clean coal technologies are:
  - ⇨ no generating capacity required until after 2010.
  - ⇨ existing capacity is relatively new.
  - ⇨ hydro focus in the region.
  - ⇨ perception is of high operating costs.
  - ⇨ limited worker skills and supporting infrastructure.
  - ⇨ deregulation and competition defer decisions and increase risk avoidance.
  - ⇨ demonstration of acceptable environmental performance on local coal.

- Policies and measures that could overcome the barriers are:
  - ➩ catalyze economic growth.
  - ➩ apply joint implementation/activities implemented jointly provisions of the UN FCCC.
  - ➩ increase the communication of RD&D technology information.
  - ➩ improve costs, availability and reliability.
  - ➩ direct government intervention, e.g. financial incentives.

OECD Asia/Pacific

- Growth in generating capacity in the region until 2015 is projected to be 303 GW with 45 GW of coal-fired capacity and 43 GW of that installed in Japan.
- The attitude towards the clean coal technologies is shaped by the following factors:
  - ➩ deregulation/competition is becoming a significant factor in capacity choices.
  - ➩ environmental limitations are important.
  - ➩ Japan's capacity choices driven by national goal of diversification of fuel mix to increase the security of supply.
  - ➩ return on investment, environmental, politics and capital cost drive capacity decisions.
- Barriers to the take-up of the clean coal technologies are:
  - ➩ deregulation/competition in electricity industry.
  - ➩ lack of proven availability and financial risk at unit sizes greater than 500 MW.
  - ➩ trend toward cost cutting.
- Policies and measures that could over come the barriers are:
  - ➩ government financial incentives.
  - ➩ encourage market competition between technologies.
  - ➩ better methods for disseminating information.

V. REFERENCES

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INTERNATIONAL ENERGY AGENCY
COAL INDUSTRY ADVISORY BOARD

INDUSTRY PERSPECTIVES ON INCREASING THE EFFICIENCY OF COAL-FIRED POWER GENERATION

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ABSTRACT

Independent power producers will build a substantial fraction of expected new coal-fired power generation in developing countries over the coming decades. To reduce perceived risk and obtain financing for their projects, they are currently building and plan to continue to build subcritical coal-fired plants with generating efficiency below 40%. Up-to-date engineering assessment leads to the conclusion that supercritical generating technology, capable of efficiencies of up to 45%, can produce electricity at a lower total cost than conventional plants. If such plants were built in Asia over the coming decades, the savings in carbon dioxide emissions over their lifetime would be measured in billions of tons.

IPPs perceive supercritical technology as riskier and higher cost than conventional technology. The truth needs to be confirmed by discussions with additional experienced power engineering companies. Better communication among the interested parties could help to overcome the IPP perception issue. Governments working together with industry might be able to identify creative financing arrangements which can encourage the use of more efficient pulverised clean coal technologies, while awaiting the commercialisation of advanced clean-coal technologies like gasification combined cycle and pressurised fluidised bed combustion.

EXECUTIVE SUMMARY

- New generating capacity required globally between 1993 and 2010 is estimated to be around 1500 GW, of which some two-thirds will be outside the OECD, and some 40% in the Asian non-OECD countries. Coal is likely to account for a substantial fraction of this new generation, and with liberalisation of electric power markets driven by the need for inward investment, independent power producers are likely to build a substantial number of the coal-fired power plants in developing countries.

- Today's state-of-the-art supercritical coal-fired power plant has a conversion efficiency of some 42-45%, about 5 percentage points higher than that of the conventional subcritical plants which continue to be built in most projects in non-OECD countries. If supercritical plants were to be built instead, the amount of incremental carbon dioxide not released to the atmosphere over the next few decades as a result of electricity generation would be measured in the billions of tons, without constraint on energy and economic growth. Depending on the generating efficiencies achieved, the CO_2 emission reductions over the lifetime of the plants built during one decade of growth in Asia alone could amount to 5-10 billion tons.

- With more than 350 supercritical units operating world-wide today, and more than two decades of experience and development of this technology, their reliability today is assessed by authoritative observers and operators of power plants to be at least as good as that of conventional sub-critical plants.

- A new engineering assessment by an international power engineering firm concludes that the capital cost increase associated with a supercritical or ultra-supercritical pulverised coal power plant compared to a conventional subcritical plant is small to negligible. The reason is that capital cost increases specific to the supercritical plant (e.g. associated with superior materials and other design features) are counter-balanced by the capital cost savings associated with the fact that the boiler and ancillary equipment can be smaller due to the increased efficiency.

- The increased efficiency associated with the supercritical plant leads to an actual reduction in the total cost of electricity generated in cents/kWh, relative to a conventional plant. In fact, depending on fuel price, an ultra-supercritical plant with flue gas desulphurisation, selective catalytic reduction for post-combustion NOx control, and a high efficiency baghouse for particulate control, can produce marginally cheaper electricity than a conventional subcritical plant with only an electrostatic precipitator for particulate control.

- Despite this, the independent power sector continues to build subcritical plants and has no near-term plans to increase the efficiency of power plants in the projects it is developing. There is a clear perception among IPP companies that supercritical technologies are both more expensive and contain more risk than subcritical technologies. Part of the reason for this appears to be innate conservatism among their technology suppliers and project financiers.

- IPP companies' decision-making is driven primarily by the issues of reliability, technology cost, government regulation, and lender attitudes or financing constraints. Generating efficiency is perceived to be of second-order importance.

- Advanced clean coal technologies such as integrated gasification combined cycle and pressurised fluidised bed combustion will be selected for independent power projects only in very specific circumstances, where their technology and other risks are fully covered and their incremental costs are recovered in the price of electricity. Market penetration on a wider scale is seen by the IPPs as being in the 2005-2010 timeframe or beyond.

- It appears that the only way to accelerate this is to complete a number of successful demonstrations which, in particular, show that advanced clean coal plants can be operated reliably and with superior performance, and specifically that their present estimated capital costs can be reduced substantially to a point where they are competitive with state-of-the-art pulverised coal technologies. These second- or third-of-a-kind demonstrations are likely to require financial support by governments if they are to be realised.

I. INTRODUCTION

The CIAB's Global Climate Committee was asked by the IEA to assess the evolution of energy-efficient coal-fired power generation in non-OECD countries.. The primary market for coal over the coming decades will be electricity generation, especially in the newly industrialising countries of the developing world. Estimates of the amount of new generation required between 1993 and 2010 are in the region of 1500 GW, of which more than 700 GW are in the non-OECD countries (Figures 1, 2). Coal is expected to account for a large proportion of new electricity generation (Figure 3).

The global issues of sustainable development and the enhanced greenhouse effect are topics of importance to IEA Member governments and CIAB members. Coal, as a fossil fuel with a reserve base measured in centuries rather than decades, is an important part of the global economic-energy-environment equation. It is clear that for the newly industrialising economies to sustain the major growth phase now in progress, coal must play its part as an efficient and environmentally sound source of energy.

Today's state-of-the-art supercritical pulverised coal-fired power plant has a conversion efficiency of some 42-45% (lower heating value - LHV), about 5 percentage points higher than that of the conventional subcritical plants which continue to be built in most projects in non-OECD countries. The main question addressed by this paper is, what would be needed to have state-of-the-art technology accepted for new power projects in these countries? If this were achieved, the amount of incremental carbon dioxide not released to the atmosphere over the next few decades as a result of electricity generation would be measured in the billions of tons, without constraint on energy and economic growth.

The necessary growth of electricity generation capacity in the industrialising countries will require very substantial inward investment. In order to attract this investment, generation of electricity is being privatised in an increasing number of countries. The involvement of independent power producers (IPPs) in private power projects in a number of countries is an important part of this process.

The CIAB took a two-pronged approach to the issues related to improving generating efficiency in new coal power generation in non-OECD countries. A consultant, SEPRIL, jointly owned by the Electric Power Research Institute and Sargent & Lundy), was engaged to provide an analysis of costs and other issues in the comparison of subcritical, supercritical and ultra-supercritical pulverised coal plants in these countries. At the same time, in order to benefit from the insights which IPPs have gathered as a result of their experience to date in private power projects and business development in newly industrialising countries, the CIAB designed a relatively simple survey by telephone interview. The most appropriate people to respond to such a survey were identified and the interviews carried out between April and July 1996.

The results of the IPP Survey are summarised in the next Section. The findings of the cost and performance comparative analysis are presented in Section III.

II. OVERALL SUMMARY OF SURVEY RESULTS

A total of fourteen companies took part in telephone interviews and/or provided written responses to the CIAB Questionnaire. The companies taking part in the Survey were:

ABB Carbon	AES Corporation
Babcock and Wilcox	Black and Veatch
Community Energy Alternatives	CMS Generation
Duke Energy	Edison Mission Energy
Elsamprojekt	Entergy Power Systems
IVO Energy International	National Power
NRG Energy	Southern Electric International

The majority of those interviewed represented independent power producing companies involved in developing power projects in non-OECD countries. However, representatives of several power engineering/construction companies and technology suppliers also participated. Those who agreed to take part in the Survey were assured that the anonymity of their responses would be protected, and that the results of the Survey would be shared with them as soon as possible.

There was a high degree of consensus among the participants in their response to the questions, which makes it relatively simple to draw broad conclusions. The main lessons to be drawn from the Survey are the following:

1. Technologies used or foreseen

The vast majority of projects use or plan to use sub-critical pulverised coal technologies for larger plants, with some smaller projects using atmospheric fluidised bed combustion (AFBC) technology. Supercritical pulverised coal technology is viewed as technically commercialised but riskier and more costly, and needing incentives such as high priced fuel to be the technology of choice. Pressurised fluidised bed combustion (PFBC) and integrated coal gasification combined cycle (IGCC) technologies may be used in special circumstances (e.g. government support) in the coming years, but are unlikely to come into widespread use by IPPs until 2005-2010 or beyond.

2. Environmental Requirements

The World Bank Environmental Guidelines play a major and increasing role in most countries. Most IPPs and developing countries are aware of a 1995 draft of these which is stricter than the 1988 official version, and believe these new guidelines will be implemented shortly. Some IPPs have corporate environmental guidelines which go beyond the World Bank ones; however, to go too far beyond raises economic competitiveness issues.

3. Main Factors influencing Technology Selection

The results of a poll included in the Survey, on the principal factors influencing technology selection and their relative importance in decision-making, are shown in Table 1 below.

TABLE 1

CIAB IPP Survey Responses
Impact of Different Factors on Coal Power Generation Technology Selection
1 = Not important 5 = Extremely important

Response No.	1	2	3	4	5	6	7	8	9	10	11	12	14	15		Mean	S.D.
Environment	4	4	3	4	2	4	5	3	4	3.5	4	4	5	5		3.9	0.83
Efficiency	4	3	3	4	2	3	4	3	5	4.5	3	5	4	3		3.7	0.9
Reliability	4	4	4	5	5	5	4.5	5	5	5	3	5	4.5	5		4.6	0.6
Maintainability	3	5	4	5	4	5	4	5	4	4	3	4	4	5		4.2	0.68
Technology Cost	5	5	5	4	4	5	5	4	5	5	5	4	3.5	5		4.6	0.55
Technology Maturity	3	4	4	4	5	3	4	4	4	4	4	5	3	5		4	0.65
Technology Risk	3	4	4	5	5	3	3	4	4	4	4	4	5	5		4.1	0.7
Build Time	4.5	4	3	4	3	3	3	3	5	4	3	4	3	3		3.6	0.78
Fuel Flexibility	2.5	4	2	4	2	3	5	3	3	3	3	5	5	2		3.3	1.07
Operational Flexibility	3	3	3	4	2	3	3	3	4	3.5	3	4	3	3		3.2	0.56
Need for Skilled Operators	3	4	1	3	3	4	3	3	3	3.5	3	4	3	5		3.3	0.88
Customer Specifications	4	5	5	4	5	2	3	3	4	4	3	4	3	3		3.7	0.88
Financing Constraints	4.5	5	4	4	3	5	5	4	5	5	4	5	5	5		4.6	0.62
Lender Attitudes	4	4	3	4	4	4	5	4	4	4	4	5	5	3		4.1	0.59
Government Regulation	3.5	4	5	5	4	5	5	4	5	5	4	5	5	1		4.4	1.08

S.D. = Standard Deviation

Reliability, technology cost, and financing constraints were voted the most important factors (averaging 4.6 on a scale of 1 to 5 in importance). The standard deviation in the responses was relatively small, of the order of 0.6, indicating a strong consensus on these factors. The next most important factors were government regulation (4.4), maintainability (4.2), technology risk and lender attitudes (both 4.1), technology maturity (4.0), and environment (3.9). Interestingly, the need for skilled operators scored relatively low in the poll (3.3), the IPP view being that it is relatively easy to find and train operators.

4. Power Plant Conversion Efficiencies

Most coal-fired power plants being planned or built today use sub-critical technology and have conversion efficiencies in the range of 37-39% on a lower heating value (LHV) basis (9200-8700 Btu/kWh). Responses on future trends in efficiency over the next 5-10 years were mixed, though few expect increases of more than a few percentage points.

5. What it would take to improve Generating Efficiencies

The present cost of fuel in non-OECD countries is perceived to be a disincentive to achieving significant increases in generating efficiency. Only when fuel is expensive will competitive pressures by themselves lead to efficiency improvements. Stricter environmental requirements could play a role (especially constraints on carbon dioxide emissions). Governments can mandate efficiency standards, but this is not seen as likely unless there is a strong national or international reason for doing so.

There is a common perception of higher capital and operating cost, and risk of reduced plant operating reliability, associated with supercritical pulverised coal technologies, both among IPPs themselves and, perhaps more important, among their engineering and technology supply partners. The latter are normally expected to bear the technology risk in an IPP project, which tends to bias them towards conservatism. Some of the higher cost may also in fact be due to the higher perceived risk premia in project-financed IPP plants. There may be an information gap here that could be bridged by further dialogue.

The responses to the IPP Survey have highlighted a perception that supercritical pulverised coal technology is both costlier and riskier than conventional subcritical technology. How justified is that perception? The other part of this assessment, described in Section III. below, attempts to respond to this question.

III. Comparison of Supercritical Versus Subcritical Plant performance

In order to assess the cost-effectiveness and environmental performance of SC and USC coal-fired generating plants versus a "conventional" subcritical plant of the type used in most IPP projects today, an analysis of comparative performance and cost was carried out using the SOAPP data-base, for a 600 MW PC-fired plant in an Asian location. The plant capacity factor is 81%. The coal sulphur content is 0.9%.

For this case study, the following scenarios were evaluated:

(1) 2400 psig subcritical plant with an electrostatic precipitator for particulate control and low-NOx burners, but no post-combustion sulphur or nitrogen oxide controls (Conventional Plant).

(2) 3500 psig supercritical plant (SC).

(3) 4500 psig ultra supercritical plant (USC).

(4) 4500 psig ultra supercritical plant with spray dryer FGD, SCR, and baghouse for particulate control (USC w/FGD, SCR).

The analysis was carried out for two variants of capital cost and for two types of coal. The higher level of capital cost (~$800/kW for a subcritical plant without FGD) corresponds to that for a plant built in an advanced OECD country, and the lower capital cost (~$620/Kw) to that for a similar plant constructed in a developing country such as China. The lower priced coal (~$15/short ton, heating value 7900 Btu/lb) might be that for a minemouth coal plant, and the higher coal price (~$40/short ton, heating value 12000 Btu/lb) might be the landed price of internationally traded coal at a coastal power plant.

1. Plant Efficiency

The plant efficiency comparison is shown in the Figure 4. Compared to the conventional subcritical plant's 38% efficiency, a supercritical plant can readily achieve 41% and an ultra-supercritical one 45% on an LHV basis. It would be possible for a subcritical plant to achieve greater efficiency via higher temperatures (up to about 40%). The "conventional" plant in this comparison, however, is intended to represent one typical of many IPP coal plants currently in operation, construction, or project development.

2. Fuel Consumption

The plant efficiency improvements result in significant reduction in fuel consumption. A 600 MW conventional plant has a primary fuel feed rate (100% load) of ~ 750,000 lb/hr. The more efficient USC plant has a primary fuel feed rate of 645,000 lb/hr. This translates to over ~375,000 short tons/year of coal not combusted, which results in a fuel cost savings of approximately $6 million/year for a USC plant vs. a conventional plant based on a fuel cost of $15 per ton delivered (calorific value 7900 Btu/lb), or approximately $10 million/year if the fuel cost is $40/ton (calorific value 12000 Btu/lb).

3. CO_2 Emissions

With the recent attention focused on the international greenhouse issue, emissions of CO_2 from coal-fired power plants have received increasing attention. The annual mass CO_2 emissions for the conventional, SC and USC plants are ~5.2 million short tons, 4.8 million tons, 4.4 million tons, respectively (Figure 5). This represents 8% emission reduction for the SC and 15% for the USC plant relative to the conventional subcritical technology. Consequently, even the intermediate step of the supercritical plant reduces CO_2 emissions by almost a half million tons per annum for a 600 MW plant, or 0.7 million tons/GW. Over the 40 year lifetime of 1 GW of new coal generation, 28 million tons less CO_2 would be emitted. Asia alone may need to construct 15 GW per year of new coal generation over the next two decades, according to the IEA's World Energy Outlook (9). Thus one year's incremental generation would produce 420 million tons less CO_2 during its lifetime, and the savings from one decade of this growth would amount to almost 5 billion tons of CO_2. And going to ultra-supercritical plants would double this. The stakes are clearly rather high.

4. SO_2 and NOx Emissions

Emissions of gaseous pollutants are also reduced by building more efficient plants. The emission control equipment required for a plant depends on the coal selected and the applicable emission regulations. Currently, most plants in Asia are being installed without FGD Systems and with low NOx boiler burner equipment. This approach is based on the use of low sulphur coal, the cost, and current national air emission regulations or World Bank environmental guidelines. Emissions of both conventional pollutants (SO_2, NO_X, particulate, etc.) and carbon dioxide are lower for the more efficient supercritical plants than for the traditional subcritical plant. When comparing plants without post-combustion air pollution controls, mass emissions of SO_2 are reduced by 3300 tons/year, and emissions of NO_x by 1180 tons/year for a USC plant compared to a conventional plant (Figure 6).

With the use of state-of-the-art air pollution controls, emissions of conventional pollutants can be reduced to ultra-low levels. The USC plant equipped with a lime spray dryer, SCR, and baghouse can produce emissions of 0.11 lb/MBtu SO_2, 0.06 lb/MBtu NO_X, and 0.005 lb/MBtu particulate. The emissions could be reduced by up to ~90% with this percentage sulphur coal. This low emissions boiler would be able to satisfy the most stringent regulatory requirements. The additional capital cost for this system on a 600 MW unit with low sulphur coal fuel (0.9%) would be approximately $130/kW. This cost increment is relatively low because the spray-dryer/baghouse combination is substituted for the precipitator included in the other cases.

5. Plant Reliability

Though this was not a variant in this assessment, it is worth a brief mention of the issue of supercritical versus subcritical power plant reliability. Experience with the higher temperatures and pressures involved in supercritical technology has grown substantially over the past two decades, and earlier technical problems have been to a large extent overcome by improvements in materials and design. There remain some corrosion problems stemming from the higher temperatures, which makes supercritical less suitable for high slagging or corrosion coals. Coal with greater than about 2% sulphur has caused some superheater and reheater difficulties. However, these difficulties are not necessarily specifically related to the sulphur content - coal chlorine and other constituents can have a major impact on the corrosion rates.

There are options which boiler manufacturers can employ with more corrosive coals to mitigate these problems. Boiler design optimisation options include a larger furnace for lower gas temperatures entering the reheater and superheater, use of higher alloy materials which have recently become available, tube shields, a tube cooling screen before the superheater and reheater, boiler water and steam circuitry to reduce high gas temperatures because of uneven gas and steam/water exchange in the combustion and other heat transfer zones, and other means.

Boiler tube leaks are a major issue for plant operation, often being the cause of loss of reliability. There is occasionally a tendency to generalise the difficulties caused by tube leakage problems, e.g. water wall leaks are not differentiated from superheater and reheater problems. However, tube leaks are often caused by water chemistry problems and not directly related to the coal quality. Many units have switched to "oxygenated" cycle chemistry, which has proven to reduce tube leaks very substantially.

It is possible that commercial risks for a supercritical plant burning greater than 2% sulphur coal might be subject to greater premiums owing to less historical experience. However, many of the plants to be built in Asia over the coming decades will use relatively low sulphur coal, so this issue may be only be encountered for plants attached to some specifically higher sulphur reserves.

IV. COST COMPARISON OF SUPERCRITICAL VERSUS SUBCRITICAL PLANTS

The capital costs differences (higher capital cost case) are shown in Table 2, which also separates out the main items for which the cost increases in the supercritical and ultra-supercritical plants relative to the conventional plant.

Table 2. Capital Costs of Supercritical versus Subcritical Generating Plants

$/kW		Subcritical	Supercritical	Ultra-Supercritical	Ultra-Supercritical with FGD System & SCR
Boiler (incl.steel;, air heater, etc.)		$142.94	$153.09	$163.52	$163.52
% compared to base		Base	107.1%	114.4%	114.4%
Boiler plant piping		$27.81	$31.03	$31.81	$31.81
% compared to base		Base	111.6%	114.4%	114.4%
Feedwater systems		28.06	$28.62	$29.18	$29.18
% compared to base		Base	102.0%	104.0%	104.0%
Turbine-Generator		$79.20	$82.37	$83.95	$83.95
% compared to base		Base	104.0%	106.0%	106.0%
Turbine plant piping		$16.25	$15.44	$15.43	$15.43
% compared to base		Base	95.0%	95.0%	95.0%
Subtotal for boiler, turbine, high pressure piping, feedwater systems		$294.26	$310.38	$323.91	$323.91
% compared to base		Base	105.5%	110.1%	110.1%
Remainder of Plant		$509.17	$500.69	$487.17	$604.76
% compared to base		Base	98.3%	95.7%	118.8%
Total Plant Cost		$803.43	$811.07	$811.08	$928.67
% compared to base		Base	101.0%	101.0%	115.6%

The plant would have two units with low NOx burners, high efficiency particulate collection equipment, once through sea water cooling, including the switch yard and all the facilities for a new site location, and a 60 month construction schedule. The capital costs in Table 2 include the plant equipment, structures, switchyard, and coal unloading facilities.

The increases in cost for the higher pressure cycles plants are not as high as was evident in previous evaluations performed several years ago, because of better materials, equipment designs and other technological knowledge, and growing experience with the higher pressure and temperature cycles. Another factor is the beneficial impact of the higher efficiency cycle on the overall plant costs, in the form of reduced costs for smaller coal handling systems, precipitators, and cooling systems, etc. These cost reductions offset the increased costs for the higher pressure and temperature cycle boiler, turbine, piping, pump, feedwater heater, etc. equipment. This is shown graphically in Figure 7.

It is of course a valid question as to whether the substantial cost savings realised during recent years in subcritical plant design and construction may not be easily translated to supercritical and ultrasupercritical designs. While it is unlikely that plant designs for supercritical have reached the same "off-the-shelf" sophistication which the construction engineering firms now offer for subcritical plants, there is no a priori reason why the same competitive forces which led to these offerings should not come into play as soon as there is a demand for cost-effective supercritical plants.

Table 3 summarises the economic parameters used to calculate the cost of electricity generated from the different types of plant.

Table 3. Economic Parameters uses in the Comparison

Plant Operating Period = 30 Years	Fuel Cost A = \$15.20/ton, B = \$40/ton
Plant Operating Hours = ~ 85% availability	Interest during construction = 9.8%
Capacity Factor = ~80%	O&M Escalation 2%
Fixed Charge Rate = 13%	\$5/ton Waste Disposal Costs
O&M (fixed) = ~ \$13/kW-year	

Capital charges and fixed O&M are higher for the SC and USC cycles, while total fuel costs are lower for the SC and USC because of the higher efficiencies. The O&M cost estimate was developed using the methods and data typically used for economic comparisons for new projects. The average availability for all three pulverised coal generating cycles included in this study is 85% and the capacity factor for all the units is 80%. This target is based on data from existing plants.

The results are shown in Figure 8(a) and (b) for the lower coal price and Figure 9(a) and (b) for the higher coal price. In each of these Figures, (a) is the higher capital cost case and (b) the lower capital cost case. As expected, the effect of fuel price is very significant. When the higher level of capital cost is used in the analysis, going from conventional to supercritical in the lower coal price case reduces the electricity cost by 0.08 cents/kWh, and in the higher coal price case by 0.23 cents/kWh - almost a factor of three. The corresponding reductions in going from conventional to ultrasupercritical are 0.14 cents/kWh in the lower coal price case and 0.48 cents/kWh in the higher coal price case. Figure 9 shows that the ultrasupercritical plant with state-of-the-art sulphur and nitrogen oxide controls and a high efficiency baghouse for particulate control can produce cheaper electricity than a conventional plant with only a precipitator for particulate control!

When the lower capital cost is used in the analysis, the corresponding reductions in going from conventional to ultrasupercritical are 0.15 cents/kWh in the lower coal price case and 0.46 cents/kWh in the higher coal price case, implying that the choice of whether to use subcritical or supercritical technologies is not very sensitive to general capital cost levels.

V. CONCLUSIONS

The independent power sector has been and remains reluctant to employ advanced clean coal technologies for power generation projects. The current standard appears to be a subcritical pulverised coal plant with flue gas clean-up adequate to meet World Bank Environmental Guidelines. Only minor improvements in generating efficiency are expected by the IPP sector over the next five years.

Advanced clean coal technologies like PFBC and IGCC are expected by independent power producers to be selected only in special cases where their risks are fully covered and incremental costs recovered in the price of electricity produced. Their market penetration on a wider scale without special treatment is seen by the IPPs as being in the 2005-2010 timeframe or beyond. It appears that the only way to accelerate this is to complete a number of successful demonstrations which, in particular, show that advanced clean coal plants can be operated reliably and with superior performance, and specifically that their present estimated capital costs can be reduced substantially to a point where they are competitive with state-of-the-art pulverised coal technologies.

Supercritical pulverised coal technology is perceived as available but more costly and containing added risk in terms of reliability. Also, there are few incentives to employ it in non-OECD countries, especially where coal is inexpensive. There appears to be a perception problem, possibly due to lack of information, which may need to be addressed by the IEA and others, if the advantages of supercritical generating efficiency improvements, both environmental and economic, are to be realised in the near future.

An economic analysis of subcritical versus supercritical state-of-the-art pulverised coal power plants, carried out for the CIAB by SEPRIL, has suggested that supercritical generation is less costly in terms of cost per kilowatt hour of electricity generated. This is especially marked for higher fuel cost but still significant for lower cost fuel.

Two types of action are being undertaken to overcome the perception barrier with regard to supercritical generating technology:

(1) Development of communication among the stakeholders - governments, IPPs, major international construction engineering companies and technology suppliers - to confirm the cost and reliability figures for supercritical versus conventional subcritical technology;

(2) Discussion with financing entities - private banks, multilateral funding organisations, and government export credit agencies - to identify the risk issues and possible creative financing incentives which would encourage the use of more efficient generating technologies.

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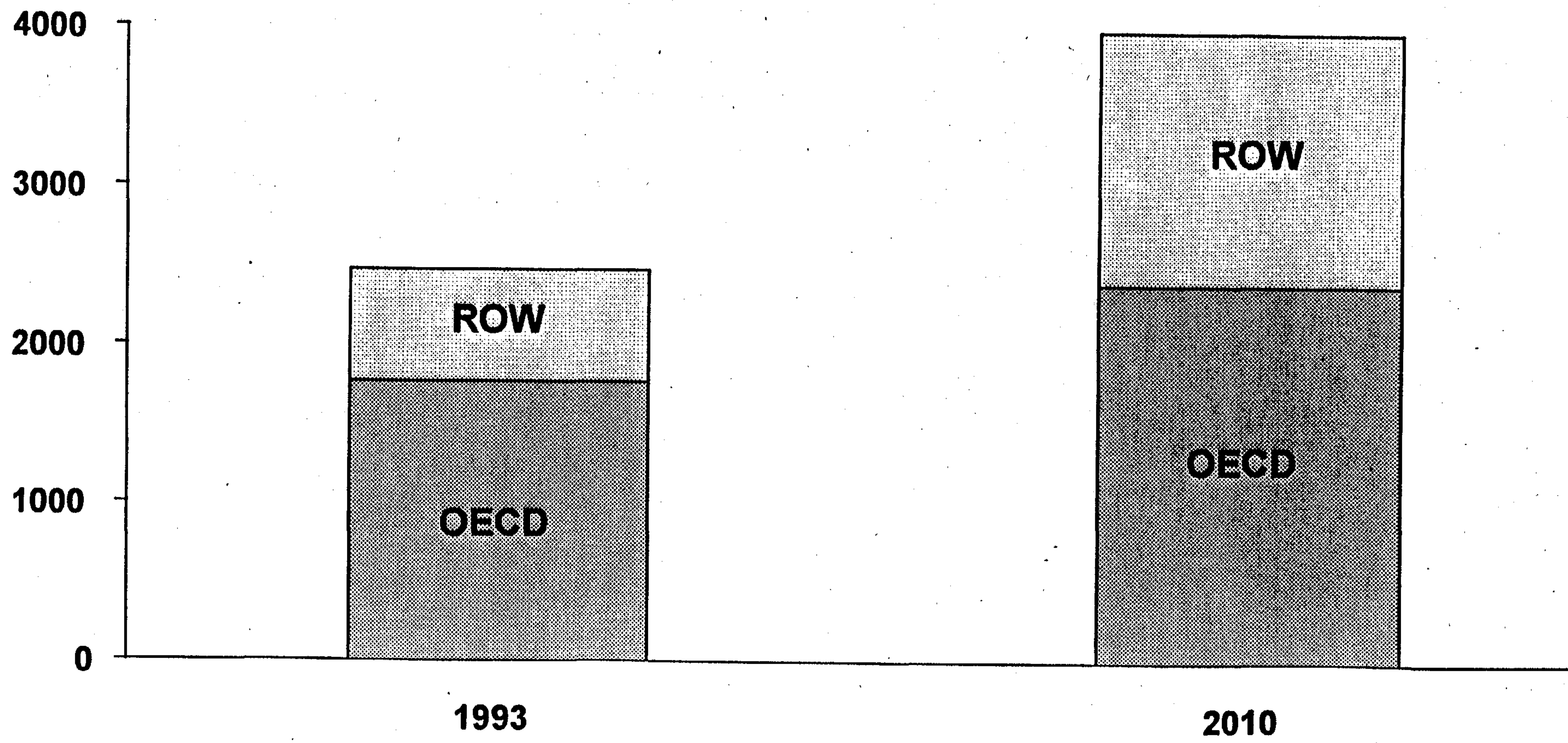
Figure 1

Electricity Generating Capacity Growth (GW)

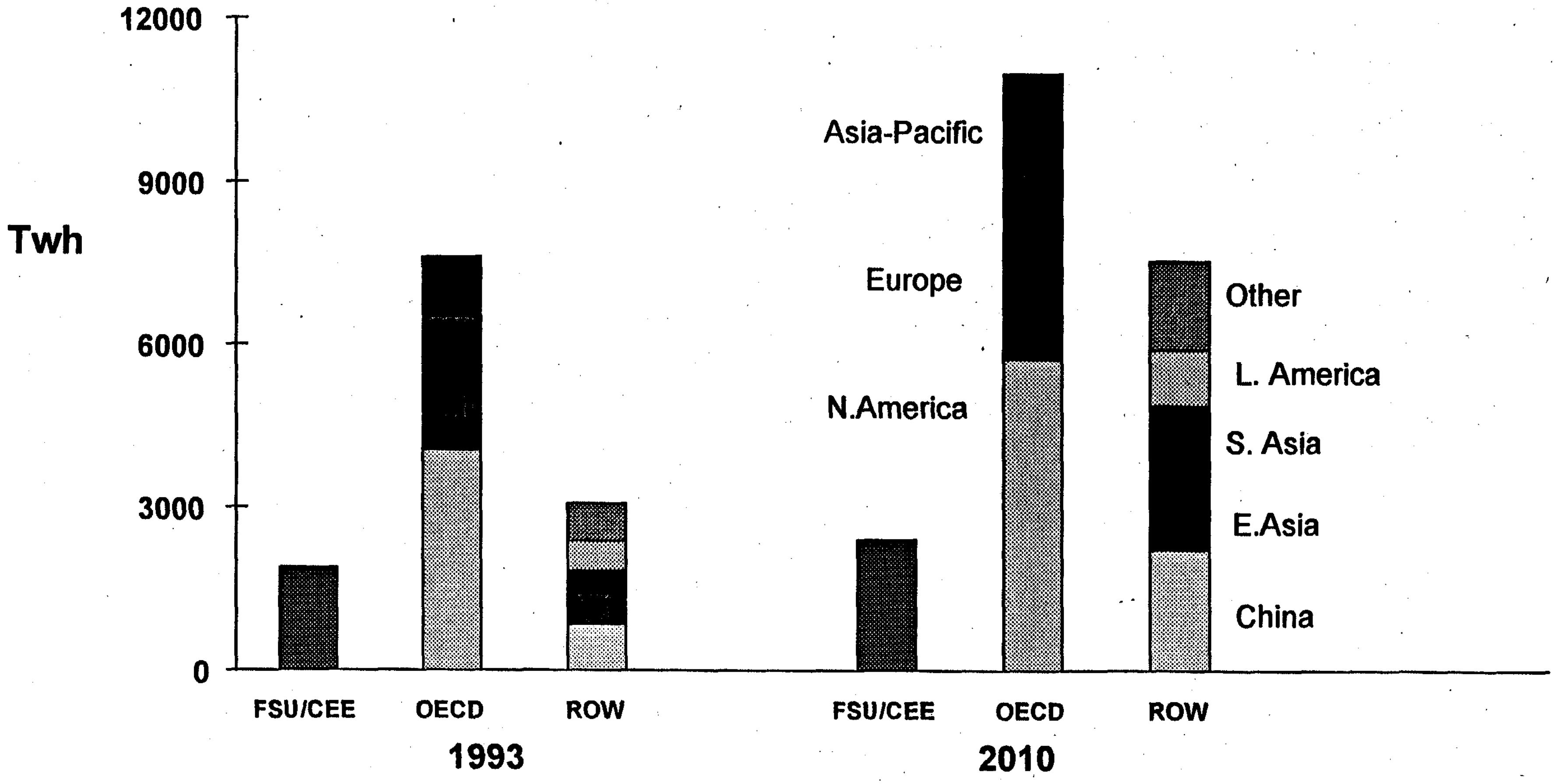
1993 - 2010



Source : IEA World Energy Outlook 1996

Figure 2

Electricity Output by Country/Region(TWh) 1993 - 2010

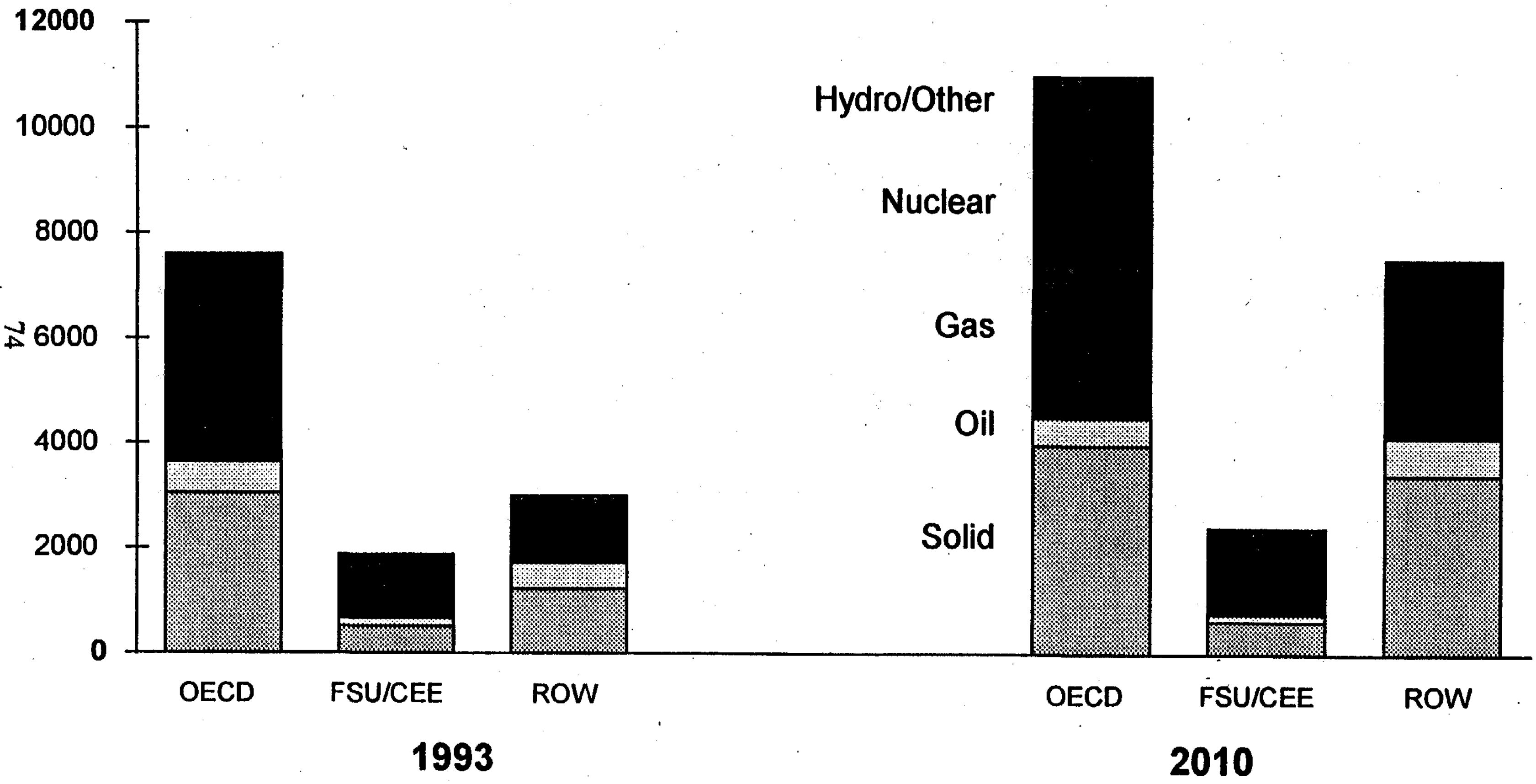


Source : IEA World Energy Outlook 1996

Figure 3

Primary Energy Shares in Power Generation (TWh)

1993 - 2010



Source : IEA World Energy Outlook 1996

Figure 4

Plant Efficiencies (LHV)
Supercritical Versus Subcritical

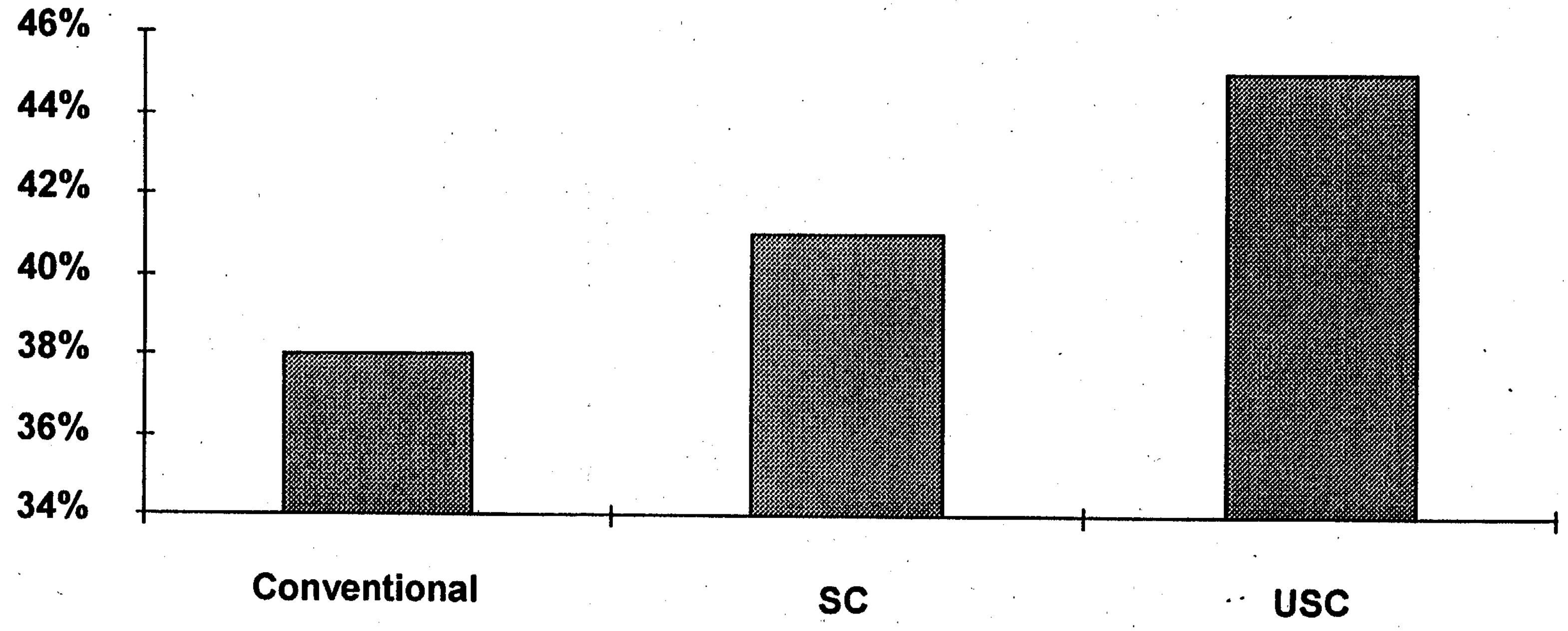


Figure 5

Carbon Dioxide Emissions
(Million Tons/year, 600 MW Unit)

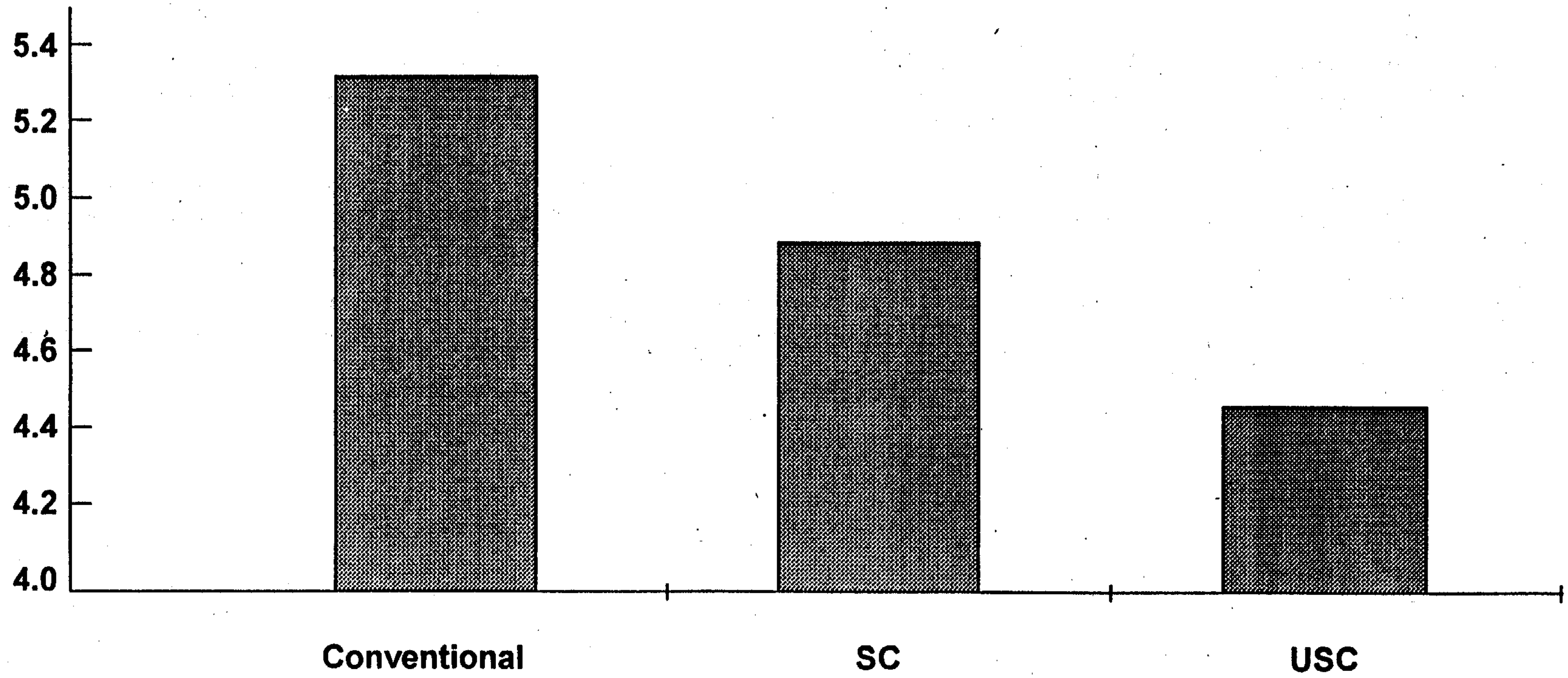


Figure 6

SO_2 & NO_X Emissions (1000 tons/year, 600MW Unit)

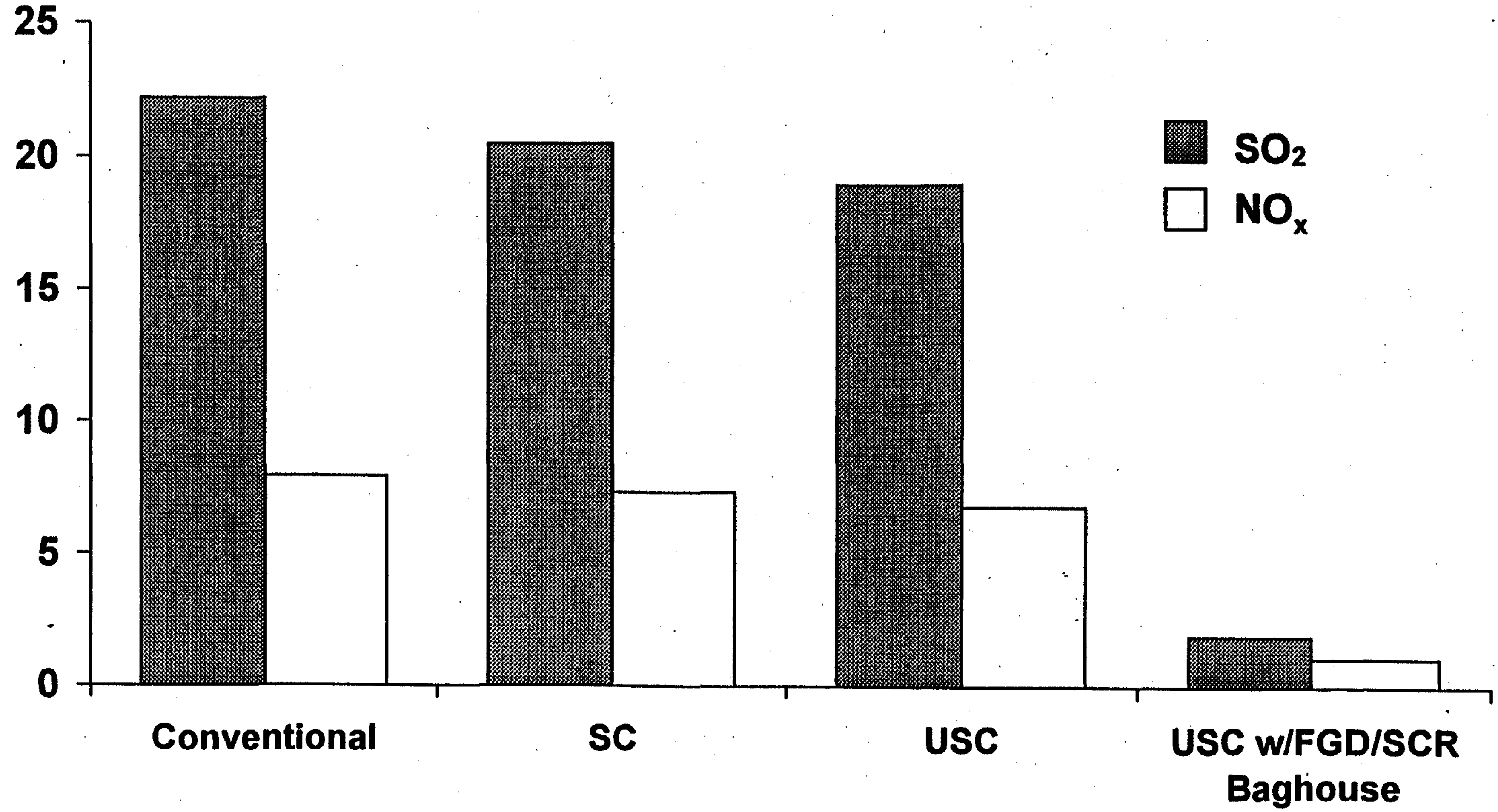


Figure 7

Capital Cost Comparison for 2x600 MW Coal Fired Powerplant

Higher Capital Cost Case

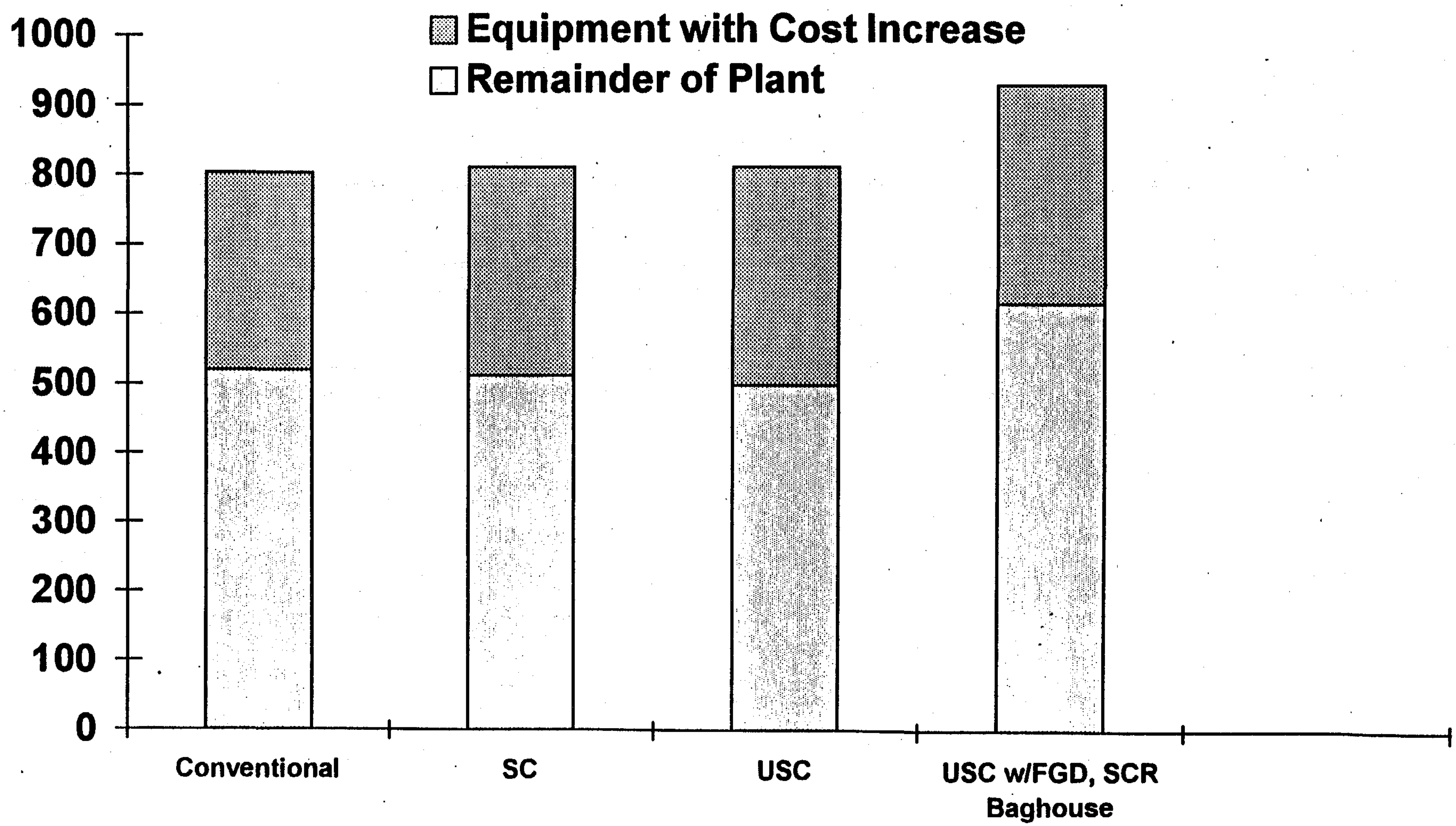


Figure 8 (a)

Cost of Electricity (cents/kWh)

Lower Fuel Cost ($15/ton)
Higher Capital Cost Case

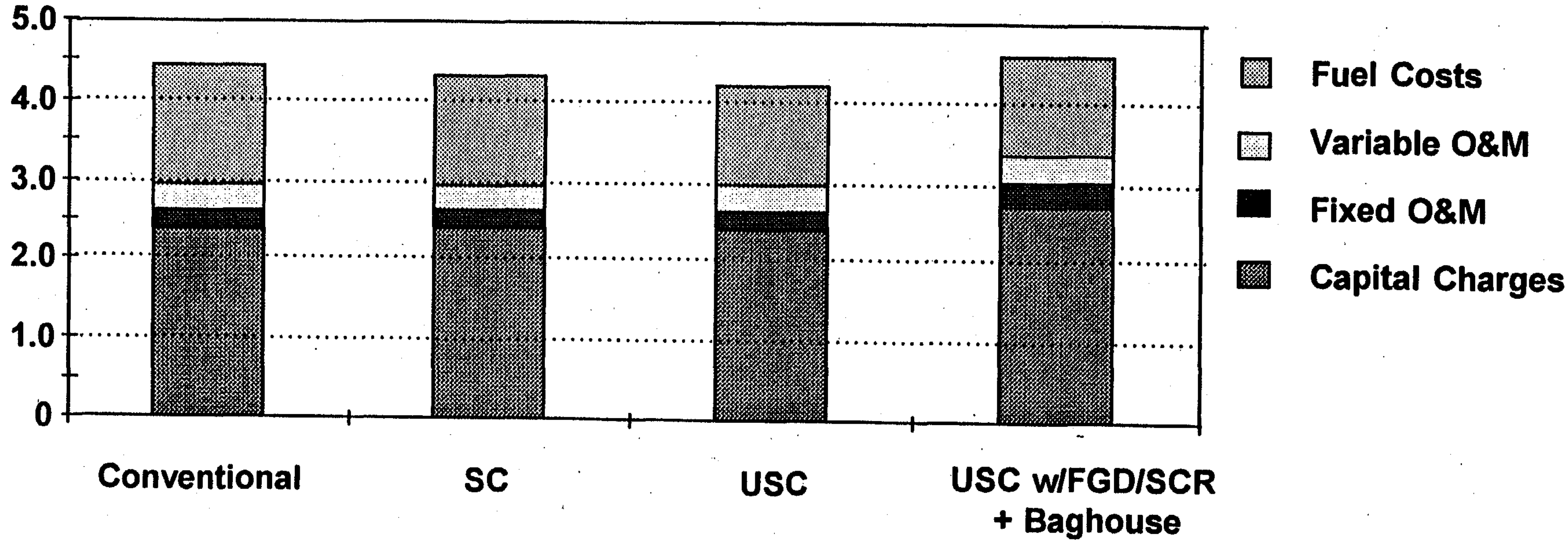


Figure 8 (b)

Cost of Electricity (cents/kWh)

Lower Fuel Cost ($15/ton)
Lower Capital Cost Case

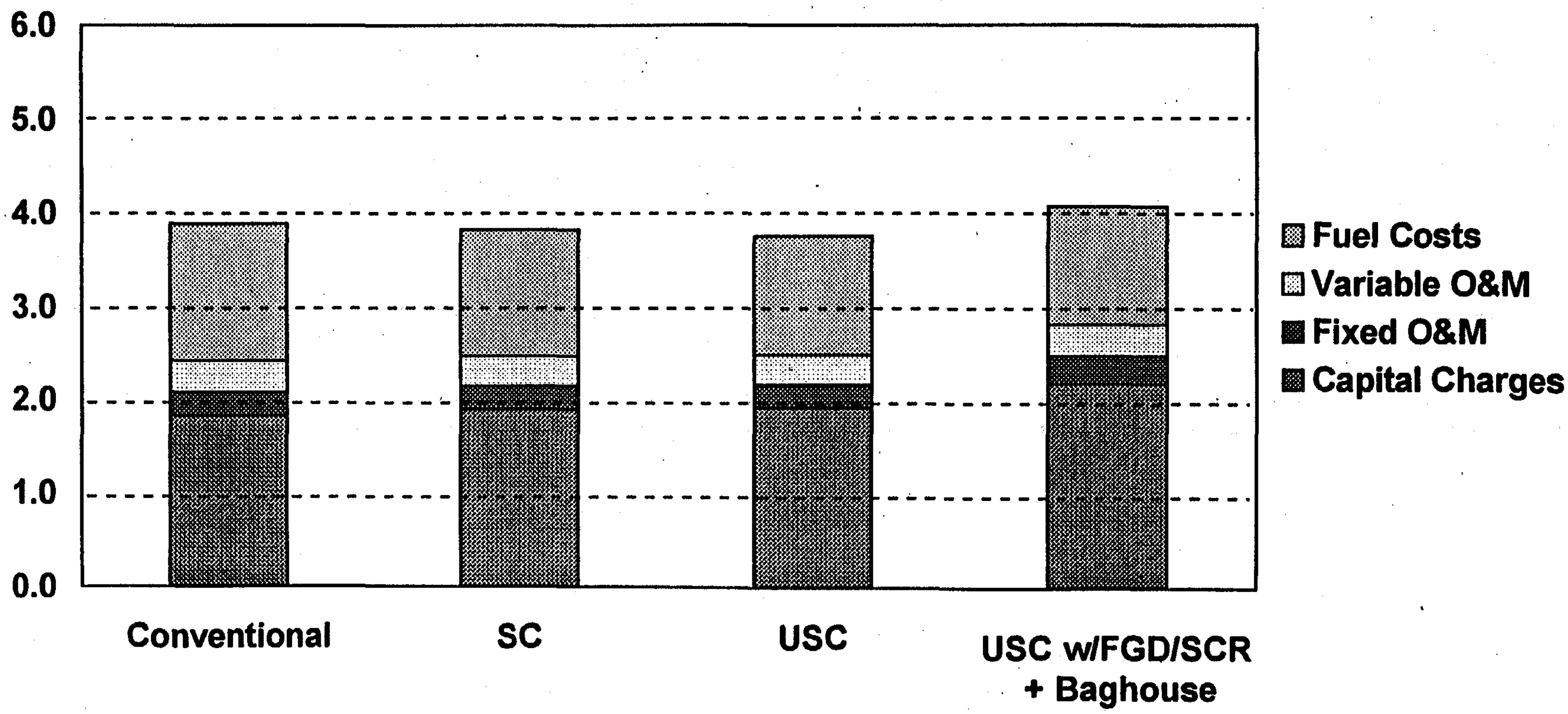


Figure 9 (a)

Cost of Electricity (cents/kWh)

Higher Fuel Cost ($40/ton)
Higher Capital Cost Case

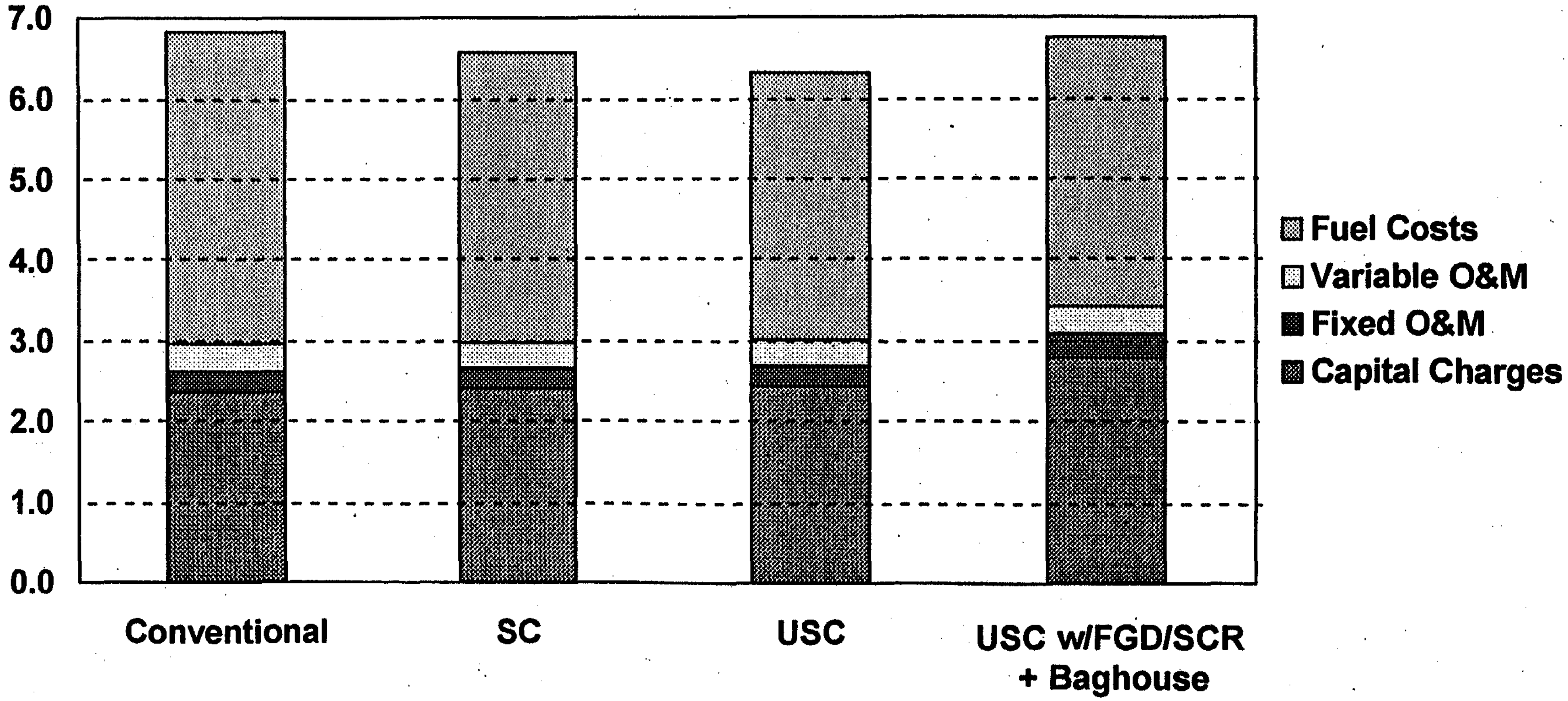
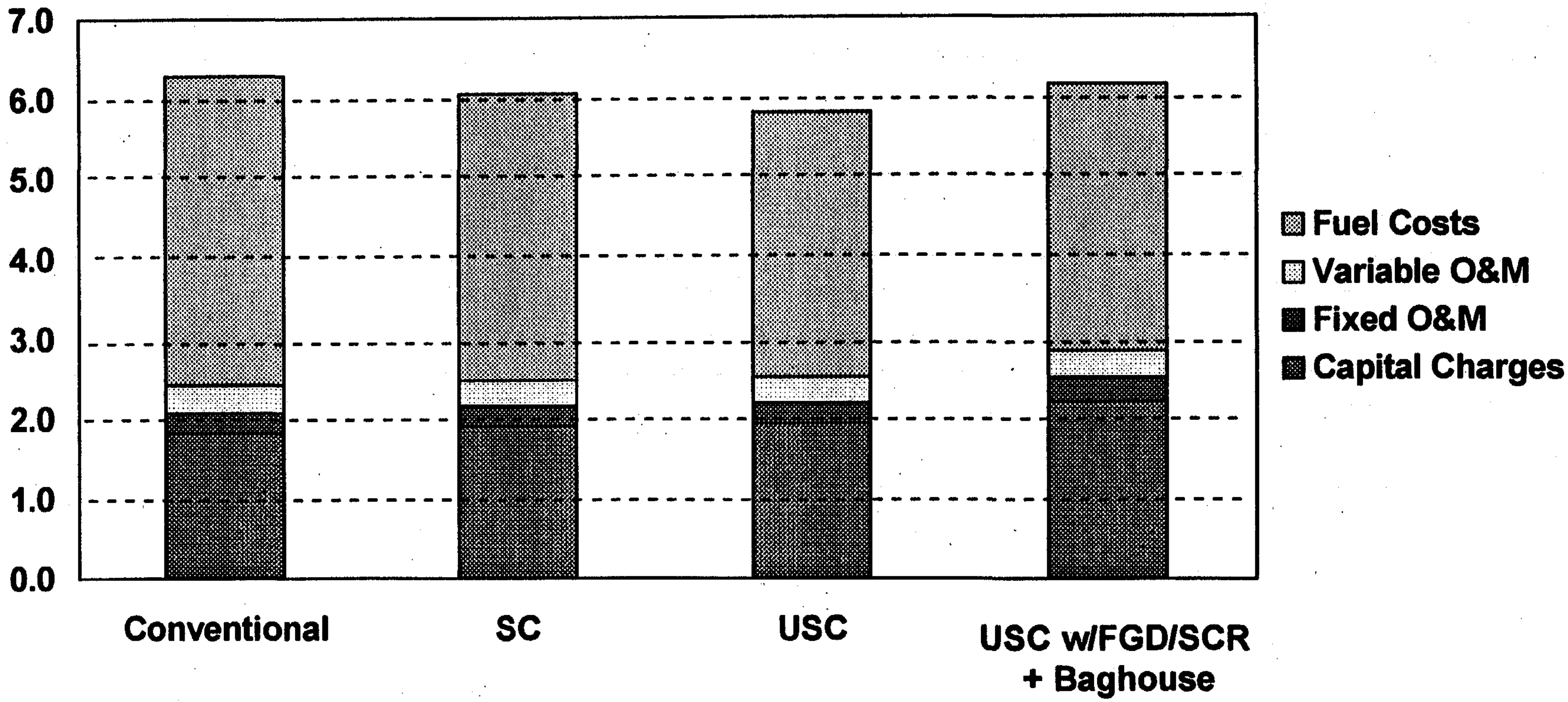


Figure 9 (b)

Cost of Electricity (cents/kWh)

Higher Fuel Cost ($40/ton)
Lower Capital Cost Case



INTERNATIONAL PROSPECTS FOR CLEAN COAL TECHNOLOGIES (Focus on Asia)

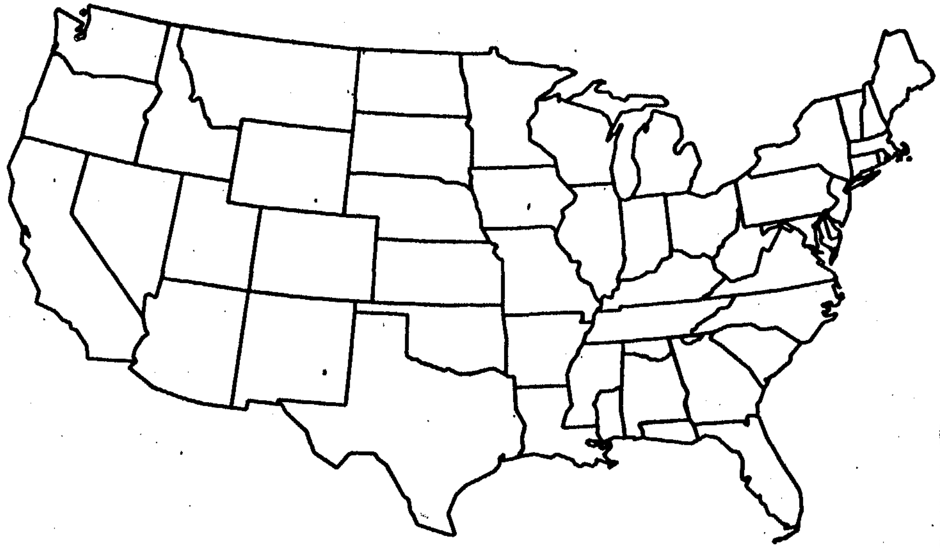
Presented by:

David T. Gallaspy

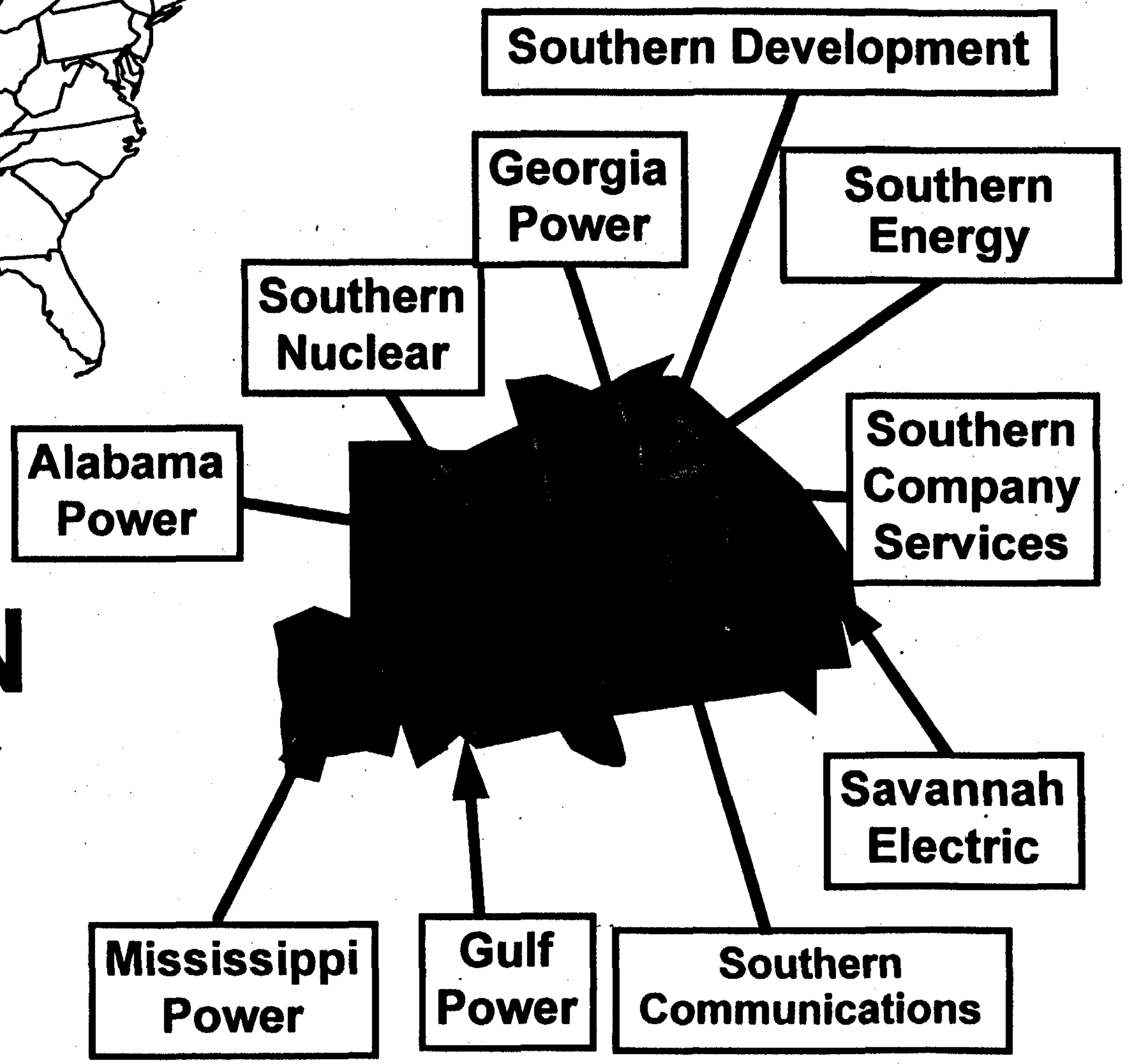
Southern Energy, Inc.

Objectives

- Propose Asia as focus market for commercialization of CCT's
- Describe principles for successful penetration of CCT's in international market - based on "CEPA" experience
- Summarize prospects for CCT's in Asia and other international markets



SOUTHERN COMPANY SYSTEM



Statistical Highlights

	Southern Energy	Southern Company System	Total
Assets	$5.0B	$25.6B	$30.6B
Annual revenues	$0.6B	$8.6B	$9.2B
Generating capacity (MW)			
Own	1,476	31,126	32,602
Operate	2,729	36,208	38,937
T&D	31,000 mi.	161,000 mi.	192,000 mi.
Employees	4,382	26,500	30,882
Service area		120,000 sq.mi.	
Population served		11M	

Worldwide Locations

Southern Company Clean Coal Commitment

- Largest purchaser of coal in U.S. (50mm tons/year)
- Wilsonville coal research heritage
  - Coal liquefaction/Solvent refined coal
  - Advanced coal cleaning
- Four Clean Coal projects
  - Low NOx combustion (2 projects)
  - Advanced FGD
  - Selective catalytic reduction
- Wilsonville Power Systems Development Facility

Acquisition of CEPA

- Consolidated Electric Power Asia (CEPA) is the largest and most successful IPP in Asia
- Executive Chairman - Gordon Wu
- Currently operates 3,995 MW in China and the Philippines (approx.. 2,000 equity MW)
- Southern Energy has agreed to acquire 80% interest in CEPA, effective January 31, 1997

With CEPA acquisition, Southern Company will extend its commitment to coal-fired generation into the fastest growing markets

What Are the International Prospects for CCT's?

- Developed countries currently represent too small a market to drive commercialization of CCT's
- Move to open access competitive markets works against coal and advanced CCT's
- Government subsidies for demonstration projects will dwindle under open markets, privatization

Near-term prospects for CCT's lie in high growth emerging markets -- primarily Asia

Widespread Commercialization of CCT's Requires ...

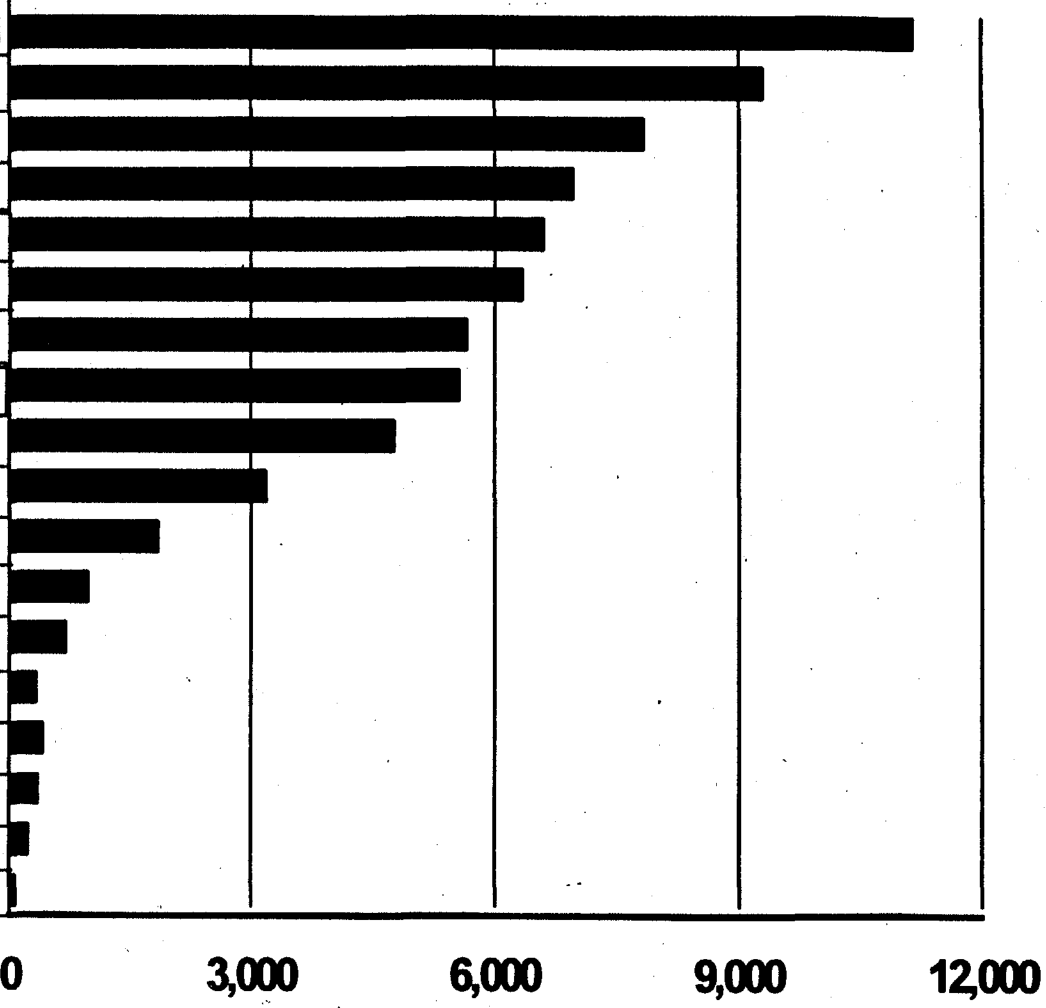
- Rapid growth in demand for new power generation
  - large-scale projects
  - high utilization factor
  - ability to replicate plants
- Availability of/dependence on coal
- Need for environmental improvement
- *Asia has all these - should be viewed as premier market for CCT application*

The Key: Growth

- Three of the four most populated countries in the world are located in the Asia region (China, India and Indonesia)
- Asia is and will continue to be the fastest growing economic region in the world
- The major source of energy for Asia is coal
- Asia has strongest, growing need for environmental improvement
- There is a tremendous and growing demand for electricity

1993 CONSUMPTION OF ELECTRICITY PER CAPITA

Country	Million kWh*	Population Million*	kWh/ Capita
USA	2,882,211	258.2	11,161
Australia	163,139	17.5	9,307
France	449,500	57.4	7,835
Germany	566,000	81.2	6,970
Singapore	18,964	2.9	6,608
Japan	788,260	124.3	6,342
Hong Kong	33,500	5.9	5,660
U.K.	322,730	58.0	5,564
Taiwan	99,203	20.8	4,765
S. Korea	140,434	44.1	3,187
Malaysia	34,305	18.6	1,844
Thailand	57,000	58.6	973
China**	812,680	1,165.0	698
Philippines**	21,780	65.7	332
Pakistan**	49,270	119.1	414
India**	314,000	870.0	361
Indonesia**	44,660	191.2	234
Bangladesh	8,776	119.3	74



*1995 Economist Diary from the Economist Newspaper Ltd.
**CEPA active

World Total Net Electricity Consumption by Region
(Billion Kilowatt-hours)

Region/Country	1990	1993	1995*	2000*	2005*	2010*	2015*
OECD							
OECD North America	3,257	3,422	3,584	3,809	4,130	4,471	4,870
OECD Europe	2,116	2,196	2,374	2,708	3,022	3,343	3,680
OECD Pacific	918	970	1,066	1,275	1,423	1,548	1,667
Non-OECD							
EE/FSU	1,907	1,656	1,523	1,689	1,850	2,022	2,205
Non OECD Asia	1,263	1,532	1,733	2,345	3,037	3,829	4,781
Middle East	190	196	245	293	339	381	426
Africa	285	299	304	362	430	507	593
C. and S. America	448	490	527	608	690	776	863
Total	10,382	10,761	11,355	13,090	14,922	16,877	19,087

Note: OECD= Organization for Economic Cooperation and Development.
EE/FSU=Eastern Europe/Former Soviet Union

* Projections

Sources: Energy Information Administration (EIA), DOE/EIA-0219(93), International Energy Annual 1993, Annual Energy Outlook 1996, DOE/EIA-0383(96) and World Energy Projection System (1996).

CEPA Experience in Asia --Illustrates Successful Application of CCT's

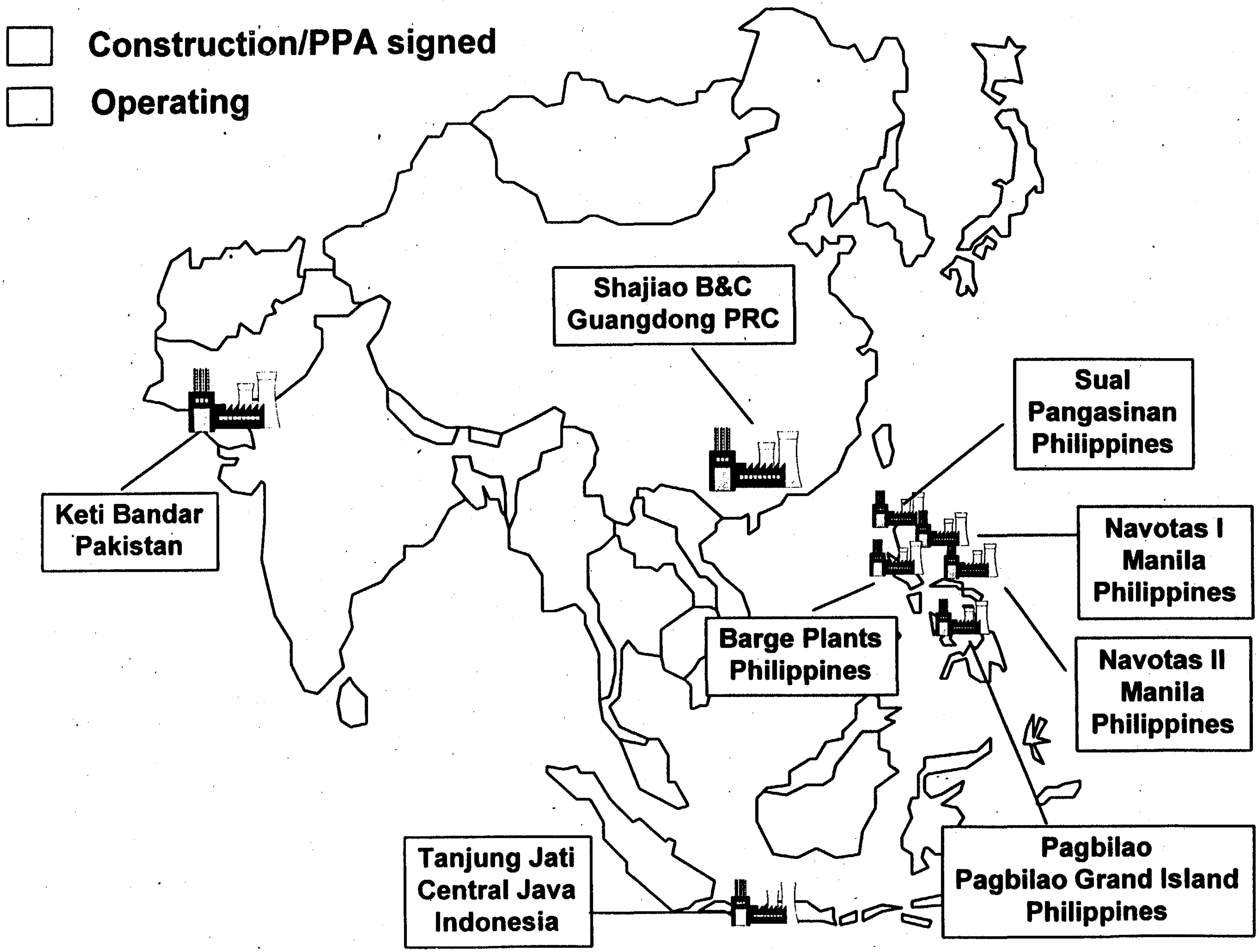
- **Premier private power company in Asia, with predominantly coal base**
- **Has consistently led a very competitive market**
- **Commitment to increasing application of CCT's while meeting market price**
- ***But ... environmental technologies limited to commercially proven, low cost***

CEPA
PROJECT LIST

Project	Location	Size	Fuel	Operation Date
Shajiao B	Dongguan, PRC	2x350MW	Coal	7/87
Shajiao C	Dongguan, PRC	3x660MW	Coal	6/96
Navotas I	Manila, Philippines	3x70MW	Oil	3/91
Navotas II	Manila, Philippines	1x100MW	Oil	3/93
Power Barges	Various, Philippines	9x30MW	Oil	2/93
Pagbilao	Quezon, Philippines	2x367.5MW	Coal	7/96
Sual	Pangasian, Philippines	2x600MW	Coal	6/99
Tanjung Jati B	Central Java, Indonesia	2x660MW	Coal	2000
Pakistan	Sindh Province	2x660MW	Coal	2001

*Under Construction
**PPA signed

Total MW	7,835
Equity MW	5,139


Construction/PPA signed
Operating
Shajiao B&C
Guangdong PRC
Keti Bandar
Pakistan
Sual
Pangasinan
Philippines
Navotas I
Manila
Philippines
Navotas II
Manila
Philippines
Barge Plants
Philippines
Tanjung Jati
Central Java
Indonesia
Pagbilao
Pagbilao Grand Island
Philippines

Basis for Success

- Early entry into difficult markets
- Application of reference plant concept to achieve scale and procurement economies (famous “12-pack”)
- Welcome involvement of multilaterals, export credit agencies
- International procurement of technology, with financing
- Project finance on commercial terms, with fair allocation of risks
- Apply well proven, but state-of-the-art technologies

CEPA Application of CCT's

- Commitment to being environmental leader
- Beginning with Sual project, all CEPA projects include:
  - low-NOx combustion
  - FGD
  - high thermal efficiency
- Contrasts with many developers in Asia, where goal is to meet the minimum environmental standards

What Will Determine the Penetration of CCT's in the Private Power Industry?

- Financing (debt and equity)
- Market Forces
- Fuel Availability and Price
- Technology Characteristics
- Government Policy

Consider each in turn ...

Financing

- ECA led: often dictates sourcing and type of technology
- Project finance implies commercial technology only, EPC wrap
- Financing typically dictates environmental standards (World Bank)--achievable without advanced CCT's

The Market

- Competitive bidding is the rule; negotiated deals going away
- Severe downward pressure on price as competitors increase, market is established
- Long term fixed price contracts support high capital cost
- But ... initial moves toward competitive market in electricity (Philippines)

Example: Evolution of Market Pricing in the Philippines

Plant	C.O. Year	Fuel	cents/kWh
Pagbilao	1996	Coal	6.9
Sual	1999	Coal	5.1
Ilijan	2002	Gas	3.1

***Note:** CEPA lost bid for Ilijan on rebid to Korea Electric. Ilijan is competitive with coal even if LNG is used.*

Fuel Characteristics

- Use of indigenous coal supports important macroeconomic objectives
  - Indigenous coal often very poor quality (e.g., Pakistan, India)
- Incentive for developing countries to export best coal, utilize worst coal
- Relatively low coal prices put lower premium on thermal efficiency

Coal Production (millions tons)

	1980	1990	1993
Australia			
Domestic Production	79.8	175.0	196.1
Imports	n.a.	n.a.	n.a.
Exports	47.6	114.6	145.3
Brown Coal	36.3	50.7	53.0
China			
Domestic Production	684	1,190	1,258
Imports	2	2	2
Exports	7	19	22
India			
Domestic Production	125.7	233.2	270.8
Imports	0.7	6.3	n.a.
Exports	0.1	0.1	n.a.
Brown Coal	5.3	15.5	14.9
Indonesia			
Domestic Production	0.3	11.6	30.4
Imports	n.a.	0.9	n.a.
Exports	0.1	5.4	18.5
South Africa			
Domestic Production	126.9	203.7	200.6
Imports	n.a.	n.a.	n.a.
Exports	32.2	54.5	58.9

U.S. coal production

1. **Nearly two-thirds of all U.S. coal production is a high-ranking bituminous product.**
2. **Nearly two-thirds of all coal is produced from surface mine operations.**
   - **Current production of 1.0 billion tons per year is dominated by over 600MM tons of surface production.**
3. **Coal consumption in the U.S. is dominated by electricity generation plants. Nearly 900MM tons/yr are consumed by these facilities.**

Coal Consumption for Major Markets
(Million short tons)

Region/Country	1990	1993	1995*	2000*	2005*	2010*	2015*
United States	895	926	937	990	1,046	1,082	1,120
Japan	130	128	126	142	150	157	160
Former Soviet Union	854	569	562	550	547	540	531
China	1,125	1,273	1,380	1,685	2,036	2,465	2,998
India	259	298	335	400	483	560	619
Other Asia	187	206	225	228	233	263	315
Middle East	7	8	10	10	12	13	13
Africa	157	157	156	166	174	183	193

* Projections

Sources: Energy Information Administration (EIA), DOE/EIA-0219(93), International Energy Annual 1993, Annual Energy Outlook 1996, DOE/EIA-0383(96) and World Energy Projection System (1996).

Technology

- Financing requirements and risk allocation dictate commercially proven technology
- Competitive bidding requires technology with multiple suppliers (not single source, royalty bearing technologies)
- Technology must be reasonably "cookie cutter," even with changing fuel and site conditions

Technology (cont)

- Growing emphasis on local manufacturing capability (e.g., China, India)
- CCT technologies must be integrated into a complete plant, with a single turnkey wrap

Government Policy

- Governments in growth markets are concerned about meeting demand at low price
- Not willing to pay extra for environmental performance
- R&D subsidies usually for manufacturing, education -- not clean coal demonstrations
- Governments have macroeconomic concerns -- favor local fuels and manufacturing

Implications - Opportunities for CCT's in International Marketplace

- Aim for high growth markets to maximize opportunities and replicate projects
- Integrate CCT's into reference plants with turnkey EPC backing
- Trade off maximum efficiency and environmental performance for low cost, high reliability

Implications (cont)

- Achieve scale economies through:
  - high unit output (300 - 500MW +)
  - emphasis on manufactured components, systems
  - worldwide sourcing
- Achieve export credit financing
  - proven technology
  - constructor/supplier guarantees

Implications (cont)

- Transition to local manufacturing capability
  - simplify designs
  - export more technology, less hardware
  - establish JV's with local suppliers (as FW, Westinghouse, others have done)
  - import highly engineered equipment

Implications (cont)

- Develop/adapt CCT's for low quality indigenous coals, fuel flexibility
  - Reduced premium on efficiency
  - Opportunity for coal upgrading technologies!
- Work with development agencies (World Bank, ADB, CDC, etc.) to meet their agendas
  - Highest growth markets are the developing countries!

Conclusion - Opportunities for CCT's Internationally?

- Wherever MW's are being added, there should be opportunities for CCT's
- Key: Aim technologies for growth markets--not mature markets--and meet their needs
- Remember that the constraints which cannot be overcome are NOT technical:
  - Market price
  - Financing

Gas Turbine Power Plants - Perfect Example of Commercialization Drivers

- What other technologies have seen such rapid and continuous improvement in:
  - Scale/size (from 20 to 200 MW in a single engine)
  - Specific power output
  - Reliability, operability and maintainability
  - Application of advanced manufacturing processes and technologies
  - Environmental emissions performance
  - Innovativeness and technology evolution
  - Engineering and applications support
  - Improved guarantees, warranties and manufacturers' backing

....all accompanied by....

- A reduction of both installed capital cost and energy cost by perhaps 50%
- No wonder this is a major success story for energy technology!!

Panel Session 2

Issue 2: Role of CCTs In The Evolving Domestic Electricity Market

CCT'S IN A DEREGULATED ENVIRONMENT:

A PRODUCER'S PERSPECTIVE

Robert F. Edmonds, Jr
Director, Business Development
Associated Enterprises Group
Duke Power Company

John O. Fayssoux
Project Director & Team Leader
Energy Services
Duke Power Company

ABSTRACT

The U.S. electric industry will be deregulated (or substantially re-regulated) within 5 years. Several states, including California, Rhode Island, and New Hampshire, already have passed legislation to introduce competition into the electric markets before the year 2000. As this trend sweeps across the country, the resulting competitive market for generation will reward the lowest cost producers and force high cost producers out of the market. As a result, at least in the short run, it may be very difficult for new power plants employing Clean Coal Technologies (CCTs) to compete. This paper discusses a producer's perspective of the new competitive market, and suggests several short and long term strategies and niches for CCTs.

I. INTRODUCTION

For more than 60 years, the electric utility industry has been highly regulated, as were industries like banking, trucking, telecommunications, and natural gas. But starting in the early 1970s, the United States began witnessing a transition from an environment of regulation to one in which market forces held greater sway. One by one over the next 20 years, these industries saw the regulatory veil lifted, exposing them and their customers to the benefits and uncertainties of market competition.

Throughout this period, many continued to believe that utilities were different and that deregulation was impractical and unnecessary. In the 1990s, however, the same forces that nurtured change in other industries — customer expectations of lower cost, more choice, greater innovation and better service — began to affect the electric utility industry. Today, the transition to a more competitive environment is well under way.

Global competition, coupled with rate disparities that can exist between assigned service territories, is the primary force behind the push for a market-driven electricity utility industry. As U.S. industries find themselves competing toe-to-toe with not only domestic but foreign enterprise, the pressure to keep production costs down is intensifying. As a result, industries are leading the call for a competitive electric market in the U.S. Many views exist of how a competitive market might function. Duke Power believes(1) a national market will evolve and that it will look much like the one now being developed in California.

Regardless of the form, there are a number of significant issues that can affect customers and the shareholders of publicly held utilities like Duke Power Company. These issues include:

- Maintaining fairness and equity between customer classes (e.g. residential, commercial, and industrial)
- Ensuring the world's most reliable electric system remains so
- Maintaining parity among competing suppliers (e.g. subsidized generators are not allowed to compete with unsubsidized generators)
- Redefining the monopoly-based obligation to build generation to serve all assigned customers
- Recovering stranded investment
- Allocating equitable sharing of societal costs

These are difficult, critical issues, but if they can be fairly and appropriately resolved Duke Power supports the concept of electric utility deregulation. Duke advocates federal legislation to provide guidance to the states for implementing deregulation, including a time frame under which it would be instituted. Following federal action, each state should then be allowed to design its own specific solutions. Duke PowerÕs position on restructuring the industry is based upon the simple premise that deregulation should offer equal treatment of all customers, provide a level playing field for all competitors, and maintain the current high reliability of the electric system.

II. ONE VIEW OF A DEREGULATED INDUSTRY

While there are three primary functions of the electricity utility business (generation, transmission, and distribution), most proposals for deregulation are limited to the generation business because of its present level of competitiveness. Even in a competitive environment, the transmission and distribution businesses would most likely be separate entities under the regulation of the Federal Energy Regulatory Commission (FERC) and state regulatory commissions.

A number of proposals have been made concerning deregulation. Among the many competitive market proposals considered, one promising idea for restructuring calls for creating a new structure built on two fundamental concepts:

- The primary source of electricity for all customers could be through a regional power pool. Participants in the power pool would primarily be generators, customer representatives referred to as ÒaggregatorsÓ or Òretail companiesÓ, and end-use customers.

- A secondary source of electricity could be through bilateral contracts between willing generators and end-use customers or aggregators.

A power pool could be comprised of two new regulated organizations: the Power Exchange (PX) and the Independent System Operator (ISO). Both would be independent businesses that would be governed and managed separately from the financial interests of market participants. Whether management of the PX and ISO would be separate entities is still an open question, but the roles and responsibilities of each are best described separately.

The Power Exchange

The role of the PX could be to facilitate trading in a visible spot market in which generating resources compete by:

- Taking supply bids from generators and demand bids from utilities, retail companies, power marketers and others;
- Allowing power producers to compete using non-discriminatory and transparent rules for bidding into the exchange;
- Ranking bids and submitting to the ISO a preferred least-cost dispatch schedule for delivering power; and
- Providing a visible market clearing price to permit customers to make efficient purchasing decisions and to adjust consumption.

Independent System Operator

The ISO would provide daily transmission system information to all market participants and collect bids by market participants to provide ancillary services for the next day. The ISO would control the transmission system and coordinate the hourly dispatch of the generation system in a reliable manner. The ISO could:

- Provide non-discriminatory open access to the transmission network;

- Coordinate day-ahead scheduling for all transmission network users;

- Control operation of the combined transmission facilities of the participating transmission owners;

- Obtain ancillary services, (reserves, for example) for all transmission network users on a competitive basis;
- Perform a settlement function to account for actual operating conditions ;
- Provide transparent information flow to all transmission network users;
- Facilitate bilateral contracts between generators and customers;
- Comply with all operating and reliability standards; and
- Manage transmission congestion and constraints on a network basis with all users subject to the same terms of access, protocols and prices.

Transmission congestion charges could be administered by the ISO (in accordance with FERC approved tariff provisions) to provide pricing signals as inducements to market participants to build congestion-relieving transmission upgrades in needed areas. A separate mechanism or regulatory "backstop" may be put in place if generation or transmission is needed for the sake of reliability and the market fails to react appropriately. The ISO will not own any transmission or generation resources, but could have compelling incentives to help ensure system reliability.

Figure 1 illustrates the basic concept of a power pool.

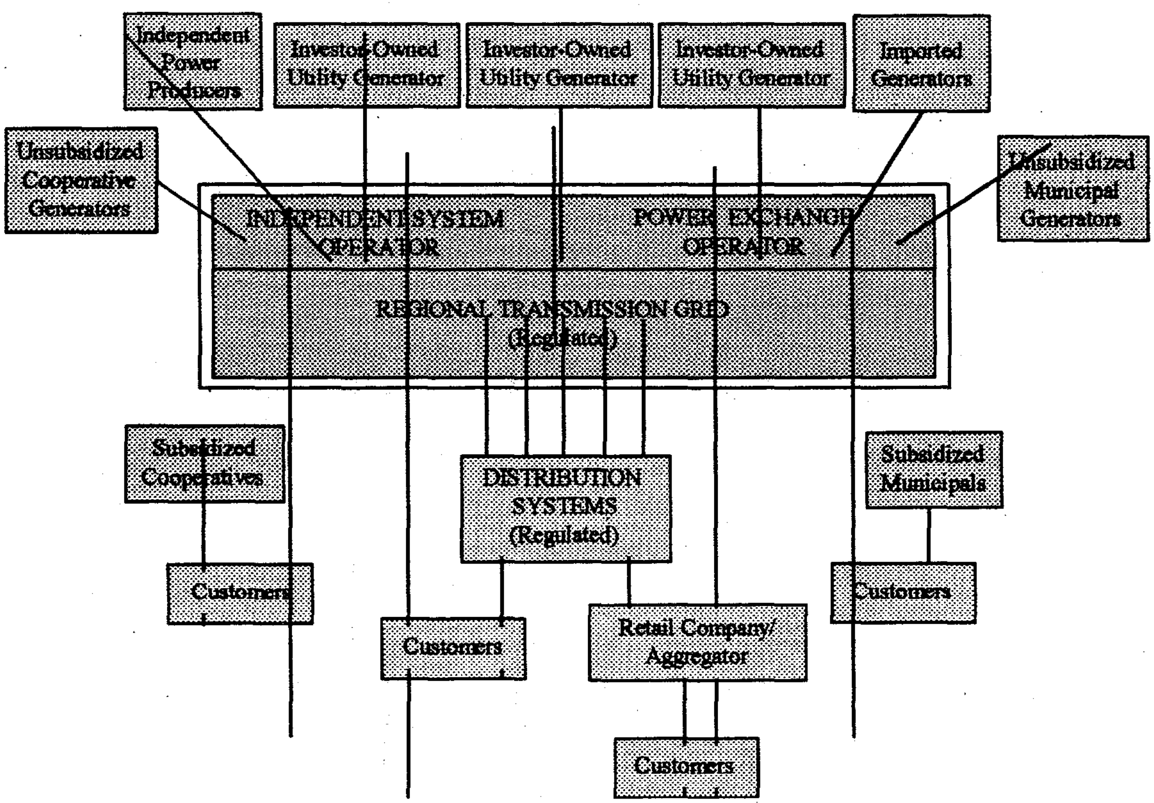


Figure 1. Basic Power Pool Operation

This combination of a PX, an ISO, and bilateral contracts is sometimes referred to as a "flexible pool" because it is designed to provide flexibility in contracting and trading arrangements. The flexible pool could offer all consumers electricity at competitive prices and also give all generators an equal chance to serve the available customer base. In some cases, an aggregator or a retail company could procure and provide these competitively bid generation services to customers.

While many details must still be resolved, the basic concept for the flexible pool could provide the foundation for advancing competition without compromising reliability or giving any competitor an unfair advantage.

III. CCTs IN THE DEREGULATED MARKETPLACE

If the marketplace described above comes to pass, it will have a number of impacts on the use of CCTs, some positive, but most negative--at least in the short run.

Lowest Operating Cost Wins

First, the competitive generation market will be more difficult for <u>any</u> new entrant, but especially so for plants with higher capital and operating cost. If existing plants are allowed to recover their *stranded costs*--i.e. that portion of their fixed costs not otherwise recovered by the competitive price of power--then any <u>new</u> plant will have difficulty competing with <u>existing</u> generators. This will hold true until the existing excess generating capacity is depleted. (Note: Depletion could be the result of demand growth, obsolescence of older plants, environmental/regulatory action against an existing technology, etc.) Then, when new generation is needed anyone considering entering the market will ask themselves these questions:

Which technology will produce power for the least overall cost?
- ➪ High cost = non-competitive
- ➪ No more automatic cost recovery in utility rates

Which technology has the least risk--technical and financial?
- ➪ Risk translates into higher cost

Which technology can be brought on line quickest?
- ➪ Time is money
- ➪ Competitive markets can be fickle, change rapidly

Currently the answer to all these questions would be combined cycle gas turbines in either a stand-alone power plant or in a cogeneration mode. As long as gas prices remain reasonably low, gas turbines will continue to be the technology of choice.

Technology Risk is a Killer

Technology risk associated with new CCT-based generators will cause these plants to suffer in the competitive market for two reasons. First, the equipment cost will have a "technology premium" to cover development costs and performance risk. Second, and probably more critical, the project owners will pay a risk premium on any borrowed funds. Lenders have shown little appetite for risk in the independent power market that has dominated the placement of new capacity for the last decade. There will be even less appetite for risk where the payment stream used for debt coverage comes from the competitive marketplace and not a "secure" long term contract with a utility, as existed in the recent past.

The "Level Playing Field" Issue

A potential obstacle to new CCT-based generation is the notion that in a competitive generation market, no generator should be allowed to compete if it receives a subsidy--such as tax-exempt bonds or government loans--that is not available to all generators. This position is held by most investor-owned utilities, including Duke Power. And, since approximately 80% of all generation in the US is owned by investor-owned utilities, this position is likely to prevail. If it does, it would mean that CCT projects which received DOE grants or loans would either have to seek special status or find ways to mitigate their competitive advantage.

Fuel Diversity is a Wild Card

Potentially the greatest advantage CCTs have in the deregulated marketplace is that they provide fuel diversity. But it is unlikely that producers, left to their own devices, will place much emphasis on fuel diversity, especially in the near term. However, two things could change that likelihood. First would be a near-term spike in gas prices. The US has seen a decade of stable, even falling, gas prices. This has caused a widespread shift away from coal and toward gas-fired technologies. Another oil embargo, a Gulf crisis, or a natural disaster in a major gas-producing region could push gas prices up to the point where generators will choose an alternative fuel.

Alternatively, the federal or state governments could weigh into the utility deregulation debate with their concerns about fuel diversity. It will likely take government intervention to force fuel diversity arguments to be heard. It appears, based on positions published before the recent election, that while the Clinton Administration is lukewarm toward electric deregulation, it will insist that fuel diversity be considered in future rules. States also, to the extent they are involved in setting the deregulation rules, may insist on fuel diversity and, possibly, use of indigenous fuels like coal.

Environmental Issues--Mixed Bag

Environmental issues are a mixed bag in terms of their impact on deployment of CCTs. Emissions limitations could force owners of older coal-fired plants to retrofit CCTs to comply with more stringent limits. This could be particularly true where older plants, many with minimal emissions controls, are pressed into service in the competitive marketplace. Capacity factors could increase dramatically on these plants as the competitive price of energy increases due to increased demand. Indeed, there is a fear among many environmentalists that this is precisely what will happen. CCTs could mitigate that fear.

But while environmental issues could increase the use of CCTs retrofitted to older plants, there does not appear to be a similar beneficial impact on new CCT-based plants. This is true because currently even the best CCT environmental emissions are no better than those from similar-sized gas turbine plants. The impressive environmental records of many of the new CCTs can certainly be used to *support* their use (for example to mitigate fuel diversity concerns) but environmental records alone will not endow a marketplace advantage on CCTs vis-à-vis gas plants.

IV. CCT OPPORTUNITIES

The major cost drivers for a new power plant are capital cost and fuel (including transportation) cost. It is currently a universally recognized fact that there are few, if any, places in the US where a coal plant can produce power cheaper than a gas-combined cycle plant, provided gas is available. And there are only two states, Hawaii and Maine, where natural gas is not available. Therefore, unless promoted for fuel diversity reasons, coal must either find ways to reduce the all-in cost of power or find niche opportunities.

Reducing Conventional Coal Plant Costs

Although the focus of this paper is on the future of CCTs, it is instructive to look at the competitiveness of a conventional coal plant in today's environment. One of the most recent conventional coal-fired plants to be brought into service in the US was Cope Generating Station, completed in late 1995 by Duke/Fluor Daniel, a Duke Power affiliate.(2) This plant, built for South Carolina Electric and Gas, is the least cost coal plant built in recent years. The $411 million plant generates 385mw at 95% valves open. At full valves open, this equates to a little over $1000/kw of capacity.

In building the Cope plant, Duke/Fluor Daniel utilized a number of cost cutting measures which had been developed in several recent international plants. Most effective were (1) world-wide sourcing of equipment, and (2) a sophisticated Computer Aided Design package developed by Duke/Fluor Daniel called PowerSuite. These and other cost saving techniques can keep the cost of coal plants down, but, as illustrated below, more is needed if coal is to compete with gas.

In contrast to the $1000/kw price for coal plants, similar sized gas combined cycle capital costs are approximately $500/kw. Assuming roughly equal O&M costs (a generous assumption for coal), approximately a 50% to 35% efficiency advantage for gas, and gas at $3.00/mmBTU, then coal prices per million BTU must be around <u>$1.00</u> to be competitive. See Table 1 below.

	Coal Plant	**Gas Combined Cycle Plant**
Capital Cost	$1000/kw	$500/kw
Efficiency	35%	50%
Fuel Cost*	$1.05/mmBTU	$3.00/mmBTU

*For power cost from coal to equal gas at $3.00, coal must be this

Table 1. Comparison of Coal And Gas Plants

Therefore, with existing capital cost and efficiencies for coal and gas plants, coal prices must be less than gas by a 3:1 margin to make the generation owner indifferent to technology. Put another way, gas prices would have to suffer a 50% increase before coal at $1.50/mmBTU would become cost competitive.

The only place in the US where coal can currently be obtained for $1.00/mmBTU is at the mine. Consequently, mine-mouth coal plants can be competitive. In the fully competitive marketplace described above, i.e. open, boundary-less transmission access, mine-mouth power plants may be an attractive option.

CCTs as Backup to Gas

As noted above, gas combined cycle plants have a significant advantage over conventional coal today. Gas can also beat any known CCT including coal gasification and PFBC. But that doesn't mean there is no place for CCTs. In fact some gas combined cycle plants being built today have included space to convert to coal gasification-combined cycle later. But one shouldn't look for CCT hardware orders soon, because no generation owner can afford to invest capital in a backup technology until there is a clear pricing signal that the fuel price advantage of gas is on the verge of changing.

Co-Production

Among the CCT's that are demonstrated and nearing commercial availability, coal gasification-combined cycle (CGCC) technologies may have a slight market edge over others since they are capable of co-production. CGCC plants are, in the simplest terms, a chemical plant that produces synthetic natural gas along with other useful byproducts such as steam, hydrogen, ammonia, sulfur and re-useable ash products. Therefore, in addition to producing useful steam and electricity in a classical cogeneration configuration, CGCC plants are capable, with additional capital investment in the gas production portion of the plant, of producing revenue-producing byproducts. Revenues from the co-production of useful chemicals and solid byproducts, to the extent they are greater than the carrying cost of the extra capital employed to produce them, can be used to reduce electricity costs. This scheme may be particularly effective if co-located with a major petrochemical plant or other chemical-based manufacturing facility.

Alternative Fuels

Although not a new idea, the concept of using alternative fuels as a substitute or supplement to coal in a CCT may allow the CCT to penetrate the market earlier than a plant fueled by coal only. Fuels like petroleum coke, sewage sludge or waste coal have been proposed by others.

V. CONCLUSIONS

The coming deregulated electric market will reward the lowest cost producers of power and punish all others. CCTs that allow older, lower cost coal plants to continue operating without pushing their production costs above the competitive price of electricity will have a bright future. New coal plants that employ CCTs must be able to generate at lower production costs than gas in order to be considered by any producer wishing to stay in business. It is not a question of "Will CCTs be a player in the deregulated marketplace?", but rather a question of "when". Or more precisely, "When will electricity prices, gas prices, and capital cost of CCTs converge favorably to the point where a generation owner will invest in the CCT?" But, in the meantime, there are some strategic reasons and some niche opportunities that may work to allow CCT-based capacity to penetrate the market earlier.

VI. REFERENCES

(1) "Restructuring the Electric Utility Industry: A Position Paper", Duke Power Company, November 1996.

(2) "Electricity Flows from New SCE&G Generating Plant", News Release, South Carolina Electric and Gas Company, January 15, 1996.

MARKET FOR NEW COAL POWERPLANT TECHNOLOGIES IN THE U.S. 1997 ANNUAL ENERGY OUTLOOK RESULTS

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ABSTRACT

Over the next 20 years, the combination of slow growth in the demand for electricity, even slower growth in the need for new capacity, especially baseload capacity, and the competitiveness of new gas-fired technologies limits the market for new coal technologies in the U.S. In the later years of the 1997 Annual Energy Outlook projections, post-2005, when a significant amount of new capacity is needed to replace retiring plants and meet growing demand, some new coal-fired plants are expected to be built, but new gas-fired plants are expected to remain the most economical choice for most needs. The largest market for clean coal technologies in the United States maybe in retrofitting or repowering existing plants to meet stricter environmental standards, especially over the next 10 years. Key uncertainties include the rate of growth in the demand for electricity and the level of competing fuel prices, particularly natural gas. Higher then expected growth in the demand for electricity and/or relatively higher natural gas prices would increase the market for new coal technologies.

I. Key 1997 Annual Energy Outlook Results

Over the next 20 years the demand for electricity is expected to continue to increase with economic growth (Figure 1). However, the combination of increased market saturation of electric appliances, improvements in equipment efficiency, utility investments in demand-side management programs and legislation establishing more stringent equipment efficiency standards has slowed the rate of growth from the level seen in the 1960s and 1970s. Overall the demand for electricity is projected to grow 1.5 percent annually, with the residential and industrial sales growing faster than commercial sales (Figure 2).

The need for new capacity, especially baseload capacity, is expected to grow slower than total demand. Between 1995 and 2015 total U.S. generating capacity increases from 767 to 970 gigawatts, an annual rate of increase of 1.2 percent. However, due to the expected retirements of 38 gigawatts of existing nuclear capacity and 71 gigawatts of existing fossil-steam capacity, total capacity additions amount to 310 gigawatts over the next 20 years (Figure 3). Nuclear plants are assumed to retire at the end of their 40-year license period or before if their operating and maintenance costs exceed 4.0 cents per kilowatt hour. Fossil-steam plant retirements include reported retirement plans from utilities and the retirement of high operating cost units that would not be competitive in a deregulated environment.

Figure 1. Population, Gross Domestic Product, and Electricity Sales Growth, 1960-2015 (Index, 1960 = 100)

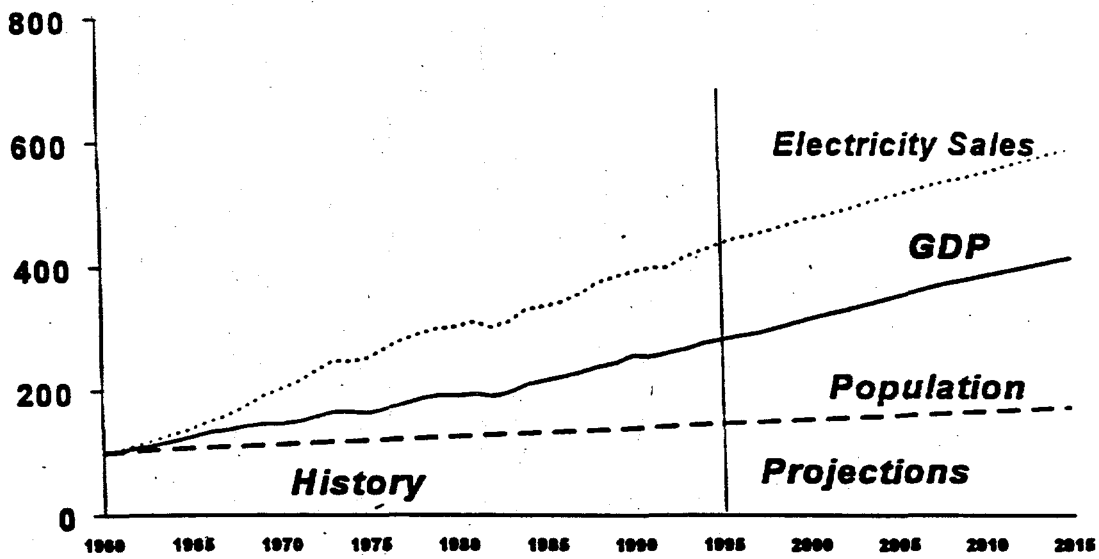


Figure 2. Electricity Sales by Sector, 1970 - 2015 (Billion kilowatthours)

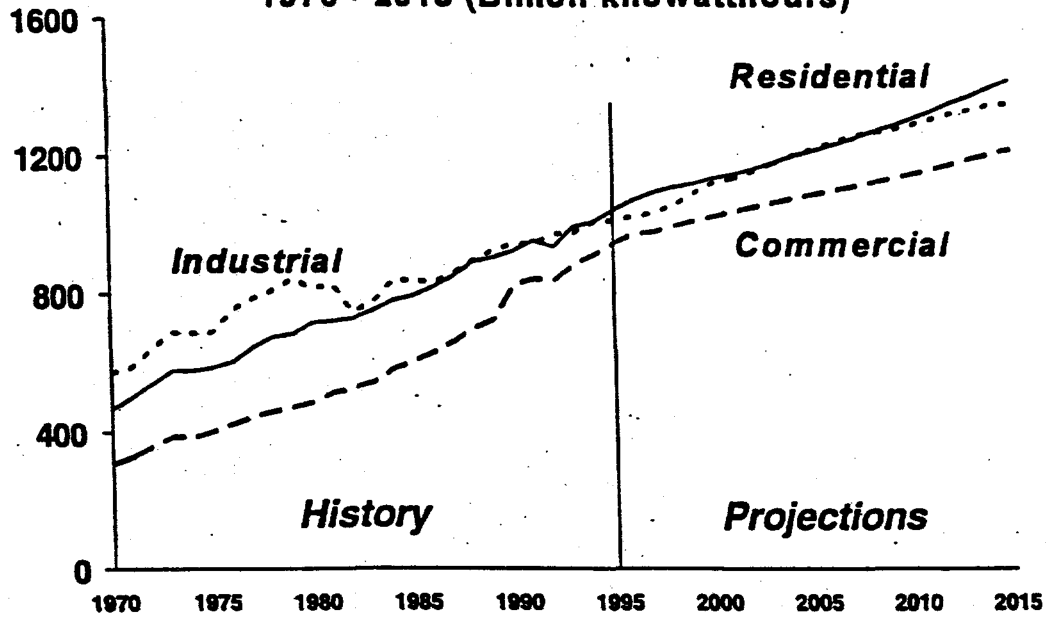
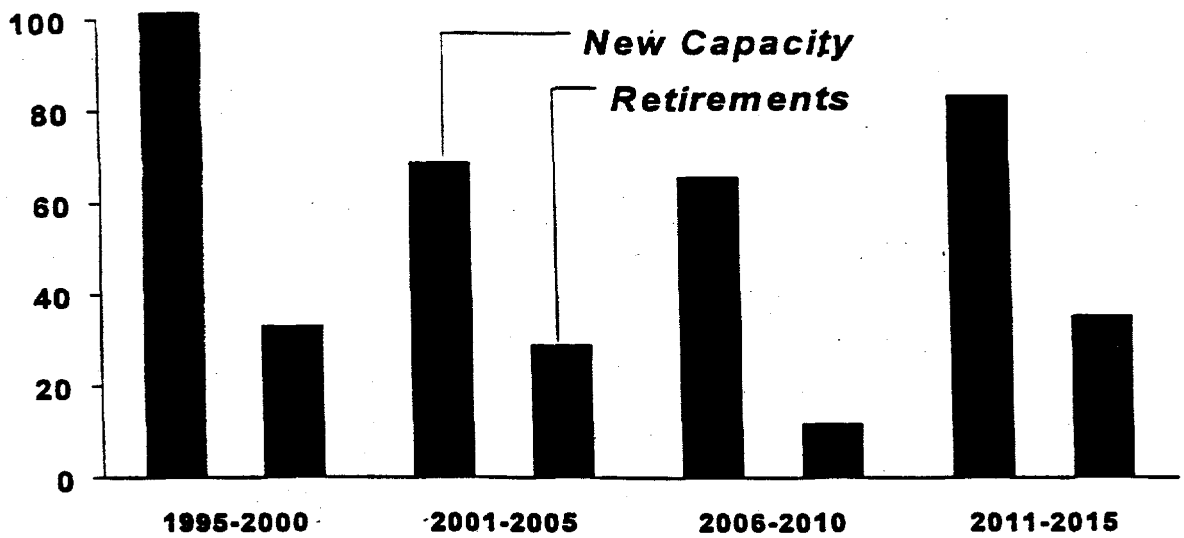


Figure 3. New Generating Capacity and Retirements, 1990 - 2015 (Gigawatts)



Natural gas-fired combustion turbines and combined-cycle units are expected to dominate new plant additions, especially in the near-term (Figure 4). About 80 percent of the capacity additions over the 1995 through 2015 period are projected to be gas-fired. Coal-fired and renewable (and other) plants account for the remaining capacity (11 and 8 percent, respectively). In the near term, between 1995 and 2000, new capacity is expected to be built to meet peaking needs. As a result, 65 percent of the gas-fired capacity built in that period are simple combustion turbines while the rest are combined-cycle plants. This pattern reverses itself in the last five years of the forecast when new plants are needed to serve growing baseload and intermediate demands. Over this 5 year period combined-cycle plants account for about 75 percent of the gas-fired plants added.

It is also during the later years of the forecast, 2005 to 2015, when most of the new coal plants projected to be added are brought on line. About 70 percent of the 37 gigawatts of coal plants projected to be built between 1995 and 2015 are brought on-line in 2005 and later. Over the 20 years of the projections, gas and coal prices to powerplants slowly diverge, with gas prices rising at approximately 1 percent per year (most of this increase occurs after 2005) while coal prices decline at a rate of 0.9 percent annually (Figure 5). In some regions of the country this widening fuel cost differential is large enough to allow new coal plants to be competitive with gas plants even though they cost much more to build. The vast majority, approximately 75 percent, of the

Figure 4. Electricity Generation and Cogeneration Capacity Additions by Fuel Type, 1995 - 2015 (Gigawatts)

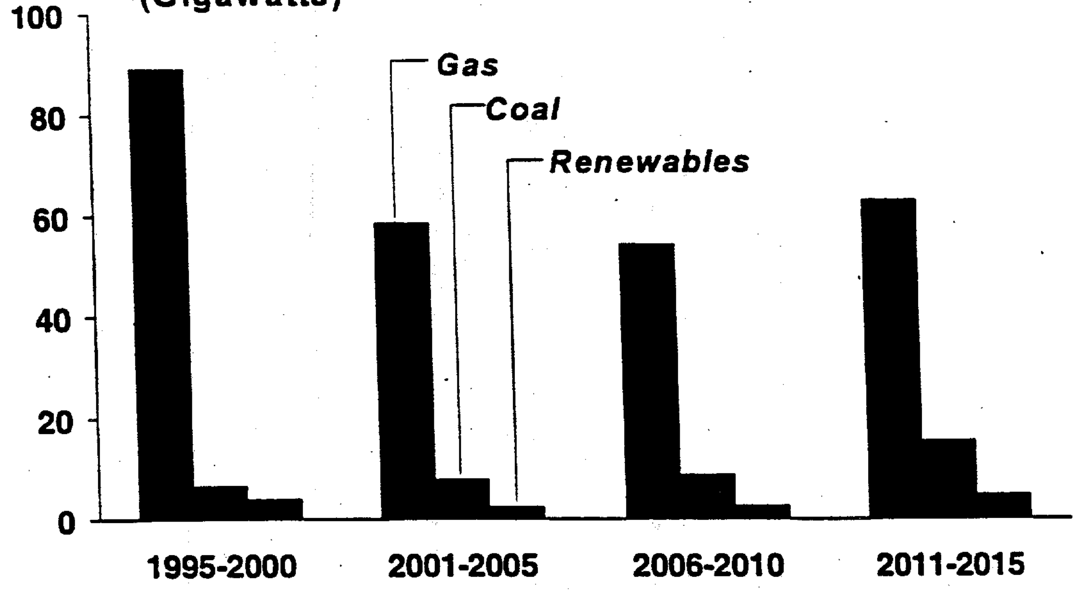
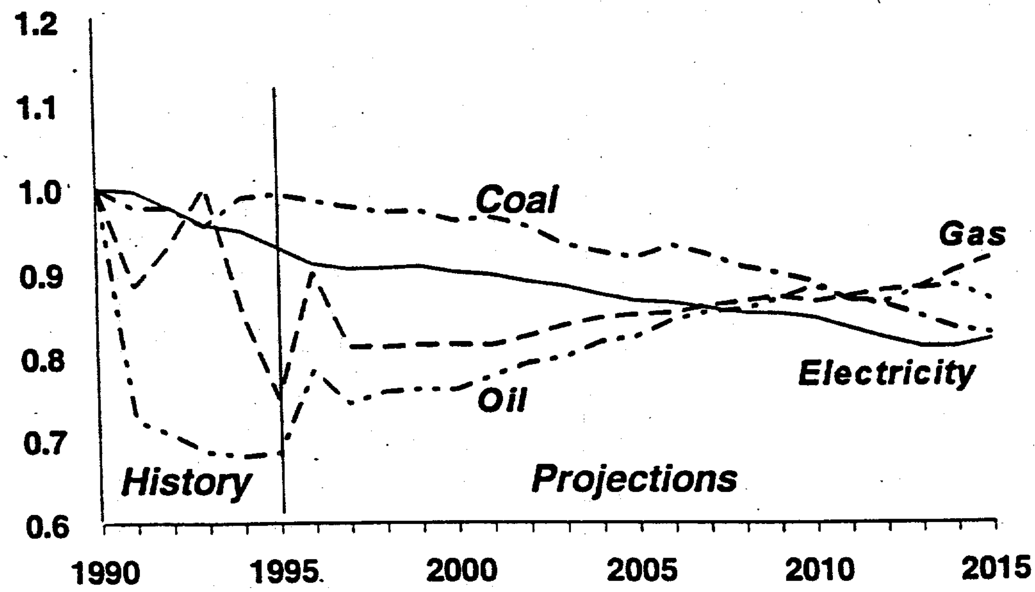


Figure 5. Fuel Prices to Electricity Suppliers and Elect Prices, 1990 - 2015 (Index, 1990 = 1.0)

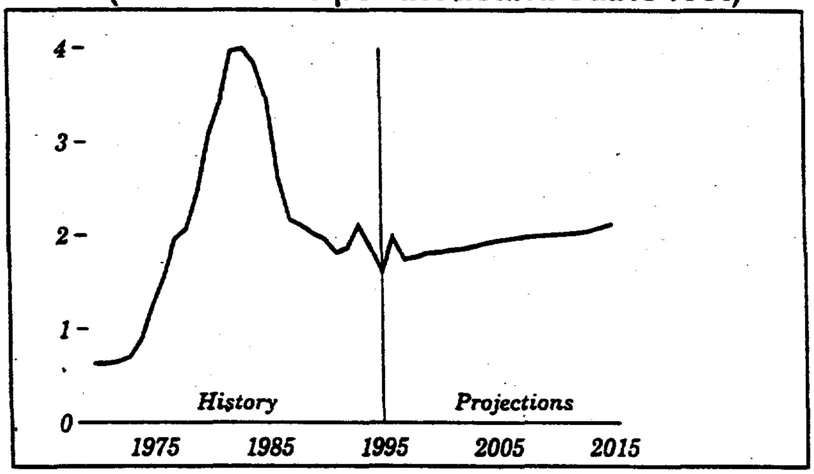


coal plants built are expected to be conventional pulverized coal plants with the remaining being integrated coal gasification plants (IGCC).[1]

II. Natural Gas, Coal, and Electricity Prices

Wellhead prices for natural gas in the lower 48 States increase by 1.4-percent annually in the reference case (Figure 6) reaching $2.13 per thousand cubic feet (in 1995 dollars) in 2015. The price increases reflect the rising demand for natural gas and its impact on the natural progression of the discovery process from larger and more profitable fields to smaller, less economical ones. In *AEO97*, technological progress arrests and even reverses declining finding rates in some regions. As a result, natural gas production is increased, with less drilling activity and at lower cost, particularly in offshore regions, where technological progress has a greater impact on the development of relatively immature fields. In addition, competition within the industry and projections of lower interest rates reduce the costs of transmission and distribution, offsetting the projected increase in wellhead prices, so that the average delivered price of natural gas declines between 1995 and 2015 at an average rate of 0.2 percent.

Figure 6. Lower 48 Natural Gas Wellhead Prices, 1970-2015 (1995 dollars per thousand cubic feet)



Coal minemouth prices are projected to decline in the forecast as a result of increasing productivity, a shift to western production, and competitive pressures on labor costs. In *AEO97*, the average minemouth price of coal is projected to be $15.46 per ton in 2015 (Figure 7). Lower coal transportation rates--leading to higher production from western mines, where production costs are lower than in the East--are the primary reason for the lower minemouth prices.

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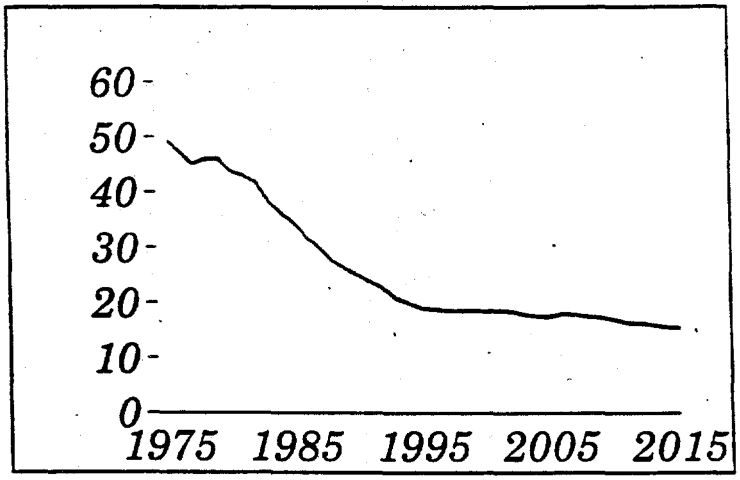
[1]The Electricity Market Module allows the representation of two coal technologies. The IGCC technology was used as representative of an advanced coal technology.

Figure 7. Coal Minemouth Price Projections, 1995-2015 (1995 dollars) (Dollars per ton)



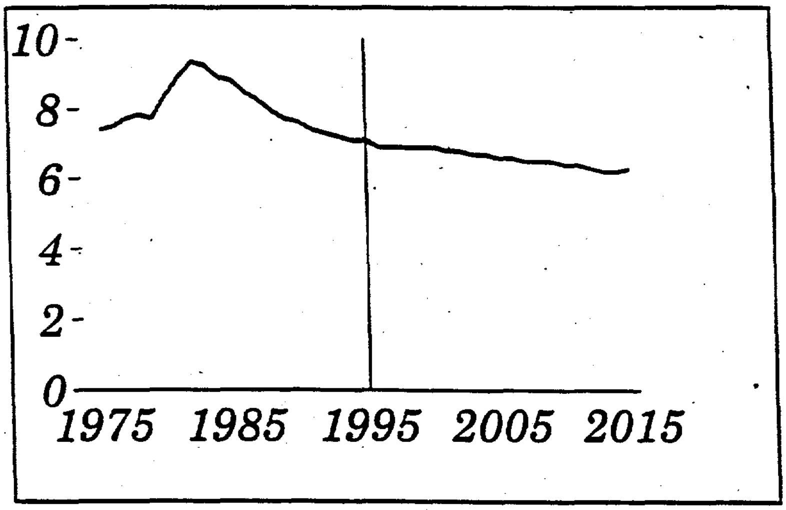
The competition between coal and other fuels, and among coalfields, is influenced by coal transportation costs. Changes in fuel costs affect transportation rates, but fuel efficiency also grows with other productivity improvements in the forecast. As a result, average coal transportation rates decline by 0.9 percent a year between 1995 and 2015. The most rapid declines are likely to occur in routes that originate in coalfields with the greatest production growth. Railroads are likely to reinvest profits from increasing coal traffic to reduce future costs and rates in regions with the best outlook. Thus, coalfields that are most successful at improving productivity and, therefore, lowering minemouth prices are likely to obtain the lowest transportation rates and, consequently, the largest markets at competitive delivered prices.

Regional differences in production and transportation costs are already affecting coal distribution patterns. Western coal is gaining share in midwestern and southeastern markets, and coal for export is moving along different domestic routes. Retirements of barge capacity have exceeded replacements in recent years, and the resulting increase in inland barge rates has caused some traffic to shift to rail or Great Lakes vessels for all or part of the journey from mines to U.S. ports of exit. In spite of railroad mergers and consolidation in the barge industry, real coal transportation costs are projected to continue their historical decline, as competition among surviving carriers forces technological improvements.

Average electricity prices also decline through 2015. The average price in 2015 is projected to be 6.3 cents per kilowatt hour, as a result of lower projected fossil fuel prices and anticipated industry restructuring (Figure 8). Increased competition in the electricity industry is assumed to lead to lower operating and maintenance costs, lower general and administrative costs, early retirement of inefficient units, and other cost reductions. The *AEO97* assumes that operating and

maintenance expenses decline by 2.5 percent annually from 1997 to 2007, continuing the trend of the previous 10-year period. Also, expenses charged to general and administrative functions (billing, salaries, and benefits) are assumed to drop by 25 percent during the same period as generators position themselves for increased competition. *AEO97* reflects the evolving trend of competition within electricity markets but does not include the full impacts of restructuring and deregulation. Although the projections include the recent actions taken by the Federal Energy Regulatory Commission on open access, specific actions to be taken by State public utility commissions and their timing are not yet known and have not been incorporated.

Figure 8. Electricity Price Projections, 1995-2015 (1995 dollars) (Cents per kilowatt hour)



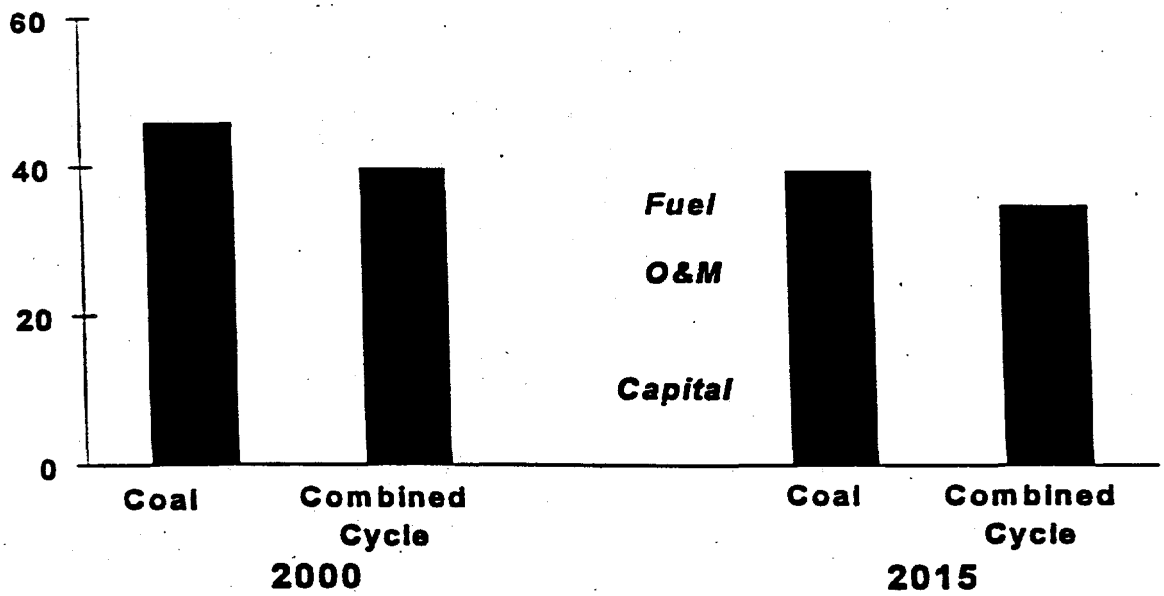
III. Economics of Coal versus Gas Technologies

The expected increasing reliance on gas-fired plants is driven by their economic competitiveness relative to other generating options. Over the last decade technological innovations in natural gas recovery and combustion have combined to lower expectations of future natural gas prices and dramatically increase the combustion efficiency of new gas plants. The result is that gas-fired plants are currently the economical choice for most applications. Figure 9 and Table 1 show the component costs of producing power from a pulverized coal plant and an advanced gas-fired combined cycle plant.[2] As shown the two technologies differ significantly in what drives their total levelized costs. Total coal plant costs are dominated by their capital costs while gas-fired combined-cycle plant total costs are dominated by fuel costs. Overall 55 to 60 percent of a coal plant total costs are related to its construction costs, while 62 to 68 percent of a gas combined-cycle plants costs are accounted for by fuel expenses.

Table 1. Costs of Producing Electricity From New Plants, 2000 and 2015

[2]The figures shown are nationwide averages. In some regions coal is more competitive while in others it is less competitive.

Figure 9. Levelized Cost of Electricity, 2000 and 2015 (Mills per Kilowatthour)



	2000	2000	2015	2015
	Conventional Pulverized Coal	Advanced Combined-Cycle	Conventional Pulverized Coal	Advanced Combined-Cycle
	1995 mills per kilowatt hour			
Capital	25.3	10.6	23.5	6.9
O&M	5.6	4.4	5.6	4.4
Fuel	14.9	24.8	10.3	23.4
Total	**45.8**	**39.9**	**39.4**	**34.5**
	Btu per kilowatt hour			
Heatrate	9,928	6,985	9,463	5,700

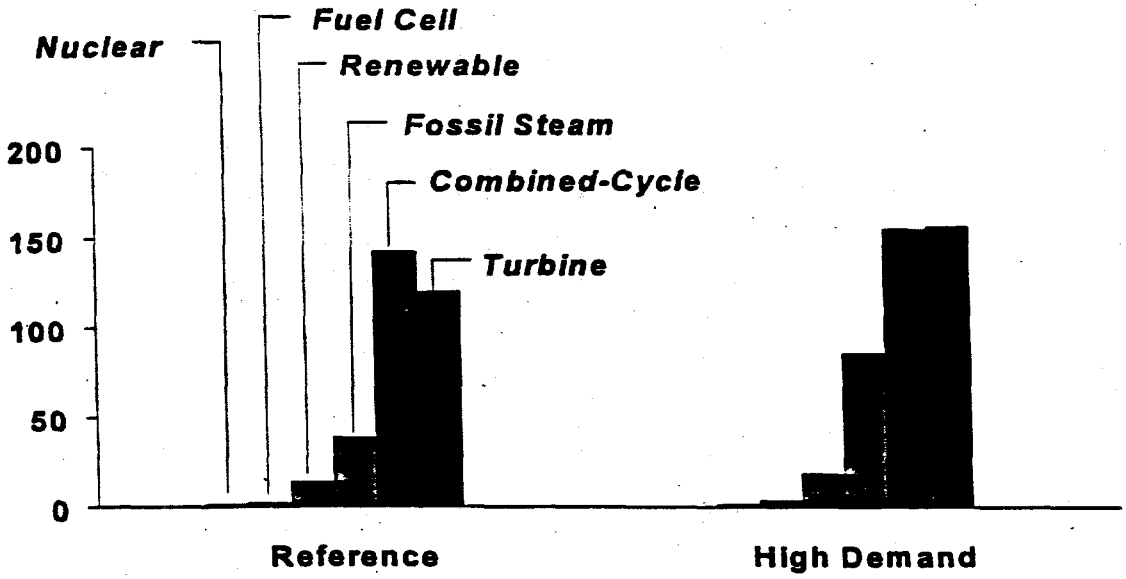
IV. Uncertainties and Impacts of Electricity Market Restructuring

Among the uncertainties with respect to the size of the market for new coal powerplant technologies are the rate of growth of the demand for electricity, the prices of competing fuels, especially natural gas and the rate of technological innovation (improvements in the cost and performance of advanced generating technologies). The restructuring of the electricity market could also have a significant impact, but its impact would affect the demand for electricity and fuel prices. While the rate of growth in the demand for electricity has slowed over the last 30 years, over the last 15 years it has averaged 2.4 percent per year. It is expected that the long-term slowing will continue, but it is possible that new electricity uses, tomorrow's VCRs, fax machines, and computers, will continue to evolve and maintain the rate of growth seen in recent years. To test the sensitivity of the results to higher electricity demand growth a case was prepared assuming a rate of growth in the demand for electricity of 2.0 percent annually, much higher than the 1.5 percent annual growth rate in the reference case. The impact on the need for new capacity is large, over 100 gigawatts of capacity beyond that required in the reference case is brought on line (Figure 10). The higher demand growth increases the market for all capacity types, but coal plants gain the most. Between the reference case and the high demand case the amount of new coal plants added more than doubles, reaching a cumulative total of over 80 gigawatts between 1995 and 2015. The reasons for this are twofold. First, the higher demand level increases the total need for new capacity. And, second, the higher demand level has a stronger impact on natural gas prices than it does on coal prices making new coal plants relatively more economically attractive.

If, as many expect, the restructuring of U.S. electricity markets results in lower electricity prices the demand for electricity is likely to be somewhat higher, though how much is unclear. However, this may not result in increased needs for capacity. The need for capacity is determined by the highest demand for electricity occurring during a given period, the so called peak demand. Prices during these supply constrained time periods may actually be much higher in a restructured electricity market than they are today and consumers may respond by reducing their consumption during these time periods while increasing it in lower cost time periods. The net result of this shifting demand could be increasing utilization of existing lower cost facilities, but a reduction in the need for new capacity for some time.

Two additional cases were prepared to assess the sensitivity of the results to the rate of technological improvement. In the reference case, higher initial capital costs are assumed for new, advanced generating facilities, to account for both technological optimism and inexperience in constructing the new designs. The costs are assumed to decline as a function of market penetration. To examine the effects of these assumptions, a high technology case was developed, with capital cost reductions due to learning effects assumed to be 50 percent greater than in the reference case, and optimism factors (which increase the cost of the earliest units constructed) assumed to be 50 percent lower than in the reference case. These assumptions result in costs for advanced technologies being approximately 12 percent lower than in the reference case. A low technology case was also prepared assuming that only those technologies available (beyond the initial testing and pilot program phase) as of 1996 are permitted to compete. The most

Figure 10. New Generating Capacity by Fuel Type in Two Demand Cases, 1995-2015 (Gigawatts)



significant result between the low and high technology cases is the shift from conventional gas-fired technologies to advanced gas-fired technologies (Figure 11). Advanced coal and renewables plants only penetrate by small amounts.

Two alternative *AEO97* analyses--the high and low nuclear cases--show how changing assumptions about the operating lifetimes of nuclear plants affect the reference case forecast of nuclear and fossil capacity. The low nuclear case assumes that, on average, all units are retired 10 years before the end of their 40-year license periods (93 units by 2015). Early shutdowns could be caused by unfavorable economics, waste disposal problems, or physical degradation of the units. The high nuclear case assumes 10 additional years of operation for each unit (only 4 units retired by 2015), suggesting that license renewals would be permitted. Conditions favoring that outcome could include continued performance improvements, a solution to the waste disposal problem, or stricter limits on emissions from fossil-fired generating facilities. In the low nuclear case, more than 100 new fossil-fueled units (assuming an average unit size of 300 megawatts) would be built to replace retiring nuclear units. The new capacity would be split mainly between coal-fired (37 percent) and combined-cycle (47 percent) units. The additional fossil-fueled capacity would produce 43 million metric tons of carbon emissions above those in the *AEO97* reference case, in 2015 (1,799 million metric tons total, 678 million metric tons from electric generators). Also, 3 gigawatts of additional new renewable and fuel cell capacity would be built. In the high nuclear case, 32 gigawatts of new capacity additions--mostly fossil-fueled plants--are avoided, as compared with those in the *AEO97* reference case, and carbon emissions are reduced by 29 million metric tons (4 percent of total emissions by electricity generators).

Figure 11. Unplanned Capacity Additions in Three Technology Cases, 1995-2015 (Gigawatts)

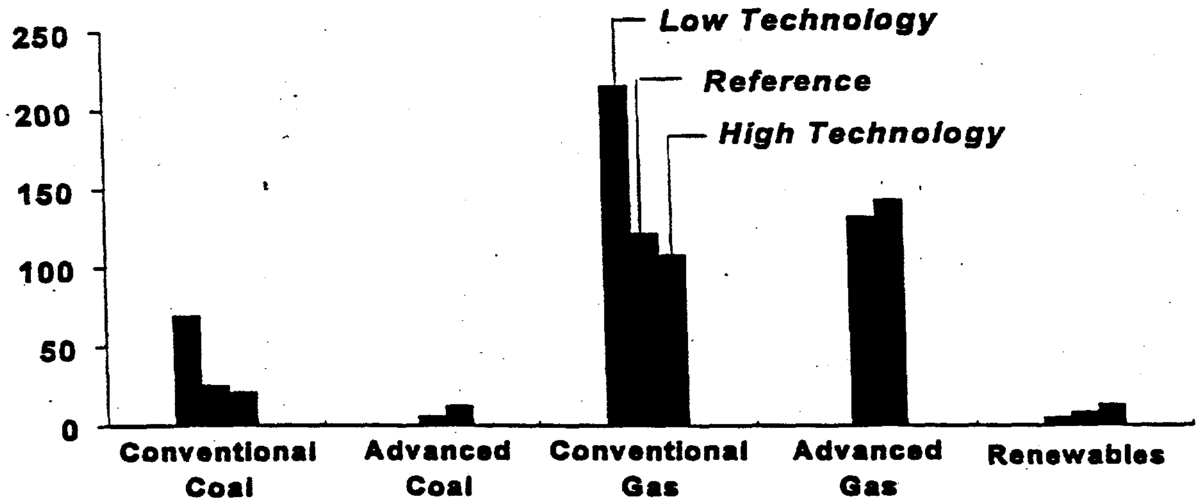
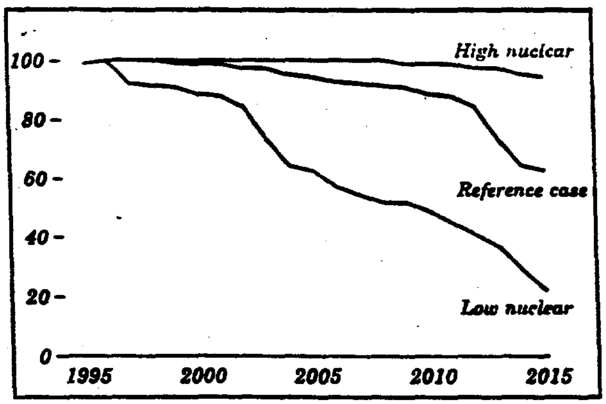


Figure 12. Operable Nuclear Capacity in Three Nuclear Cases, 1995-2015 (Gigawatts)



V. Conclusions

Over the next 10 to 20 years natural gas-fired generation technologies are expected to meet most of the needs for new capacity. Their relatively low capital costs, high thermal efficiencies and low emissions rates make them very attractive. New coal fired technologies are expected to account for around 11 percent of new capacity added, though that number could be larger if the demand for electricity or natural gas prices prove higher than expected. The major market of new clean coal technologies in the U.S. may be in retrofitting or repowering existing plants to meet new environmental requirements.

Figure Notes

Figure 1. Population, Gross Domestic Product, and Electricity Sales Growth, 1960-2015
History: Energy Information Administration, *Annual Energy Review* 1995, DOE/EIA-0384(95) (Washington, DC, July 1996). **Projections**: *Annual Energy Outlook* 1997, Tables A8 and A20.

Figure 2. Annual Electricity Sales by Sector, 1970-2015
History: Energy Information Administration, *Annual Energy Review* 1995, DOE/EIA-0384(95) (Washington, DC, July 1996). **Projections**: *Annual Energy Outlook* 1997, Table A8.

Figure 3. New Generating Capacity and Retirements, 1990-2015
Annual Energy Outlook 1997, Table A9.

Figure 4. Electricity Generation and Cogeneration Capacity Additions by Fuel Type, 1995-2015
Annual Energy Outlook 1997, Table A9.

Figure 5. Fuel Prices to Electricity Suppliers and Electricity Prices
History: Energy Information Administration, *Annual Energy Review* 1995, DOE/EIA-0384(95) (Washington, DC, July 1996). **Projections**: *Annual Energy Outlook* 1997, Tables A3 and A8.

Figure 6. Lower 48 Natural Gas Wellhead Prices, 1970-2015
Annual Energy Outlook 1997, Table A1.

Figure 7. Coal Minemouth Fuel Price Projections, 1995-2015
Annual Energy Outlook 1997, Table A1.

Figure 8. Electricity Fuel Price Projections, 1995-2015
Annual Energy Outlook 1997, Table A8.

Figure 9. Levelized Cost of Electricity, 2000 and 2015
Annual Energy Outlook 1997, National Energy Modeling System, run AEO97B.D100296K.

Figure 10. New Generating Capacity by Fuel Type in Two Cases, 1995-2015
Annual Energy Outlook 1997, Tables A9 and F6.

Figure 11. Unplanned Capacity Additions in Three Cases, 1995-2015
Annual Energy Outlook 1997, Tables A9 and B9.

Figure 12. Operable Nuclear Capacity in Three Cases, 1995-2015
Annual Energy Outlook 1997, Table F5.

An Analysis of Cost Effective Incentives for Initial Commercial Deployment of Advanced Clean Coal Technologies

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This analysis evaluates the incentives necessary to introduce commercial scale Advanced Clean Coal Technolgies, specifically Integrated Coal Gasification Combined Cycle (ICGCC) and Pressurized Fluidized Bed Combustion (PFBC) powerplants. The incentives required to support the initial introduction of these systems are based on competitive busbar electricity costs with natural gas fired combined cycle powerplants, in baseload service.

A federal government price guarantee program for up to 10 Advanced Clean Coal Technology powerplants, 5 each ICGCC and PFPC systems is recommended in order to establish the commercial viability of these systems by 2010. By utilizing a decreasing incentives approach as the technologies mature (plants 1-5 of each type), and considering the additional federal government benefits of these plants versus natural gas fired combined cycle powerplants, federal government net financial exposure is minimized. Annual net incentive outlays of approximately 150 million annually over a 20 year period would be necessary. Based on increased demand for Advanced Clean Coal Technologies beyond 2010, the federal government would be revenue neutral within 10 years of the incentives program completion.

I. INTRODUCTION AND BACKGROUND

Over the last 20 years, numerous financial incentives studies have been performed with the aim of assisting new energy systems in their early commercial introduction into the electric power and other energy sectors. These studies have focused on: a) financial support or incentives for production of fuels e.g. oil, gas, and coal, b) introduction of new power systems e.g. nuclear power, c) synthetic fuels production from domestic resources, and d) incentives for the introduction of early commercial Advanced Clean Coal Technologies.

With the strong awareness of the need to minimize further federal funding for Clean Coal Technologies, the U.S. DOE Fossil Energy Office requested that a thorough review be made of the most pertinent incentives studies and recommendations be developed for their further consideration. Emphasis was placed on developing a federal incentives approach which would be tax revenue neutral to the federal government i.e. the public taxpayer, at least within a meaningful planning horizon.

Within this context, a critical analysis was initiated of these previous studies, and specific incentives were estimated to enhance the early commercial introduction of Advanced Clean Coal Technologies (ACCTS) such as Integrated Coal Gasification Combined Cycle (ICGCC) power systems and Pressurized Fluidized Bed Combustion (PFBC) powerplants.

II. OBJECTIVES OF THE ANALYSIS

The specific objectives of the analysis are to:

* Critically Review Specific Previous Incentives Studies.

* Identify Incentives Which Balance Risk Among Stakeholders/ Minimize Federal Expenditures.

* Develop a Federal Tax Based Revenue Neutral Advanced Clean Coal Technology Commercial Deployment Approach.

* Recommend Specific Options for Further In Depth Analysis and Consideration by the U.S. Department of Energy, Fossil Energy Office.

All of these objectives have been specifically addressed and met within the scope of this analysis.

III. PERSPECTIVE ON PREVIOUS FEDERAL INCENTIVES FOR DOMESTIC FUELS AND COMMERCIAL DEPLOYMENT OF POWER TECHNOLOGIES

In order to place the incentives necessary for initial commercial Advanced Clean Coal Technologies in proper perspective, a brief review of previous federal incentives used to stimulate fuels/energy production was conducted.

A study conducted for the U.S. DOE by Battelle Pacific Northwest Laboratory, "A Analysis of Federal Incentives Used to Stimulate Energy Production", Reference 1, provided an excellent perspective basis. Although the report was prepared in 1980, and should be updated, it provides an interesting perspective on U.S. federal incentives for various fuels and energy systems.

Table I summarizes the federal incentives provided for various energy sources in the period 1950 to 1978 in billions of 1978 dollars. Of course, since many of these incentives are "running" i.e. currently in place, the total incentives would be substantially greater today. In fact, it is recommended that this analysis be updated to a current basis.

However, it is clear from Table I that a) the federal government has provided substantial tax and other incentives for producing fuels, energy, and electricity in the past, in fact over 250 billion dollars thru 1978, b) production of oil has received the most favorable tax treatments by the federal government, tax

Table 1

Federal Incentives Used to Stimulate
Energy Production (1950-1978) in Billions of 1978$

Energy Source	Estimated Amount	Type of Incentive
Nuclear	21.0	R/D/D, Enrichment Plants
Hydro	16.9	Producing/Marketing Power
Oil	123.6	Tax Deductions (IDC, D.A.)*
Natural Gas	14.6	Reduced Taxes (IDC, D.A.)*
Electricity	64.5	Public Utility Debt Subsidy
Coal	11.7	Water Borne Movement of Coal, Tax Incentives, R/D/D

* I.D.C. - Intangible Drilling Costs; D.A.- Depletion Allowance

incentives being nearly 10 times those for either natural gas or coal, and c) electricity production subsidization has previously primarily benefitted nuclear power and public utility entities such as the rural electric co-operatives and federal power programs.

It would appear that a federal government financial incentives program, building on the 7.1 billion dollar industry/federal government partnership in the Clean Coal Technology Program, would be warranted, in relation to federal incentives, which have been provided for other fuels and power sources.

This analysis will focus on defining a minimum federal outlay incentive program to stimulate commercialization of Advanced Clean Coal Technologies, namely Integrated Coal Gasification Combined Cycle (ICGCC) and Pressurized Fluidized Bed Combustion (PFBC) power systems and to develop a perspective on the projected costs of power from these systems, compared to natural gas fired systems.

IV. SUMMARY OF PREVIOUS INCENTIVE STUDIES

The key results from each of 8 previous incentives studies which impacted directly on the approach taken in this analysis include:

* Use of highly leveraged financing to minimize capital return requirements; thus cost of capital.

* Deferred income taxes from the FOAK plants.

* Emphasis on performance based incentives, as contrasted to capital subsidization.

* Clear need for "benchmark" technology performance and electricity cost for defining electricity price parity incentive requirements.

* The need for adequate financial rewards for risk taking of First-of-a-Kind (FOAK) and early commercial plants.

* The importance of a federal government role in overcoming high financial costs of early ACCT plants.

* Importance of balancing financial risks among all stakeholders i.e. the power produces, ratepayers, the federal government, taxpayers, and state governments.

* Any federal incentives to assist the introduction of ACCT's should have a decreasing incentive basis as later units of a particular technology type are deployed. Federal government incentives should be utilized to both assist and force the technologies to achieve mature status after the first 4 or 5 units of each advanced

plant type are deployed.

* Decreasing incentives with deployments of later versions of each plant type should be in both magnitude of the incentive and duration of financial support.

* The benchmark technology against which ACCT's should be compared should be Natural Gas Fired Combined Cycle (NGCC) powerplants. Meaningful real natural gas price escalations should be used to clearly identify the incentives required, particularly for the first five plants of each ACCT. A range of fuel price escalation scenarios should be used to demonstrate the uncertainties surrounding premium fossil fuel i.e. natural gas price projections.

* Care should be taken in defining incentives which do not result in a "windfall" profit to the power generator shareholders at the expense of the federal government, taxpayers, or at the expense of the ratepayers of the specific utility producing or purchasing the power.

* Differential tax revenues between NGCC powerplants and ACCT plants may be an effective way of reducing the full incentive burden on the federal government.

V. DETAILED INCENTIVE ANALYSIS

As was discussed above, the necessary financial incentives will be defined by comparing "benchmark" electricity costs from NGCC plants relative to those from ACCT's. In order to define a clear basis for the financial incentives necessary to bring ACCT's into electricity price parity with NGCC powerplants, financial, performance, and cost bases for each plant type must be defined. Those bases are summarized in Table 2 for powerplant capacities of 500 Mwe and an annual capacity factor of 0.65.

A. Natural Gas Fired Combined Cycle Powerplants

Because of the significance of projected natural gas prices, three cases were evaluated, namely:

* EIA-96 Reference Gas Case (Reference 2)

    * $2.41 per million Btu (96$ in 2005), escalated from $2.31 per million Btu in 94$, with a long term real price escalation rate of 1.4% per annum (Case 1).

    * $2.55 per million Btu (96$ in 2005), escalated from $2.44 per million Btu in 94$, with a long term escalation rate of 2.7% per annum (High Economic Growth - Case 2).

Table 2

Financial Analysis Bases for Incentives Comparison

Parameter/Units	Range of Value Considered	Value(s) Adopted
Levelized Current Dollar Fixed Charge Rate	0.106 to 0.16	0.144
Natural Gas Fired Combined Cycle Powerplants		
* Plant Capacity, Mwe	500	500
* Capital Cost, $/kwe(96$)	600-700	600
* Annualized Heat Rate, HHV Btu/Kwhr	6000-6800	6000
* Natural Gas Prices/Real Price Escalation Rates, $\$/10^6$ Btu, %	2.41-3.36[1] 1.4-5.0%	2.41, 1.4% (Case 1) 2.55, 2.7% (Case 2) 3.36, 5.0% (Case 3)
* O&M Costs, mills/kwhr	4	4
* Annualized Capacity Factor	0.65	0.65
* Levelized Current Dollar Cost of Electricity, cents/kwhr		3.83 (Case 1) 4.11 (Case 2) 5.40 (Case 3)

(1) Prices are 1996$ in 2005, starting date for the comparative analysis

Table 2 (Cont'd)

Financial Analysis Bases for
Incentive Comparison

Parameter/Units	Range of Value Considered	Value(s) Adopted
Advanced Clean Coal Technologies (ICGCC & PFBC)		
* Plant Capacity, Mwe	500	500
* Capital Costs, $/Kwe (1996$)	1100-1500[1]	1500 (Case 1) 1300 (Case 2) 1100 (Case 3)
* Annualized Heat Rate,HHV, Btu/Kwhr	6800-8400	8400 (Case 1) 7800 (Case 2) 6800 (Case 3)
* Coal Prices, $/10^6 Btu,	0.87-1.17	0.87
Escalation Rate, %	1.4%	1.4%
* O&M Costs, mills/kwhr	6-8	7
* Annualized Capacity Factor	0.65	0.65
* Levelized Current Dollar Cost of Electricity, cents/kwhr		5.45 (Case 1) 4.87 (Case 2) 4.26 (Case 3)

(1) Prices are 1996$ in 2005, starting date for comparative analysis.

* High Gas Demand Coupled with High World Oil Prices (Extension of EIA Forecasts)

  * $3.36 per million Btu (96$ in 2005), with a long term real price escalation rate of 5% per annum (High Economic Growth Escalation Rates from EIA 96 in 2010-2015 - Case 3).

These natural gas prices/escalation rates result in levelized current dollar costs of electricity from baseload natural gas fired powerplants of 3.83, 4.11, and 5.40 cents per kwhr, using a 1996 dollars initial basis in 2005, as shown in Table 2, and a 2.5% per annum average inflation rate beyond 2005.

B. Advanced Clean Coal Powerplants

The Advanced Clean Coal Technologies, Integrated Coal Gasification Combined Cycle (ICGCC) and Pressurized Fluidized Bed Combustion (PFBC) powerplant performance is also shown in Table 2. There may be some differences in the performance of each of these systems; however for purposes of this analysis, the same performance is used for both systems, as they mature.

Three cases are also considered for these 2 ACCT's, but they represent both potential capital cost reductions/performance improvements as the technologies are deployed and reach mature commercial plant status. The three cases are:

* First-of-a-Kind Plants: First 2-500 Mwe units of ICGCC and PFBC powerplants - $1500/Kwe, capital costs, and 8400 Btu/Kwhr, annualized heat rate (Case 1).

* Enhanced Plants: Plants 3 and 4 of each ACCT plant type - $1300/Kwe, capital cost, and 7800 Btu/Kwhr, annualized heat rate (Case 2).

* Mature Commercial Units: Plants 5 and beyond, $1100/Kwe, capital costs and 6800 Btu/Kwhr, annualized heat rate (Case 3).

All costs are in 1996 dollars.

Although coal costs will clearly vary with location, a 1996 high sulfur coal cost of 87 cents per million Btu was adopted, with a real price escalation rate of 1.4% per annum. These costs result in levelized current dollar costs of electricity of 5.45, 4.87, and 4.26 cents per kwhr, respectivley. It is recognized that Case 3 is a stretch goal, but is consistent with a 30% learning curve capital cost reduction from today's costs of approximately $1500 to $1700/kwe for the 250 Mwe Clean Coal Technology/Demonstration Projects. (Reference 3)

C. Projected Incentives to Produce Levelized Electricity Price Parity

These costs can now be compared for each of the three natural gas price scenarios and the three ACCT cost/performance improvement projections. This comparison is shown in Table 3, wherein the differential current dollar levelized cost of electricity is shown in a three by three matrix. It is clear that significant financial incentives are necessary to bring early First-of-a-Kind (FOAK) ACCT plants into price parity with NGCC powerplants. Specifically, the electricity price differentials initially would be approximately 1.62 cents per kwhr for FOAK plants. As the ACCT's mature and projected gas prices escalate, the ACCT's should become competitive; however if natural gas prices escalate only moderately,,i.e. at less than 2% real per annum, the ACCT systems will not become competitive, even with mature costs and performance.

VI. RECOMMENDED ELECTRICITY PRICE INCENTIVES APPROACH

A. Application to ICGCC and PFBC, Initial Plants

Table 3 provides a basis for defining a federal incentives program to stimulate commercialization of ICGCC and PFBC systems. The required incentives would result in price parity between ACCT's and NGCC plants. As may be seen from Table 2 and 3, early FOAK plant price subsidies of 1.62 cents per kwhr would be necessary. This represents approximately a 30% price support level for FOAK plants, for each ACCT system.

As discussed above, this incentive provides levelized electricity price parity between NGCC and FOAK ACCT's over their 30 year electricity production periods. As both engineering design experience and field data are obtained, this incentive should be decreased. The key problem is that in a rapid deployment period, say 2005 to 2010, only limited new operating experience will be available between each of the first 2 ICGCC and PFBC powerplants at a 500 Mwe capacity. This would argue for a full 30 year price guarantee, for each plant. However, in discussions held with regulated utility and independent power producers (IPP's), during a preliminary review of this study, they recommened that the first plants of each type receive a 20 year price guarantee incentive. This also provides some risk sharing between the federal government and the power producer.

As some engineering experience is gained, capital costs decrease, and performance improves, plants 3 and 4 of each type should receive a lesser incentive. From Table 3, it appears that a 20 year price incentive of 1.04 cents per kwhr might be adequate for plants 3, and 0.76 cents per kwhr for 15 years for plant 4. Plant 5 might receive a small incentive of 0.5 cents per kwhr for

Table 3

Differential Levelized Cost of Electricity
Comparison Between Advanced Clean Coal Technology[1,2]
Powerplants With Natural Gas Fired Combined Cycle Systems
(¢/Kwhr)

NGCC Systems	ACCT Systems	1st & 2nd of Kind Plants	3rd & 4th of Kind Plants	Mature Plants
Case 1, EIA96 Low Gas Price Growth		1.62	1.04	0.43
Case 2, EIA96 Mod. Gas Price Growth		1.34	0.76	0.15
Case 3, EIA96 High Gas Price Growth		0.05	(0.53)	(1.14)

(1) ACCT's Are ICGCC and PFBC in This Analysis

(2) Bases Are Initial Costs in 1996$ for Plants Starting Up In 2005-2010

10 years, if natural gas prices remain low or none if gas prices escalate rapidly.

This incentive approach, along with the estimated total incentive required, is summarized in Table 4. The total incentive amount would be approximately 5.42 billion dollars for the first 5 ICGCC and PFBC plants.

Although this is a significant amount, part of this incentive would be made up from the higher federal taxes which would be produced from the ACCT's, compared with NGCC powerplants. (See Following Analysis)

B. Potential Financial Risk to the Federal Government

As shown in Table 4, the total potential financial exposure to the federal government of the recommended incentives program for ACCT's is estimated to be 5.42 billion dollars. However, the capital intensive nature of the ACCT's will produce significantly greater tax revenues than from NGCC powerplants.

An estimate of the federal income tax from each of the first 2 ICGCC and PFBC plants in their first 20 years of operation is approximately 450 million dollars, compared with approximately 180 million dollars for an NGCC powerplant. This produces a net tax benefit to the federal government of 270 million dollars per plant. Similarly, plants 3 and 4 of each type produce a net tax benefit of approximately 210 million dollars, each, in their first 20 years of operation. Plant 5 of each type would have a projected net tax benefit of 150 million dollars.

The implications of these tax benefits are shown in Table 5. The incremental tax benefits are projected to be 2.22 billion dollars for the first five ICGCC and PFBC powerplants, which is approximately 40% of the recommended federal incentives amount. Thus, the net incentive to the federal government is reduced to 3.20 billion dollars. These costs are on a current dollar basis since the levelized cost of electricity is on a current dollar basis, but represent a current dollar amount based on initial dollars being 1996$.

If this incentive is distributed as a price guarantee over approximately a 25 year period, i.e. plants coming on line from 2005 to 2010, net annual expenditures for such a program are approximately 130 million dollars per year. This would appear to be a very low cost to insure that Advanced Clean Coal Technologies are fully commercial and ready for deployment, should natural gas prices begin to escalate rapidly.

In fact, if natural gas price projections change dramatically beyond 2005, the federal government might negotiate a lesser price guarantee for the out years of any price guarantee agreements, since the ACCT's would be producing competitively

Table 4

Recommended Declining Incentive Approach
Electricity Price Guarantee to IPP or
Regulated Utility

Initial Commercial Plants[1]	Incentive Amount ¢/Kwhr	Duration Years	Total Incentive Amount (Billions of $)	Rationale
First	1.62	20	1.84	Low Gas Esc. High Coal Plant Cost
Second	1.34	20	1.52	Mod. Gas Esc., High Coal Plant Cost
Third	1.04	20	1.18	Low Gas Esc., Imp. Coal Plant Cost
Fourth	0.76	15	0.64	Mod. Gas Esc., Imp. Coal Plant Cost
Fifth	0.43	10	0.24	Low Gas Esc., Mature Coal Plant Cost
		Total	5.42	

(1) Each Plant Type - ICGCC or PFBC

Table 5

Net Federal Incentive Analysis for
Advanced Clean Coal Technology Commercialization
(Billion of $)

Initial Commercial Plants[1]	Total Federal Incentive	Incremental Tax Income[2]	Net Incentive
First	1.84	0.54	1.30
Second	1.52	0.54	0.98
Third	1.18	0.42	0.76
Fourth	0.64	0.42	0.22
Fifth	0.24	0.30	-0.06
	5.42	2.22	3.20

(1) One ICGCC and One PFBC Per Incentive

(2) Incremental Federal Tax - Advanced Coal Vs NGCC

priced electricity, and with their low heat rates, would be preferentially dispatched.

One note of caution. This analysis did not consider the additional taxes which may be derived from the natural gas sales to the NGCC plants compared to sales of coal to the ACCT's. This should be considered in more detail in order to determine if this would have any significant effect on the differential tax revenues.

C. Federal Government Revenue Neutral Estimates

The federal incentive program recommended above results in a net incentive requirement from the federal government of approximately 3.2 billion dollars. One of the objectives of this analysis is to define a revenue neutral basis for the federal government. This does not appear to be possible within the context of deployment of the first 5 plants of each ACCT.

However, once these technologies have matured and become the technology of choice for future baseload capacity, there will be a continuing stream of net tax revenues flowing to the federal government. This increased tax revenue over Natural Gas Fired Combined Cycle powerplants will begin to offset the net incentive costs to the government during the 20 year price guarantee period.

If we assume that mature plant capital costs are 1100 dollars per kwe, each plant has a net tax benefit of 150 million dollars, as discussed previously. Thus, the deployment of approximately 21 plants, or 10,500 Mwe of capacity, would make the federal government revenue neutral. If this capacity is added in the 2010 to 2015 time frame, when new coal plant additions are expected to be required (Reference 4), the federal government would be revenue neutral in less than 10 years from the completion of the incentives program outlays, and perhaps sooner. However, since tax revenues from commercial units are being acquired in parallel with the incentive outlays, the federal government only has a 10 year net outlay period, and total net exposure of $1.0 billion.

The above situation most likely represents a worst case situation. For example, if nuclear powerplant retirements should accelerate the need for Advanced Clean Coal Technologies, the federal government would be revenue neutral on a shorter time frame. In addition, if ACCT's have capital costs greater than 1100 dollars per kwe, less plants are necessary to make the federal government revenue neutral. Since plant capital costs in 2010-2015 dollars may be substantially higher than the 1100 dollars per kwe mature plant cost projections, this will also shorten the time to achieve a revenue neutral situation.

Thus, in summary, a federal government incentives program to accelerate and insure commercialization of ICGCC and PFBC advanced coal powerplant technologies would support approximately 4000-5000 Mwe of initial capacity additions for 3.2 billion dollars. Within 10 years of the completion of the outlay program, the federal governments' outlays would be compensated with the addition of approximately 10,000 Mwe of advanced coal capacity. If a greater number of commercial ACCT's are deployed rapidly, these plants would generate additional net tax revenues which would decrease the time period to achieve a revenue neutral situation. This seems like an extremely prudent program for the federal government to support, with minimal financial risk, to assure commercialization of Advanced Clean Coal Technologies.

VII. SUMMARY OF RESULTS/BENEFITS

This incentives analysis provides a basis for the federal government to develop and implement a program to accelerate and insure commercial availability of Advanced Clean Coal Technologies, namely ICGCC and PFBC power systems. If this program were oriented towards deployment of 500 Mwe scale plants in the 2003-2010 time period, these Advanced Clean Coal Technologies would be mature technologies by 2010.

The recommended program of an electricity price guarantee for approximately 20 years would stimulate regulated utilities and independent power producers to commit resources to these technologies. The use of an electricity price guarantee to provide parity with NGCC powerplants would "level" the playing field for early commercial units and establish the performance and operability of ICGCC and PFBC systems.

A price guarantee approach provides a major incentive for the power generator to achieve cost and performance targets, as well as high plant availability/operability. It places the risk of managing capital and operations and maintenance costs on the power producer; thus sharing the risks in these plants. Graduated price supports for the first 5 commercial scale ICGCC and PFBC plants produces an incentive for risk taking on the First-of-a-Kind plants which should attract regulated utility or independent power producers to commit to these technologies.

This approach does not produce a large front end financial burden on the federal government since it is a "running" incentive, rather than a front end incentive. The estimated federal government net obligation of 3.2 billion dollars is outlayed over a 20 year period; therefore annual costs are approximately 150 million dollars. This is a level well within the federal government's previous financial support levels for various advanced power technologies. The federal government recoups all of its net incentive outlays within 10 years of program completions, as the Advanced Clean Coal Technologies are deployed to meet future power demands, and its actual net exposure, including the tax revenues from the commercial ACCT's, is approximately $1.0 billion. Further, this approach will enhance the use of high sulfur eastern coals, and help to maintain electricity prices stable by broadening the acceptable coal sulfur content base.

If natural gas prices escalate more rapidly than projected by the DOE-EIA forecasts, the federal government may be able to reduce its financial support obligation. In any case, this program clearly would establish the basis for coal to compete with natural gas in the 2010-2015 time frame, when significant new baseload powerplant additions will be necessitated. In addition, by designing, constructing, and operating these commercial scale ACCT's, these technologies will be solidly established for both domestic and international markets.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The recommended federal government price guarantee program for up to 10 Advanced Clean Coal Technology powerplants, 5 each of Integrated Coal Gasification Combined Cycle and Pressurized Fluidized Bed Combustion systems would establish these technologies commercially by 2010. By utilizing a decreasing incentives approach as the technologies mature, and considering the additional federal government tax benefits of these plants versus natural gas fired combined cycle powerplants, federal government net financial exposure is minimized. The federal government is essentially revenue neutral within 10 years of the outlays and perhaps sooner.

Absent this program, or one comparable to it, natural gas will be the primary, and perhaps, only, new powerplant fuel in the near future. If natural gas prices begin to escalate rapidly due to increased usage for power generation, conventional coal technology, with its low coal to electricity efficiencies, will be the only viable coal alternative.

The proposed approach provides a balanced risk sharing among the federal government, electricity producers, ratepayers, and taxpayers. Further development of this incentives approach should involve the states most likely to benefit from the program. This would provide the state entities, e.g. Public Utility Commissions, the opportunity to offer additional supporting incentives. This should be particularly attractive to high sulfur coal producing states.

This program will complete the effort initiated by the federal government, in association with industry, which provides the technology base i.e. the Clean Coal Technology Program presently underway. This program may also be of strong interest to the United Mine Workers Union, as it will enhance and perhaps significantly expand, the need for deep coal miners.

Finally, this program provides the basis for high efficiency coal power systems, which minimize all emissions, to become major elements of the U.S. and international electric power systems.

Recommendations

It is strongly recommended that:

1. The U.S. DOE Fossil Energy (FE) Office consider initiating this incentives program, or one comparable, to it, in the FY 1997 or FY 1998 DOE Authorization Process. Actual outlays of funds would not occur until after 2000, probably near 2005, but the program initiation would stimulate industry to begin planning full commercial scale ICGCC and PFBC projects.

2. DOE-FE review these results further with a set of representative regulated utility and independent power producer executives to obtain their reactions to such a program. Preliminary discussions with 2 independent power producers and 1 major regulated utility were favorable, but there needs to be further dialogue with them.

3. A dialogue be developed between the U.S. DOE-FE and key states to define additional financial incentives which could be provided by the states to support this program.

4. DOE-FE consider having a more detailed financial analysis of these proposed incentives performed utilizing discounted cash flow utility financing methodolgy. Although this levelized cost of electricity approach should be quite accurate, perhaps a broader range of fuel price forecast and financing approaches should be considered prior to formal program initiation.

5. An examination be made of differential federal income taxes between the use of natural gas for power generation, compared with the use of coal. This analysis should include the following considerations: differences in tax revenues from a) power generation types (to confirm these analysis results), b) fuel sales to the powerplant, and c) personal incomes associated with each plant type.

6. The DOE-FE should also consider updating the Battelle Northwest study to provide a current perspective on incentives provided for other fuel and power systems.

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THE ROLE OF CLEAN COAL TECHNOLOGIES IN A DEREGULATED RURAL UTILITY MARKET

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ABSTRACT

The nation's rural electric cooperatives own a high proportion of coal-fired generation, in excess of 80 percent of their generating capacity. As the electric utility industry moves toward a competitive electricity market, the generation mix for electric cooperatives is expected to change. Distributed generation will likely serve more customer loads than is now the case, and that will lead to an increase in gas-fired generation capacity. But, clean low-cost central station coal-fired capacity is expected to continue to be the primary source of power for growing rural electric cooperatives. Gasification combined cycle could be the lowest cost coal based generation option in this new competitive market if both capital cost and electricity production costs can be further reduced. This paper presents anticipated utility business scenarios for the deregulated future and identifies combined cycle power plant configurations that might prove most competitive.

I. NRECA and RER

NRECA is the national trade association representing the nation's nearly 1000 consumer-owned electric cooperatives. Recognizing the importance of science and technology to the success of its electric cooperative members, NRECA administers a research and development program for its member systems known as the NRECA Rural Electric Research (RER) Program. RER is voluntarily funded by participating member cooperatives at approximately $4.5 million annually. RER works closely with EPRI and other utilities to ensure that industry-wide technology developments may be applied to the unique needs of rural electric systems in a cost-effective manner.

II. UNIQUENESS OF ELECTRIC CO-OPS

Electric cooperatives, for the most part, serve sparsely populated rural and agricultural areas of the U.S., representing some of the nation's least developed and roughest terrain. Even so, co-ops sell about 7.5% of the nation's power to 30 million consumers in 46 states, and own nearly half of the distribution line miles in the country in order to deliver this power to their consumers. Co-ops average about five consumers per mile of line compared to the rest of the electric utility industry's average of around 40 customers per mile. Since electric revenue is a direct function of customer density, providing economical electric services to rural consumers is a challenge. This is complicated by the fact that much of rural electric load growth occurs at the end of long feeders. Thus, expensive transmission and distribution right-of-ways must be acquired in order to upgrade or provide new lines for increased power supply to these locations via conventional central station service.

III. CO-OP POWER SUPPLY TODAY

Currently, nearly one-half of electric cooperative power needs are provided by 60 generation & transmission (G&T) cooperatives. These G&T cooperatives are owned by the distribution cooperatives they serve. From an operational point of view, rural electric generation facilities are not very different from the rest of the utility industry. Where co-ops are different is that they own a high proportion of coal-fired generation, in excess of 80 percent of their generating plant capacity. Co-op generating facilities are environmentally the cleanest in the industry because they are the newest. Forty-four percent of the co-op coal-fired capacity already has flue gas scrubbers compared to 20 percent nationwide. All together, co-ops own or have ownership in 11 of the nation's lowest-cost power producers.

IV. DEREGULATION

NRECA and its member systems have actively participated in the policy deliberations involving deregulation of the nation's electric utility industry. Chief among the possible changes anticipated is the "unbundling" of the services performed by what has historically been a vertically integrated industry. Unbundling proposals could separate the electric utility industry into four distinct components: generation, transmission, distribution and energy services.

Generation Company (GENCO)

The generation part of the business will in all likelyhood compete in an open wholesale market. Restructuring advocates often propose that the generation component of an electric utility's business be sold to an independent company or spun off to a separate unregulated utility affiliate, a GENCO. The power would be sold at whatever price the seller could obtain in the generation market at a given time—known as a *market-based* rate. This means that power rates would not be *cost-based* on what it took to produce the power, but rather only the price the power could command in the marketplace.

Transmission Company (TRANSCO)

Transmission, following the finalization of Federal Energy Regulatory Commission (FERC), Orders Nos. 888 and 889, will be an open access system. Restructuring proposals often call for the transmission component of an electric utility's business to be given to a separate regulated TRANSCO, or even handed off to an "Independent System Operator" (ISO). Most proposals would continue regulation of transmission, on the assumption that it is unlikely for substantial competition to develop in the transmission sector. This is due to the difficulties and high costs of building transmission lines, getting rights of way and obtaining needed environmental and land-use clearances. Since bulk transmission lines often transmit power that comes from other states, plans call for FERC to regulate the price for and terms of transmission services.

Distribution Company (DISCO)

Under many restructuring proposals, the distribution component would be handed by a separate regulated distribution company, called a DISCO. Like transmission, most proposals would continue the regulation of DISCOs, because of the high cost of building duplicate distribution lines, and the aesthetic/environmental constraints. Virtually, all plans call for state regulation of DISCOs.

However, DISCOs would not necessarily perform all of the functions that we currently think of when we think of electric distribution companies. Many proposed DISCOs would carry out a pure *wires* (electricity delivery) function. The actual sale of electricity at retail is generally proposed to be open to competition. Retail customers would pick their electric power supplier just like they now pick their long-distance telephone service provider. This separation of the *wires* functions from the actual sale of the power is the essence of *retail wheeling, retail access,* and *customer choice,* terms we have all heard as part of the restructuring debate. Retail access is at the heart of the restructuring debate. Restructuring advocates want retail customers to be able to purchase their electric power from any one of a number of suppliers, with the power being transmitted and delivered by an entity distinct from the supplier. For the utility that owns the DISCO to compete for actual electricity sales to retail customers, it would have to form its own separate marketing entity, and that entity would have to use the DISCO for delivery service, just like any other supplier.

Energy Service Company (ESCO)

Retail electric distribution service may be split up into a number of parts: *delivery, retail sales,* and *energy services.* Retail sales could be made by generators, marketers, brokers, aggregators of all sorts. The providers and types of energy services are just beginning to emerge. Some envision separate energy service companies (ESCOs) that would become the marketers of a wide-range of services such as purchasing electricity from power producers, repackaging the electricity with valued-added consumer services and seeking out markets in which compete.

V. IMPACT OF DEREGULATION

These potential changes will have a substantial impact on every aspect of the electric utility business. A broadly-based task force drawn from NRECA's membership studied the likely industry changes and recently issued an initial report on the resulting competitive issues. The task force arrived at five conclusions that will receive a great deal of attention from electric cooperatives and may have implications for the entire industry. These are felt to be valid regardless of how the industry finally restructures:

- Customers will have their choice of an energy provider;
- There will be increasing pressure to regulate all distribution operations;
- The future of all power supply arrangements is unclear;
- The advantage of electric co-ops is their strong relationship with consumers;
- Future success requires being competitive on price, service and reliability.

Even though the final industry restructuring is not yet known in detail, one can draw certain general conclusions about the four proposed utility functions that may evolve:

Transmission

This part of the business will be regulated as an open access network by the federal government through FERC. The past decade has seen a four-fold increase in bulk power transfers across the country. Now, 40% of the electricity generated in the U.S. is sold by the producing utility on the bulk power market before it reaches consumers. Such wholesale transactions, which involve electricity transfers over transmission networks, are expected to increase significantly because of federal deregulation producing open access to the networks. Transmission systems, for example, now experience loads at 70% or more of their capacity less than 20% of the time. For distribution systems, the corresponding capacity utilization occurs less than 5% of the time. Thus, there appears to be adequate capacity to handle the increased transactions that might result from deregulation. But technology is expected to be able to accomodate substantially greater power transfer capability over existing systems if needed.

Distribution

This part of the business will likely be regulated by the states. There is a consensus that it does not make sense for multiple wires and service entrances to be installed depending upon who you elect to provide your power. As a result, regulations will be necessary to compensate the one *wires* company delivering power, while preventing monopolistic pricing policies that would be unfair to the customer. While state-level deregulation will give consumers greater choice among electricity providers, at the same time, consumers are increasingly concerned about the power quality. Momentary disturbances that would have gone unnoticed in the past will become a major concern in the future, causing computers and other digital equipment to malfunction (i.e., the "blinking clock syndrome"). As a result, successful DISCOs will be those that deliver high-quality power at low cost and follow it up with excellent customer service.

Energy Services

ESCOs would likely be unregulated entities competing in the marketplace to provide power to customers. ESCOs would be able to buy bulk power and resell it to consumers along with additional services, or provide distributed generation at or near a customer site. In either case, economics will dictate the choice of generation selected by the ESCO for a particular application. Some predict distributed generation to be as much as 30% of new electric generation by 2010. If true, that would be more than 50 gigawatts of the 175 gigawatts of generation growth that the U.S. Energy Information Administration (EIA) expects by then. NRECA believes distributed generation will be a valuable power supply option for servicing many rural customer loads. But, the electric co-ops see a much more modest growth in distributed generation by 2010, probably not exceeding 5 to 10 percent of total generation expansion, if that much.

Generation

Although FERC and others are still working out the details, it appears likely that the generation part of the business may ultimately become totally deregulated and truly compete on the open market to sell the electricity it produces. This power will be sold as a commodity like oil or corn. In fact, electricity futures markets are already being formed in anticipation of the public buying and selling bulk electricity transactions just as is the case with other commodities.

In such a marketplace, only the low-cost providers survive. Unlike ESCOs that will provide distributed generation at a premium cost level of perhaps 4 to 5 cents/kWh or more along with services to solve a customer problem, GENCOs will sell bulk power strictly on the basis of what the market will pay for this commodity. Average power production costs in the U.S. dropped below 2 cents/kwh for the first time since 1981 according to the Utility Data Institute. So it is reasonable to assume that the production cost threshold could be around 2 cents/kWh or less in order to successfully compete with bulk power sales in the new electricity marketplace. Thus, decisions to build new central station power plants in the future will be based on three criteria:

- Cost of electricity;
- Short construction lead time;
- Flexibility of the technology to achieve performance and cost goals in plant sizes ranging from 100 mW to over 1000 mW;
- The ability of the technology to meet ever-tightening environmental requirements without significant additional capital costs.

NRECA sees a continuing important role for coal in the new generation business. Central station power has the capability to achieve the low cost of electricity that the new marketplace will demand. And domestic coal reserves will provide the long-term low-cost fuel that can make this possible. However, the economics of scale of central station facilities is essential for coal plants to realize low-electricity production costs.

VI. TOMORROW'S COAL-FIRED POWER PLANTS

A consensus exists in the rural electric program that new central station power plants will generally be smaller than in the past. A few hundred megawatts will be more typical than a thousand megawatt or more. And modular plants offering short construction lead times and consistent performance over a range of sizes will dominate.

Although the generation part of the utility business will likely be unregulated and compete in the open market for electricity sales, from the environmental point of view, it will continue to be strictly regulated.

Hundreds of pages of regulations have been drafted to implement power plant SOx and NOx reductions required under the nation's 1990 Clean Air Act. Now, in 1996, the legislative and regulatory focus has shifted to reduce the output of CO2 and other "greenhouse gases," which some scientists believe are causing global warming.

Too, solid waste from power plants is increasingly the focus of proposed regulations under such legislation as the Endangered Species Act, the Clean Water Act, the Toxic Substances Control Act, the Resource Conservation and Recovery Act, and the Comprehensive Environmental Response Compensation and Liability Act - better known as Superfund.

The evolutionary development process leading to vast improvements in coal-fired central station power plants began in the 1960s with the development of fluidized-bed boilers. Atmospheric fluidized-bed (AFB) and pressurized fluidized-bed (PFB) boilers were seen as a potentially better way for utilities to burn virtually all ranks of coal directly while meeting the old 90 percent sulfur-removal requirements of the nation's first Clean Air Act. While direct combustion of coal via fluidized-bed boilers offers many advantages and will continue to be an important power plant option in many parts of the country, NRECA believes that coal gasification offers more advantages than direct combustion for the long-term highly competitive utility generation market.

Integrated Coal Gasification Combined Cycle (IGCC)

Coal gasification, in combination with new advanced power conversion technology such as high temperature turbines and fuel cells, clearly holds the key to central station coal-fired power plants that can compete in the bulk power generation market of the future.

In the early 1980s, ground was broken for the nation's first IGCC power plant at Southern California Edison's Coolwater site in Daggett, CA. This fundamental change in research direction away from direct coal combustion toward coal gasification was in recognition of the greater potential that coal gasification offered in terms of overall environmental performance and costs.

With direct coal combustion, impurities such as sulfur compounds and particulates must be cleaned from the post-combustion gas stream. The key advantage of IGCC is that gasification changes the fuel form from a solid to gasified coal which enables the impurities to be removed before combustion.

In the 100 mW Coolwater demonstration plant, a coal-water slurry was gasified in the presence of oxygen using a Texaco gasifier. The hot raw gas was cooled down, ash particles and other carry-over were scrubbed from the mixture, and then sulfur was chemically stripped from the gas.

The end product was a clean gaseous coal-derived fuel burned in a combustion turbine to produce electricity. Waste heat from the turbine exhaust was recovered to produce additional electrical power through a steam turbine.

And now, in the late 1990s, the U.S. Department of Energy, along with continuing electric utility industry R&D, has made significant progress toward demonstrating major improvements to the basic IGCC cycle

that could usher in coal gasification combined-cycle as the standard central station power plant for the next century.

An IGCC plant based upon the Coolwater configuration could be built today to operate on high-sulfur coal while emitting fewer pollutants than a comparable sized oil-fired power plant. But, the technology has improved from the Coolwater design at a significant rate due to advances being demonstrated under DOE's Clean Coal Technology program. The advanced IGCC system soon to enter demonstration testing at Sierra Pacific Power in Nevada will validate a number of these important advances. Technologies in Sierra Pacific's IGCC such as the pressurized fluidized-bed coal gasifier with in-bed desulfurization and full-stream hot gas cleanup, along with the use of a new generation of high-firing temperature combustion turbines, are critically important steps toward achieving the reduced electricity production costs that will be necessary to compete in the new competitive bulk power market.

Integrated Gasification Humid Air Turbine (IGHAT)

Further improvements to reduce the capital cost of IGCC plants will also be needed to ensure their success in this new competitive market. One approach to lower the cost of an IGCC power plant is to eliminate or perhaps simplify the equipment that is used to recover waste heat from the turbine exhaust and generate additional electricity. EPRI research on IGCC has been focused on how the waste heat could be recovered and expanded through the primary gas turbine power source instead of requiring a separate steam turbine to generate the additional electricity.

Under an EPRI research contract, engineers at Fluor Corporation identified a promising new concept for recovering the exhaust heat. Rather than having air pass directly from the compressor stage of a gas turbine into the combustion stage, this process diverts it into a cooler and then into a vessel known as a saturator. After the compressed air enters the bottom of the saturator, it flows upward against a stream of water that has been heated by the turbine exhaust, the compressed-air cooler, and any other sources of low-level heat. When the air leaves the top of the saturator, it has been humidified to between 10 percent and 40 percent water vapor. This humidified air is then further heated by the turbine exhaust and sent to the combustor, where fuel is added and burned.

In the process, the power produced by a gas turbine expander is proportional to the density of the combustion products that are being expanded. So, by substantially humidifying the air going into the combustor, the density of the combustion stream is greatly increased. Thus, the power extracted by the turbine expander is proportionally increased, thereby producing much more electricity from the gas turbine generator. As a result, a power plant based on a coal gasifier and this turbine could have a heat rate as low as 8,500 Btu/kWh (over 40 percent efficiency) without using a steam bottoming cycle but still reclaiming low-level heat that would be difficult for other cycles to utilize.

In addition, use of the IGHAT cycle could help lower the capital cost of a gasification-based power plant by nearly 20 percent compared with the Coolwater IGCC approach. The reason is that in an IGCC plant, heat for raising steam is obtained by passing the coal gas through large coolers, which are the most expensive components of the gasification system. With the IGHAT cycle, the gas could simply be quenched with water.

A prototype of this turbine has not yet been constructed. But because of the relative simplicity of the IGHAT cycle, and the fact that it is based on current component technology, EPRI believes it could be fully commercialized by 2003.

Integrated Gasification Fuel Cell (IGFC)

An even more dramatic improvement to the coal gasification power plant involves eliminating the combustion turbine altogether and using a fuel cell to convert the coal gas directly to electricity through an electrochemical process. Such direct conversion potentially offers the highest efficiency and lowest emissions of any coal-based plant yet devised.

The integrated fuel-cell coal-gasification power plant, which could be commercially available by approximately 2010, might represent the final step in the nation's quest for clean coal technology. This system could potentially offer the following operational advantages:

- Virtually no SOx and NOx emissions, even with the very highest-sulfur U.S. coals;
- Modularity that lends itself to short construction lead times;
- A capital cost comparable to today's best technology, a new pulverized-coal-fired (PC) power plant with flue gas scrubbers;
- A 20 percent reduction in the bus-bar cost of electricity compared to today's PC plant with scrubbers; and
- A full 30 percent reduction in heat rate - which translates to a 30 percent reduction in CO2 discharge, should that become required as U.S. policy develops on global climate change.

Ideally the fuel cell selected for use with a coal gasification unit should operate at about the same temperature as the gasifier. The most promising candidate is a fuel cell using a molten carbonate electrolyte. The molten carbonate fuel cell (MCFC) technology has been operated successfully on gasified coal. Moreover, it is now operating in a 2 mW electric utility demonstration plant at Santa Clara Municipal Utility in Southern California, and it is being accelerated into commercialization by the electric utility industry's Fuel Cell Commercialization Group (FCCG).

An MCFC produces electricity directly from either gasified coal or natural gas fuel and air without a combustion process. An electrochemical reaction takes place between the hydrogen from the fuel and the oxygen from the air in a closed container, with the molten carbonate electrolyte maintained at 1200°F.

This reaction produces electricity in a manner resembling a battery. It makes no noise. The byproducts are pure water and carbon dioxide.

The first integrated gasification fuel cell cycle will likely be achieved by substituting a molten carbonate fuel cell for the gas turbine in the standard IGCC plant. This alone is predicted to offer a significant improvement in heat rate from 8,900 Btu/kWh down to 7,500 Btu/kWh, with a slight reduction in bus-bar electric costs.

But the big improvement is realized when the molten carbonate fuel cell is "chemically integrated" with the coal gasifier. With this approach, the heat rate of the IGFC plant could be further lowered down to 6,000 BTU/kWh, achieving a coal-pile-to-bus-bar efficiency approaching 60 percent, compared with about 37 percent for today's best pulverized-coal technology.

Chemical integration, the key to such attractive performance, involves configuring the system in a manner such that the fuel cell's unconverted fuel and the fuel's heat content is recycled back into the gasifier. A special methane-producing gasifier would be required to maximize the chemical content of the coal-derived gas. Also, a hot gas clean-up step would be employed to clean the coal gas for use in the fuel cell without first cooling it down.

These are, of course, engineering developments that would have to take place successfully before such an advanced IGFC could be commercialized. But these are just engineering problems to be solved, and do not require any scientific breakthrough to achieve. As a result, EPRI believes this promising IGFC plant could become a commercial reality by 2010. If so, it could truly represent the final developmental step in the quest for clean coal-power generation.

VII. CONCLUSIONS

Deregulation of the electric utility industry would result in many changes to the way business is done today. In the unregulated, market-driven GENCO and ESCO businesses, electricity sales will be dominated by the low-cost providers.

ESCOs could successfully capture up to about 10 percent of the 175 gigawatts of new U.S. capacity needed by 2010 with dispersed generation. Dispersed generation electricity costs will be able to bear a premium above central station bulk power generation because the ESCO customers will be provided additional value-added services. Also, distributed generation will realize some payback from deferred transmission or distribution construction.

Central station power plants are expected to continue to provide the major portion of the nation's new bulk power needs. But only very competitive low-cost generating stations will be constructed. These will

likely be built in smaller increments of 100 mW or so compared to today's larger plants.
Coal will continue to be a major factor in central station bulk power generation. And the economics and environmental performance of coal gasification combined cycle power plants will likely position this option as the dominate technology for coal fired central station generation.

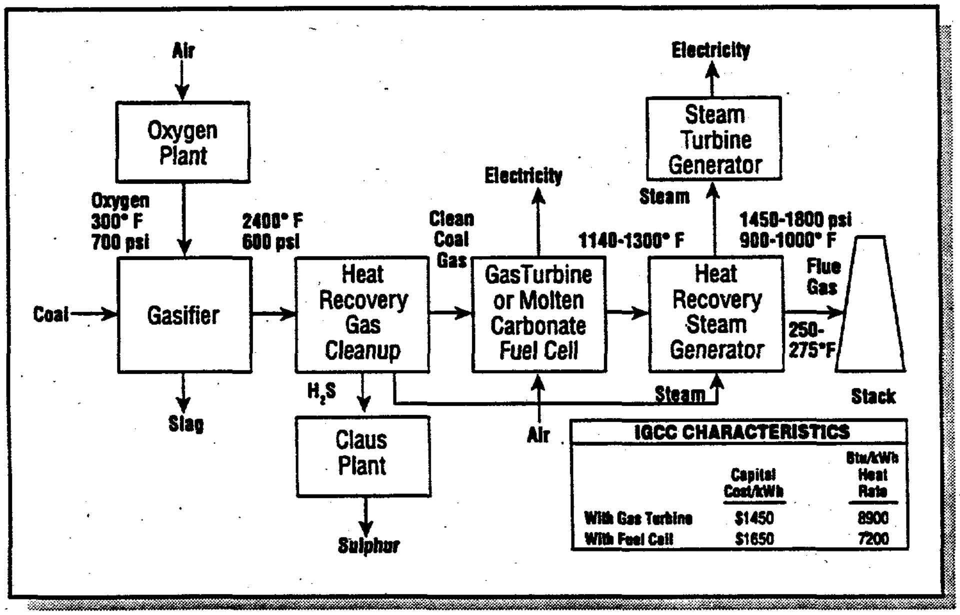
DOE's clean coals technology program has been a major factor in bringing coal gasification combined cycle power plants to commercial readiness. Without this promising option, the nation's abundant coal resource might not continue to be in demand in competitive utility markets where low-cost dominates but emission regulations continue to tighten. But further progress on capital cost reduction and performance improvement is essential to ensure coal's long-term place in such a market.

LOW COST COAL-FIRED ELECTRIC CO-OP GENERATING PLANTS
(Ref: Utility Data Institute 1995 Ranking)

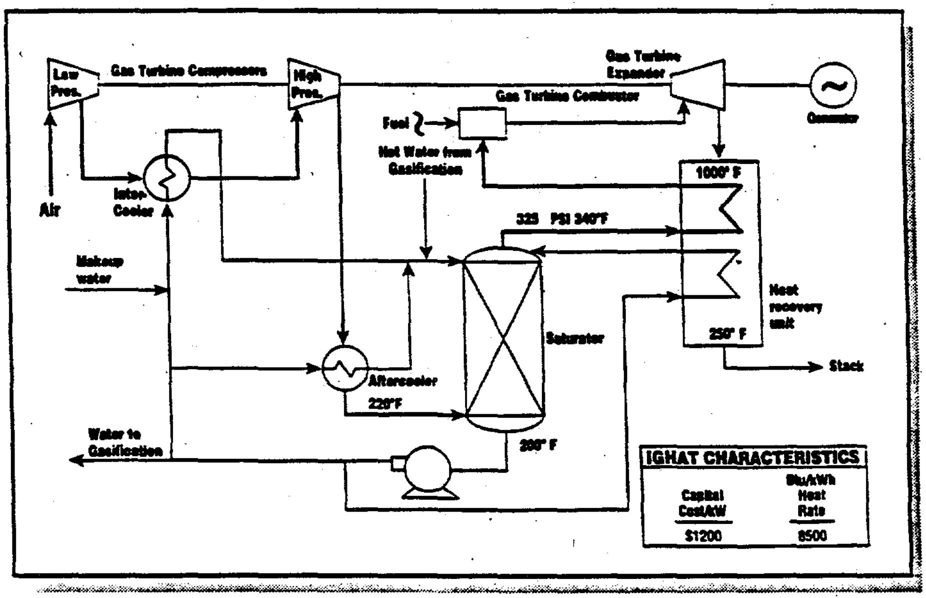
G&T Co-op	Plant	Location	Production Cost (cents/kwh)
Basin Electric Power	Laramie River	WY	0.983
Associated Electric Co-op	Thomas Hill	MO	1.127
Basin Electric Power	Antelope Valley	ND	1.136
Minnkota Power	Young	ND	1.189
Old Dominion	Clover	VA	1.213
Associated Electric Co-op	New Madrid	MO	1.250
United Power Association/ Cooperative Power Association	Coal Creek	MN	1.260

Generation Options	SO_x Removal (%)	NO_x Emissions (lb/MBtu)	Solid Waste (lb/MBtu)	Heat Rate (Btu/kWh)	Capital Cost ($/kWh)	Potential COE ($/kWh)	Commercial Availability (Yr)
PC W/FGD	90	0.3	110	9300	1160	2.0	Now
AFB	92	0.1	147	9700	1600	2.2	Now
PFB	92+	<0.1	144	8720	1500	2.1	1997
IGCC	99	0.14	50	8900	1450	2.0	1997
IGHAT	99	<0.0005	44	8500	1200	1.7	2003
IGFC	99.9+	0.0	29	6500	1200	1.6	2010

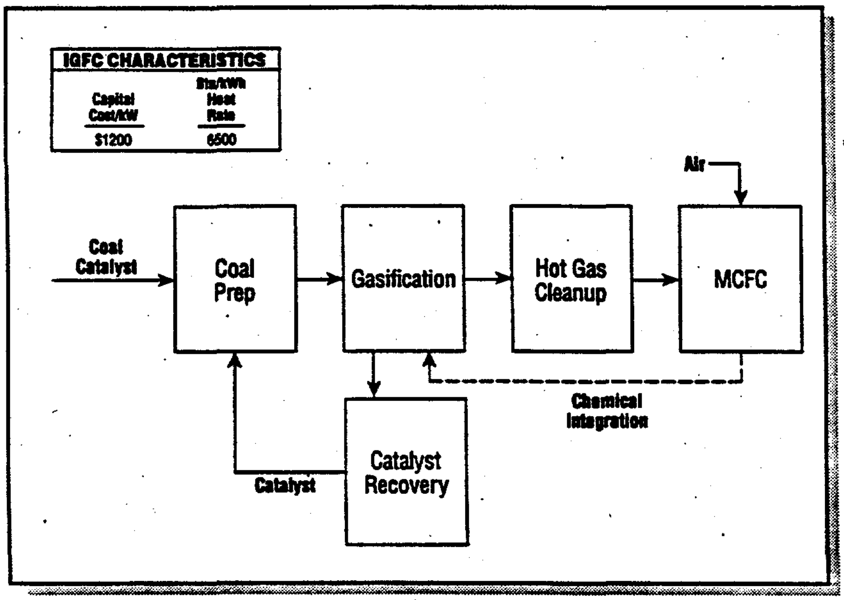
The integrated coal gasification combined cycle (IGCC) power plant could become the most environmentally superior and economically competitive coal-fired generation option compared to today's standard pulverized-coal (PC) plant with flue gas desulfurization (FGD). Improvements such as the integrated gasification humid-air turbine (IGHAT) and integrated gasification fuel-cell (IGFC) plant will offer substantial environmental and economic advantages compared to today's PC plant or advanced direct coal combustion options such as atmospheric fluidized-bed (AFB) or pressurized fluidized-bed (PFB) boilers.



Integrated coal gasification combined cycle (IGCC) based on Southern California Edison's demonstrated Coolwater Plant design could be configured with a gas turbine or a molten carbonate fuel cell (MCFC) as the primary generation source. MCFC carries a $200/kW capital cost premium, but overall electricity cost and plant heat rate would be improved.



Integrated gasification humid air turbine (IGHAT) improves IGCC plant performance and cost by expanding warm humidified air directly through the gas turbine, thus eliminating the IGCC heat recovery steam generating equipment.



Simplified Plant Configuration for an Integrated Gasification Fuel Cell (IGFC) power plant employs a methane-producing gasifier, chemically integrated with a molten carbonate fuel cell, and hot gas cleanup. Such a plant potentially offers nearly zero SOx and NOx emissions, the lowest electricity cost and the best heat rate (nearly 60 percent efficiency) of any power plant configuration yet investigated for use with high sulfur coal.

Luncheon Address

The Changing Face Of International Power Generation

THE CHANGING FACE OF INTERNATIONAL POWER GENERATION

Ian Lindsay
Secretary General
World Energy Council
London, United Kingdom

Ladies and Gentlemen,

I think it was Churchill in his great Iron Curtain speech at Fulton, Missouri, at the end of the last war, who referred to the American and the British as "Two great peoples divided by a common language" - I sincerely hope his remark will prove invalid today. At least during lunch, we will not have to resort to instantaneous translation as I did a few months ago in Moscow, when I was giving another short talk. Towards the end I noticed that terrible glazed look on the faces of the audience, which betrayed the fact that I had said something - through the interpreter - which was obviously totally incomprehensible. In fact I had used the expression "Out of sight, out of mind," but it was not until afterwards that I discovered it had been translated as "Invisible Idiot." Let that be a lesson against using the vernacular.

Before starting, just a few words about the World Energy Council. It was started in 1923, and with over a hundred member countries, is today the world's prime energy strategy and analysis organisation. Our study projects carry input from the industrialised world, the developing world, and of course the economies in transition in E. Europe and the Former Soviet Union. Almost more important, by working "bottom up" from the grass roots of local energy sectors we both collect input from the operatives - the very people, like yourselves, who manage energy - and we cross-fertilise data, information, and the results of our study work worldwide. We are increasingly acting as "facilitators" to "get things done." An example was holding the first ever African Energy Ministers Conference, which concentrated on power pooling arrangements and the first attempts at coordinated regional energy development. Before the conference such interconnections really only existed in the seven Southern African countries. Today, 1½ years later, interconnections are already being started in the six East African countries, the Arab Grid is being extended in the Maghreb (North Africa), and a central plan has recently been approved for power pooling in the French-speaking countries of Central and West Africa.

Although we are non-commercial and non-governmental, we work closely with governments the world over, as well as with over 40 of the leading institutions in the energy and energy-related sectors

- the World Bank, the principal regional financing agencies, the single energy associations - The World Petroleum Congresses, International Gas Union, UNIPEDE the European electricity institution, the World Trade Organisation, International Chamber of Commerce, the UN in all its guises, etc.

You may well not have heard of us if you are not intimately concerned with the international energy scene. Alternatively, you may have heard or seen references too much of the longer term work we do, but in either case I would suggest you are going soon to hear a lot more about us. The WEC US Member Committee is based in Washington and called the US Energy Association. Every three years we hold a major international Congress, always in a different country, and the next, the 17th WEC Congress, is being organised by the USEA in Houston in September 1998. Barry Worthington, its Executive Director, is with us today, and if you want to know more about its menu and attractions, please ask him.

"The Changing Face of International Power Generation" is a subject which could occupy several hours, but don't let me give you indigestion too early on. I will limit my remarks not to changing technologies and improved performance, not to changing fuel mixes, not to the incessant - but so far unproven CO_2 problems, not to SO_x's and NO_x's, of which you will have had your fill during this Conference, **BUT** to the international generator's marketplace, and even here I will devote little of what I have to say to the OECD countries but much to the developing world. I shall speak to future global electricity demand, generating capacity build, its financing issues, and to the commercial generating opportunities which now abound outside the States.

Such a rich diet may go some way to proving Voltaire's maxim that "Thinking depends on the stomach." So, while I remain hungry, you can chew over what I have said, because I get the very pronounced feeling in the current turbulence caused by the upheavals in your own domestic power sector, that US utilities are missing out on commercial opportunities in many overseas markets which, with prudence, could eventually offer attractive returns.

First of all, the general context. Energy demand perspectives including our own, those of the IEA, the World Bank and others, all point to a virtual doubling of global primary energy demand over the next 25 years. Let me interpret what that means. By 2020 more than 90m b/d of oil are likely to be consumed annually - an increase over today of 27m b/d, or the whole of OPEC's current crude oil production. Annual coal output will double to about 7 billion tonnes - almost double the entire known reserves in Canada or the UK. Annual gas demand will more than double to approximately 4 trillion cubic meters - almost equal to the entire current US gas reserves. In all this, fossil fuels will continue to dominate the global energy sector for decades to come, albeit with some ultimate growth of both nuclear and hydro. We see new renewables (solar, wind, etc.) remaining at or close to their 2% - 3% share of today's global demand, unless massive government or other funds are allocated to support their growth. Energy lead times are long and it is unlikely over the next 25 years that new renewables will either make in-roads into existing systems or play much of a part in the incremental growth during this time, unless the potential CO_2 problem becomes a scientific reality.

So much for the contextual perceived wisdom. It is not until these global demand figures are analysed, however, that the picture becomes clearer as to where or why the main demand will occur.

Up to 2020 it is likely that some 90% of this natural energy growth will occur in the developing countries - mainly in Asia and Latin America. North America, by contrast, will probably experience only a 12% - 13% growth up to 2020, while the 60% of global demand consumed by the OECD will drop to under 50% for the first time. By contrast, the developing countries demand will increase from 28% today to about 40% of the total by 2020. The East European and CIS demand is likely to remain constant at about 13%. But in this alarmingly short space of only 25 years, let us go further into the analysis. 90% of incremental energy demand growth will occur in developing countries, because of rapid population growth and economic development and the fact that growth in many cases will start from a low base. Over half of this incremental growth is likely to take place in just six areas: China, India, Indonesia, Brazil, Pakistan and the Malaysia/Thailand peninsula.

What of electricity generating capacity in all this? Well, we in the WEC, like many others, are predicting that more generating capacity will be built in the next 25 years than was built in the last one hundred. Much of this will result from the rapid urbanisation of developing countries, and much from the march of technology in transmitting power efficiently over much greater distances. In 1960 only 28 countries had greater urban than rural populations By 2020, 88 countries are expected to have 50% or more of their populations living in cities. Cities like Delhi, São Paulo, Manila, Bombay, Beijing, Jakarta and Teheran are all recording annual population growth rates of +3% or more - and do not forget that an annual growth rate of 3% means a doubling of population in 23 years. Do not also forget the result of a recent IEA study which showed that per capita consumption of energy in urban and peri-urban areas is usually between 2.5 and 3.0 times that experienced in rural communities. As an example of the long haul grid transmission, the huge 40 Gigawatt Inga hydro scheme on the Zaire River as the future supplier to markets as far afield as Egypt and Southern Africa, separated by 8,000 miles, is probably only some 20 years off. The feasibility study is already nearing completion and the political and economic in-fighting has already begun, not only for the project itself, but also for grid wayleaves, etc.

In 1920 Lenin defined communism as "Soviet power plus the electrification of the whole country." He meant by this the projection, in one leap, of the whole of a backward country into the forefront of industrialisation. He might have been proved right had it not been for the might of your own economy together with those of others and backed by our political wills to overcome. However, let us concentrate today not on the flagging energy sectors of Eastern Europe and the CIS - where, to give you some idea of current economic regression, the Russian Federation consumed 20% less oil in 1994 than it did in 1993 - not on the slow growth of the OECD generating sectors - but on the developing countries and their rapidly expanding electricity demand.

Here we should differentiate between what I call "old assets" (existing power systems) and "new assets," involved in the massive incremental growth of the power generating sector. The growth of these "new assets" is not only a phenomenon in its own right, it is turning out to be a considerable stimulus for global capitalism. Let us not forget that the global power sector at nearly 40% is by far the world's greatest absorber of infrastructure capital. Electricity development consumes more finance than communications, highways, or water. It also carries huge political clout. A developing country politician can win more votes faster - if he or she operates within a voting system - by bringing in electrification to a village. Go to a country like Uganda and you will see this. Rural power development there has not followed any logical pattern - it has largely followed the whims of individual ministers. Utilities in many such countries have until now been government owned and run, financed starved and the primary cause of lack of industrial productivity due to black and brown outs and general inefficiency. Often their revenues did not even cover their fixed costs because to a greater or lesser degree governments supported subsidies to consumers, who in many cases were unable economically to pay tariffs which covered costs.

Approximately 60% of all energy supplied globally to consumers today is subsidised by governments in one form or another - and a large part of this 60% inevitably occurs in the developing world. Consumer tariffs are therefore often low and many do not allow of a decent return on capital invested. So, with regard to such "new assets" the message must be to investigate and take action with great prudence and almost inevitably in conjunction with a local partner which knows the local scene.

But all this is changing. Governments faced with huge and increasing demand for electrification and new assets, are realising that they cannot cope with the pressures for finance, control and the day-to-day management and maintenance essential for all this new capacity. This has resulted in a number of different national reactions. On the one hand markets are being liberalised - although by different methods and at different rates, and this may offer commercial opportunities for the astute external investor: But, on the other hand, developing country governments often maintain their ingrained belief that energy must belong to the national patrimony, and some are correspondingly reluctant to adequately loosen controls. This causes a range of problems.

"Old electricity assets," the existing power systems, are in many cases also being liberalised. Let me give you some examples. Brazil is about halfway through its privatisation programme. Chile has fully privatised with adequate commensurate changes to government regulation to ensure overall economic and social success. Argentina is in the process of privatising by individual sector, generating, transmission and marketing. The Venezuelan electricity sector now has local private investors as well as foreign owned assets. In Africa, Egypt has privatised its generating sector. Kenya Light and Power, previously 100% government owned, now has only a minority government shareholding. In Zimbabwe ZESA, the national generator, with some 2,000Mw now has Malaysian minority shareholders, who will become majority shareholders when capacity is increased by 50% over the next 4 years. Of almost more importance, industrial consumer prices in Zimbabwe have been increased by some 250% and the "new asset" investment in generating capacity has a planned 20% real rate of return. In Zambia, the Copperbelt Power Company is to be sold; in Botswana a privatisation plan is to be announced shortly; and in Namibia local private sector shareholders now own all the principal generating and transmission assets. Further south, South Africa is in the throes of liberalising its power sector which generates 67% of all the power in the Continent of Africa.

In Asia, China and India, with some 10% of total current global electricity demand, are planning to build new capacity up to 2020 which, by that year, could equate to 25% of global generation. This could mean the construction of a medium sized power station every week up to 2020. In Malaysia and Indonesia, power demand is growing faster than the already rapidly expanding economies.

But there are caveats; relate all this growth to population predictions and you will find that by 2020 China, for example, will still only have a per head generating capacity equal to 30% that of the US today. Such rapid growth in the developing world coming on top of a lack of finance, often poor technical management, and equally poor financial control, is now faced with a fourth quandary - that of increasing local pressure to apply very much more stringent environmental protection controls first in a local sense, and probably thereafter in a global sense.

We in the WEC have done some work with the World Bank, which shows that international financing (from both agency and private sector sources) will probably cover only between 30% - 40% of the huge future requirements of the electricity sector. In my view, the outstanding questions in this entire growth scenario are "Where will the other 60%-70% come from?", and "Will the potential lack of financing become a real constraint to growth?" Can, or will, many developing countries not only liberalise their power sectors but render then sufficiently attractive to investors to mobilise local capital? And at the same time will they set up the necessary institutions to attract the often high local savings rates? To know more about all this we now await the outcomes of two current WEC study projects, due to be completed shortly: the first on "Liberalisation of the Global Energy Sector," and the second on "Future Energy Financing." The results will make fascinating reading.

The scale of such private power development of itself probably presents the greatest problem of all. As an example, private sector power development may, in India, be regarded as the solution to one of the country's major development problems, but internal bureaucracy, the rivalry between government departments, and the way legal process work have all combined to slow down the whole process of private investment. Foreign investment rates, having soared during the last three years in Malaysia, Indonesia, Argentina and Chile, have also now begun to slow down. And over this whole scene is cast the shadow of the debt crisis of the 1980s. About 30% of the money then lent to Third World governments was to have been invested in power projects. Today's scene is different, but nonetheless tense. Today's investors are considerably more prudent than yesterday's, and the loans do not necessarily go to governments but it is still necessary for such agencies as the World Bank to provide some political protection by themselves taking small stakes in satisfactory projects. Risks however remain, not least depreciating exchange rates and the inability of governments to change regulations and tariffs at the same rate as they encourage private sector investments.

This, then, is the heart of the changing face of international power generation as seen by the WEC. Let me encourage you to come and hear much more about it, by participating in the WEC's 17th Congress to be held in Houston from 13th - 18th September 1998. We are expecting between 6,000 and 7,000 delegates to the event, one of a series which over the years have established themselves as the prime global events of the international energy scene.

If I have given you indigestion, this can only have resulted from one of two causes - boredom, in which case you have my apologies; or from a surfeit of information, in which case you have my commiseration. But above all, let us not forget that to operate in the developing world we all have to deal primarily with local politics and local politicians, and in this context you may care to remember the little aphorism of one of our British maverick socialist politicians, Lord Charlfont, who maintained that "you can always rely on politicians to produce wise, intelligent and statesmanlike decisions .... having first exhausted all other options!"

Panel Session 3

Issue 3: Environmental Issues Affecting CCT Deployment

International Environmental Issues and Requirements for New Power Projects

presented by

James R. Newman Ph.D.[1] and Jeanne H. Maltby[2]

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Purpose of Presentation

- Discuss emerging role of financial entities in determining environmental requirements for international power projects

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Emerging Conditions

- Increased economic growth overseas resulting in increased demand in electricity
- Move towards privatization of electricity sector overseas

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Examples of Announced Privatization Energy Projects by County

COUNTRY	# OF PROJECTS	CAPACITY (MW)
China	6	5,850
India	6	2,879
Pakistan	3	3,766
Turkey	11	6,900
Brazil	19	11,475
Argentina	10	6,472

Source: Hagler Bailly Consulting, September 1996

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Resulting Activities

- Independent Power Producers (IPPs) investing overseas
- International Public and Private power project financing by governmental and multinational entity sources

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Types of Governmental and International Financial Entity Sources

- Seven major sources

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Types of Governmental and International Financial Entity Sources

- Multinational Development Banks (MDB)
- Regional development banks
- National development banks
- National export banks and agencies

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Multinational Development Banks (MDB)

- International Bank for Reconstruction and Development (IBRD) or The World Bank
  - International Development Association (IDA)
  - Multilateral Investment Guarantee Agency (MIGA)
  - International Finance Corporation (IFC)

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Regional Development Banks
(examples)

- North American Development Bank
- Inter-American Development Bank
- African Development Bank
- Asian Development Bank
- European Bank For Reconstruction and Development

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Electric sector projects in multilateral bank funding pipelines as of 1995 ($US milllion)

REGION	*Asia*	*LAC*	*NIS/EE*	*Africa*	*TOTALS*
World Bank	5,193	783	1,315	621	7,912
IDB	–	1,706	–	–	1,706
AfDB	–	–	–	249	249
ADB	2,065	–	–	–	2,065
Totals	7,258	2,489	1,315	870	11,932

Source: KBN, 1996.

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National Development Banks
(examples)

- Banobars
- Nacional Financiera
- Banco Nacional de Desarrollo Economico
- Industrial Development Bank of India
- National Finance Development Corporation of Pakistan

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National Export Banks and Agencies
(examples)

- US Eximbank
- Japanese Eximbank
- Overseas Private Investment Corporation (OPIC)
- US Trade and Development Agency

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Types of Governmental and International Financial Entity Sources

- Private (non-government) project financing sources
- Major international commercial banks
- Other private project financing sources

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Private (non-government) Project Financing Sources

- Major International Commercial Banks
  - Citibank
  - Deutsche Bank
  - Others

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Other Private (non-government) Project Financing Sources

- International Finance Companies
- International Investment Banks and Equity or Dept Funds
- International Corporations
- International Trading Companies

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Financing By Major Financing Entities Requires Environmental Approval

- Financing entity's own environmental policies and/or
- Policies of host country or other entity
- IPP may have its own environmental policies

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Problem For IPPs

- Similar kinds of environmental requirements and issues

but

- multiple financing entities for same project with different environmental approvals

and

different emphases on environmental requirements and issues

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Similar Environmental "Requirements"
(examples)

- Environmental Impacts Assessments
- Environmental Management Plans
- Environmental Monitoring Plans
- Risk Assessments/Risk Management Plans

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Similar Environmental Issues
(examples)

- Host country environmental policies
- International conventions
- Emission and effluent limitations
- Air, water, geological, and ecological resources
- Socioeconomic quality (especially resettlement)
- Public participation

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Confounding Conditions

- International financing entities often require or defer to World Bank's numerical pollution limits
- Approvals often must conform with unofficial, draft, and outdated World Bank guidelines
- Host country requirements often more stringent
- Some international commercial banks require USEPA type of compliance

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Consequences for IPPs

- Conflicting environmental "requirements" and conflicting emphasis on environmental issues

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Consequences

- International environmental "standards and regulations" for power projects are evolving and not consistent
- World Bank becoming international "EPA", not by design but by default

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Similarity and Differences between World Bank and USEPA

- Similarity
  - Both deal with environmental issues and give project approval
- Major Differences
  - Guidance vs. compliance
  - International vs. US setting
  - Sovereignty issue of World Bank
  - Different missions

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Different Missions

- EPA's mission
  - implement and enforce environmental policies in US
- World Bank's mission
  - promote sustainable development in developing countries
  - provide loans that contribute to economic growth

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Environmental Policies of International Financial Entities Differ Significantly

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Comparison the international environmental "Standards and Regulations" for power projects

FINANCING ENTITY	ENVIRONMENTAL POLICIES	EIA GUIDELINES, FORMATS AND PROCEDURES	NUMERICAL LIMITS FOR AIR, WATER WASTES	RISK ASSESSMENT GUIDELINES
WORLD BANK GROUP IFC MIGA	DETAILED	SPECIFIC FOR DIFFERENT PROJECT TYPES INCLUDING POWER	YES - (TRIGGER VALUES), PLUS HOST COUNTRY	GENERAL
ASIAN DEV. BANK	DETAILED	SPECIFIC FOR DIFFERENT PROJECT GROUPS	NO - DEFER TO HOST COUNTRY OR WB	DETAILED
INTERAMERICAN DEV. BANK	GENERAL	GENERALLY FOLLOW WB AND HOST COUNTRY	NO - DEFER TO WB	NO SPECIFIC GUIDELINES
OPIC	GENERAL	DEFER TO WB	NO - REQUIRES WP COMPLIANCE	NO SPECIFIC GUIDELINES
US EXIMBANK	GENERAL	DEFER TO NEPA AND WB	NOT COMPREHENSIVE, DEFER TO WB	NONE
COMMERCIAL BANKS	INTERNAL	DEFER TO WB	DEFER TO WB (SOMETIMES EPA)	NONE.

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Examples of Evolving Numerical Limits For Power Projects

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Recent Trends/Issues Involving International Power Project Approval

- Financial institutions don't understand World Bank policies and guidelines
- Projects being required to meet a common (but not agreed upon) set of environmental standards
- Increasing requirement for baseline data collection e.g. air quality

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Recommendations For Understanding/Expediting the MDB's and other financial entities's environmental approval process and how to expedite this process

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Maintain Close and Frequent Communications With Banks, Financing Entities and Governmental Agencies

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Determine All Possible Approving Entities, Realize There Are Multiple

- Host Country- federal, state and local
- Multinational financial entities, especially the World Bank
- Private financial institutions

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Know the Difference Between Approving Entity's Policies, Standards, Procedures, Recommendations and Guidelines

- What ones are in effect and apply to your project?
- Are they changing? When?
- Guidelines are often moving targets

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Define Your Project Early

- Avoid evolving engineering designs
- Understand how environmental requirements will affect your design
- Link environmental assessment with early part of financial cycle

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Other Recommendations

- Avoid poor site selection

- With increasing requirements for baseline data collection and monitoring
  - Consider effects to schedule
  - Need to negotiate reasonable requirements
  - Weigh project costs vs. monitoring costs

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Other Recommendations

- Conduct scoping
- Involve public and NGO
  (assure public participation conditions are met)
- Garner public support
- Avoid relocation and resettlement
  (moving people can be political fatal flaw)

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The Objective of a Successful EIA Strategy Is to Reduce Uncertainty in an Uncertain "Regulatory" Environment

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Climate Change: Update on International Negotiations

Linda Silverman
U.S. Department of Energy

5th Annual Clean-Coal Technology Conference

January 9, 1997

U.N. Framework Convention on Climate Change

- signed at Earth Summit in Rio (June 1992)
- entered into force in March 1994
- contains non-binding "aim" to stabilize greenhouse gas emissions in developed countries (Annex I) to 1990 levels by 2000

U.S. Plan -- *Climate Change Action Plan (October 1993)*

- *44 mitigation actions*
- *reduction of 106 MMT not realized due to faster than expected economic growth, lower than expected oil prices, and reduced funding for CCAP actions*
- *Germany and UK the only OECD countries that will meet 2000 aim*

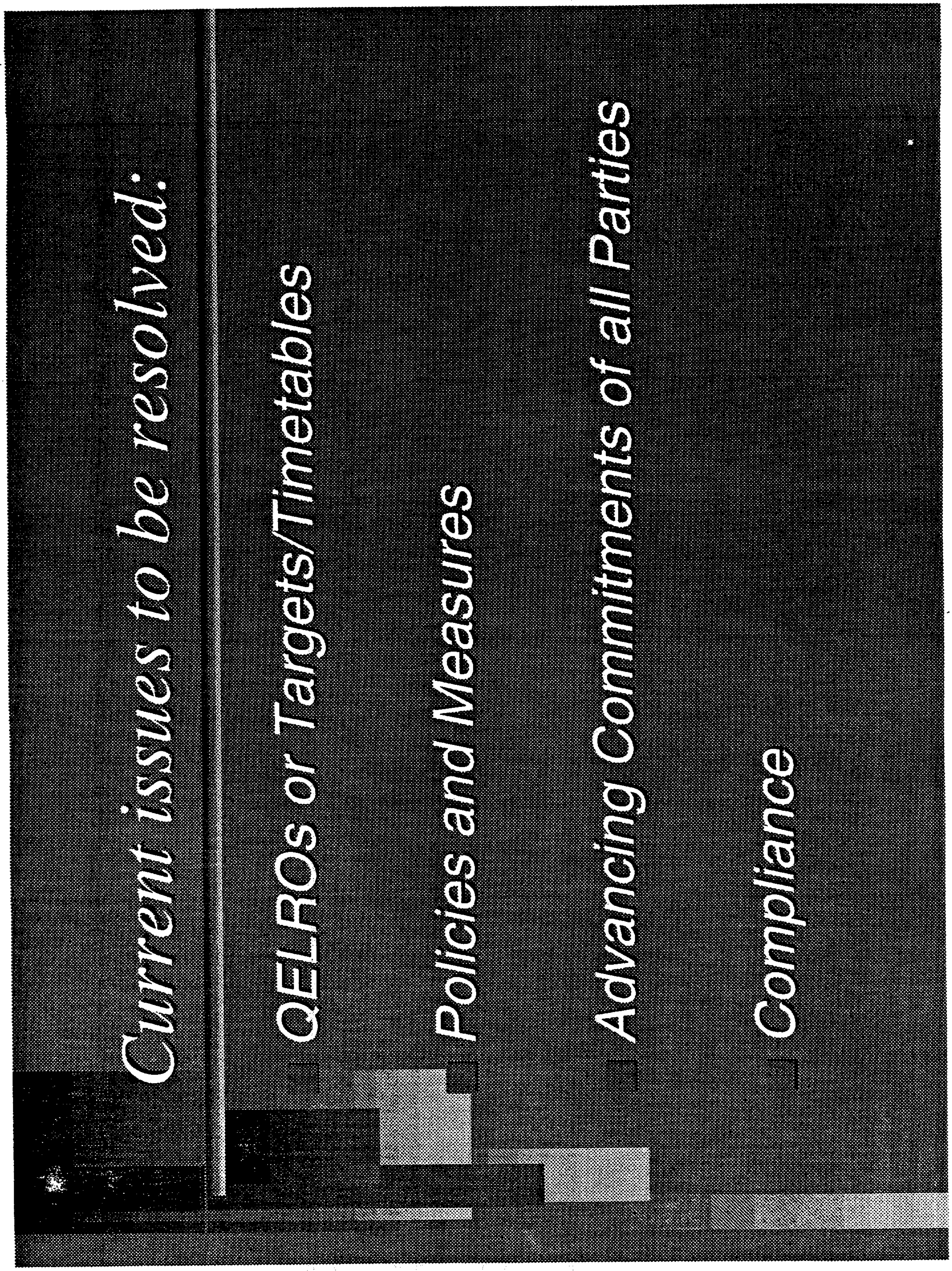
COP I in Berlin (March 1995)

Resulted in Berlin Mandate focused on post-2000 period

- QELROs (quantified emissions limitations and reductions objectives)
- Policies and Measures
- no new commitments for developing countries
- JI pilot: "Activities Implemented Jointly"

COP II in Geneva (July 1996)

- *Geneva Declaration: calls for Annex I Parties to adopt* ***legally binding*** *commitments by COP 3 (Dec 97)*
- *Based on science contained in IPCC Second Assessment Report (Dec 96)*
- *U.S. Position: verifiable, medium-term targets that are realistic & achievable, with maximum flexibility (with emissions trading and joint implementation)*


Current issues to be resolved:
QELROs or Targets/Timetables
Policies and Measures
Advancing Commitments of all Parties
Compliance

QELROs
Defining the Form of the Target

- Flat Target vs. Multi-year Target
- Differentiation among Annex I Parties
- Comprehensive (or all gas) approach
- Flexibility: Emissions Trading & Joint Implementation with credit

Policies and Measures

- European Union supports harmonized policies and measures
- U.S. opposes harmonized policies and measures


Continuing to Advance
Commitments of all Parties
Article 4.1: inventory, mitigation, adaptation, national communications, technology transfer, financial resources
Developing countries believe Annex I has not lived up to commitments
What happens with developing countries in the Kyoto agreement?

Implications for Clean-Coal Technology

- *binding target would increase need for clean coal technology*
- *joint implementation with credit could expand technology export opportunities*
- *could spur R&D funding*
- *implementation flexibility increased with emissions trading and JI + credit*

Domestic Environmental Requirements, New and Projected

5th ANNUAL CLEAN COAL TECHNOLOGY CONFERENCE

Remarks of Brian J. McLean, U.S. EPA

January 9, 1996
Tampa, Florida

ENVIRONMENTAL CONCERNS

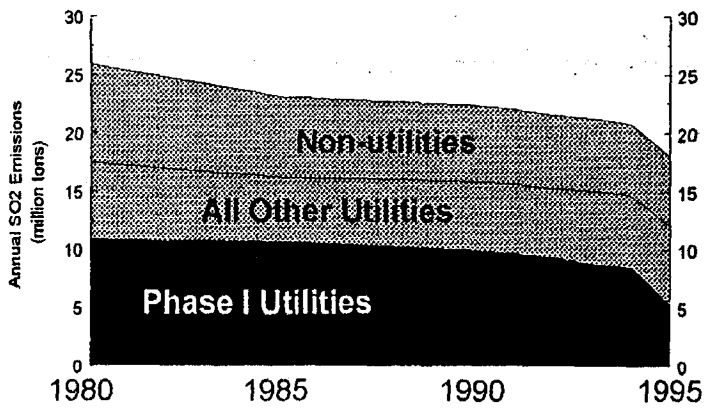
Public Health	Environment
Ozone	Acidification
Fine Particles	Eutrophication
Toxics	Materials Damage
	Crop/Forest Damage
	Visibility/Regional Haze

Climate Change

GOAL OF TITLE IV

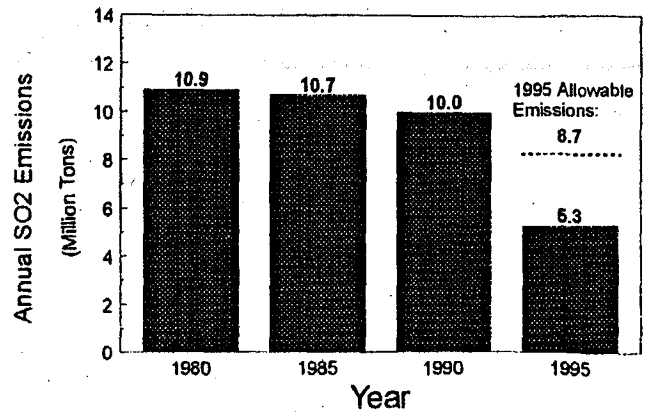
To reduce SO_2 and NOx from power generation as cost-effectively as possible in order to protect public health and the environment

NATIONAL SO2 EMISSIONS All Sources

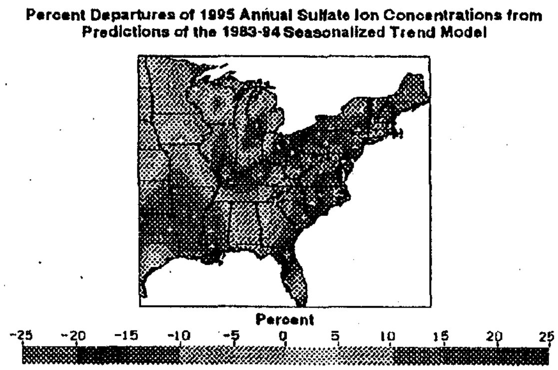


SO2 Emissions

445 Phase I Affected Utility Units



REDUCTIONS IN WET SULFATE DEPOSITION



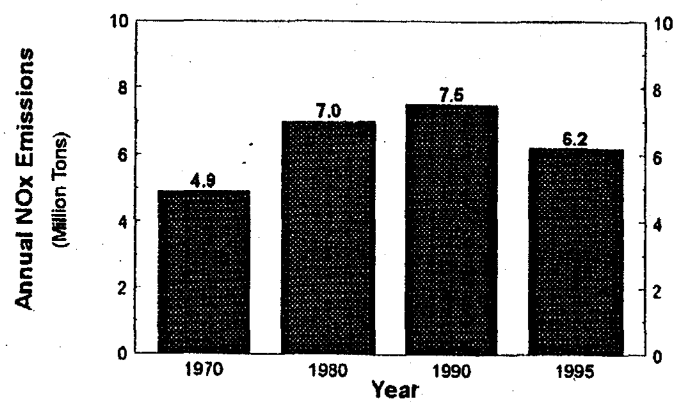
SO2 ALLOWANCE PROGRAM: BENEFITS

- Health: $12 - 40 billion per year by 2010
- Visibility: $3.5 billion per year by 2010
- Fewer acidic lakes & streams
- Reduced damage to buildings & monuments

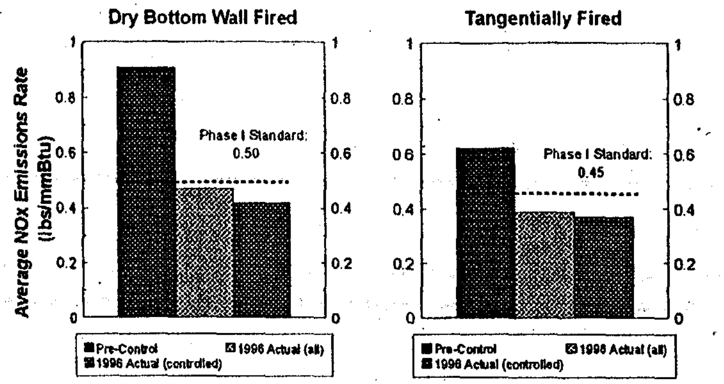
SO2 ALLOWANCE PROGRAM: COSTS

- In 1990, estimated to cost $4 billion per year by 2010
- By 1994, estimated cost dropped to $2 billion per year by 2010
- Less than half the cost of command and control: $5 billion per year
- 1 percent of government air pollution control personnel for 40 percent of emissions reductions under 1990 Clean Air Act

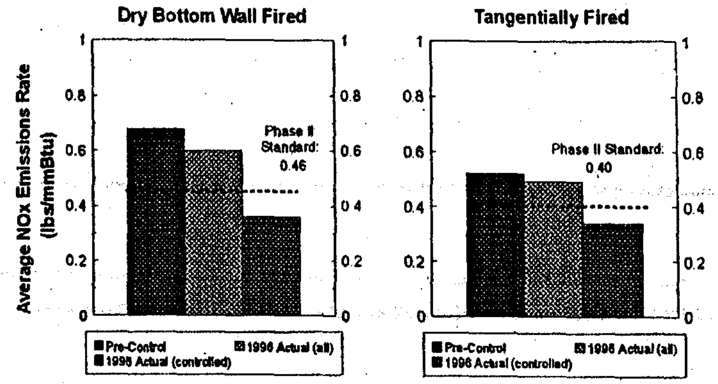
UTILITY NOX EMISSIONS (1/3 of total U.S. NOx emissions)



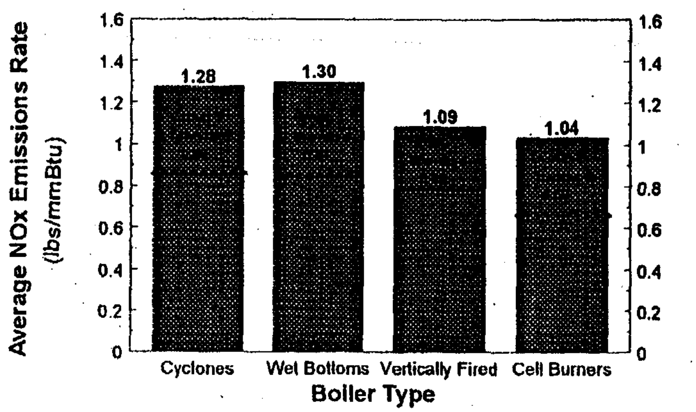
Group 1, Phase I NOx Emission Rates



Group 1, Phase II NOx Emission Rates



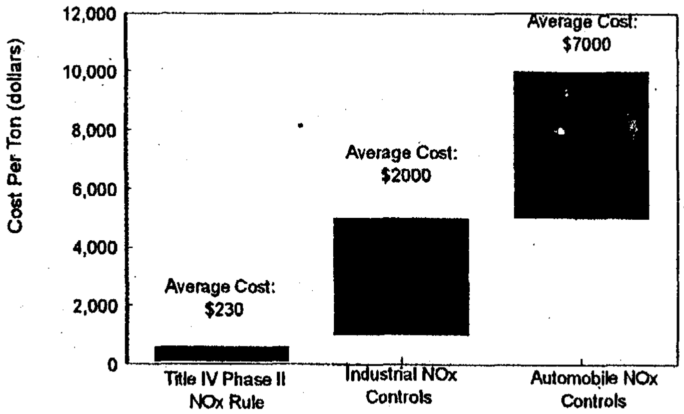
GROUP 2 BOILERS NOx EMISSION RATES



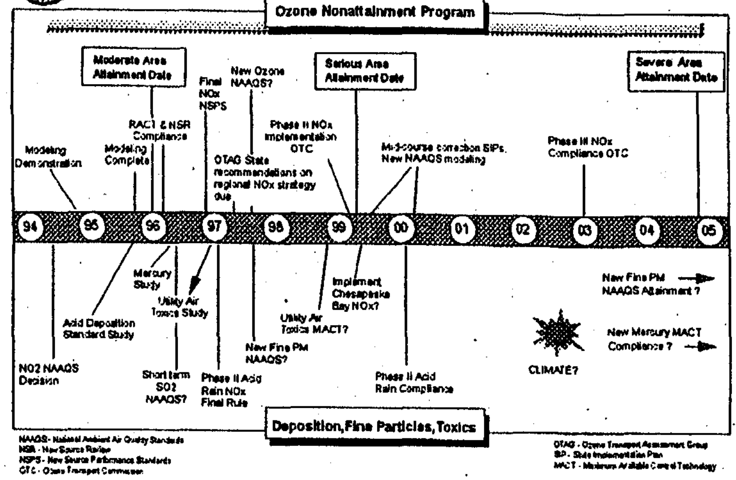
NOx COMPLIANCE OPTIONS

- Boiler-by- boiler compliance with annual emission limitation
- Emissions averaging across holding or operating company
- Altemative Emission Limitations (AEL) for boilers unable to meet limits with Low NOx Burners (LNB's) or Group 2 Technology
- Early Election option for Phase II, Group 1 boilers
- Cap & Trade option for Phase II boilers

COST EFFECTIVENESS OF NOx CONTROL (by Source Category)



Electric Power Regulations Timeline - Clean Air Act



CLEAN AIR POWER INITIATIVE

Goal: To develop an integrated strategy for achieving the goals of the Clean Air Act with respect to the power generating industry

WHAT WOULD A NEW APPROACH LOOK LIKE?

- Translate health & environmental goals into emission targets
- Employ cap & trade with banking
- Provide more certainty, flexibility, & cost savings
- Reduce continuous and disjointed regulatory hits

SCENARIOS ANALYZED

- Traditional Regulatory Approach
- Nationwide caps on NOx, SOx, (and possibly mercury), with trading & banking

NOx CAP & TRADE SCENARIOS ANALYZED

Year 2000

Set allowance caps based on Title IV NOx rule

Summer = 2.2 million tons

Winter = 2.9 million tons

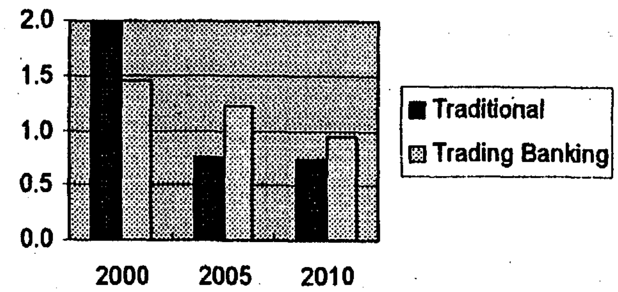
Year 2005 (3 Scenarios)

Lowered summer allowance cap to 1.3 million tons, 1.0 million tons, and 0.8 million tons (based on 0.25, 0.20, & 0.15 lbs/mmBtu rates)

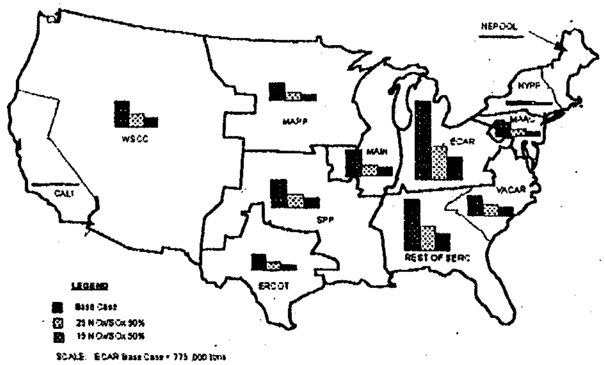
SO2 CAP & TRADE SCENARIOS ANALYZED

- Lowered Title IV allowance allocations by 50 percent in 2010
- Lowered Title IV allowance allocations by 60 percent in 2010
- Lowered Title IV allowance allocations by 50 percent in 2005

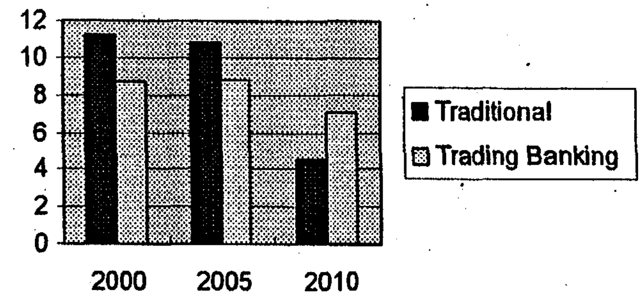
Summer NOx Emissions of the Traditional and 0.15 NOx/SOx 50% Trading/Banking Options (million tons)



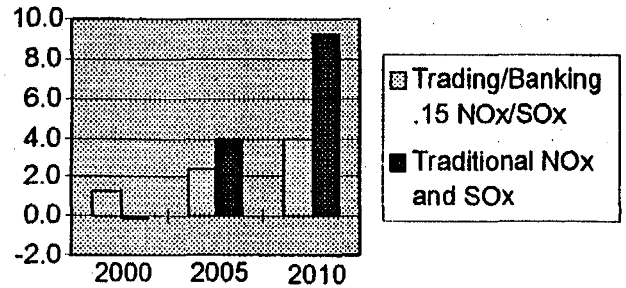
Comparison of Summer NOx Levels in 2010 for the 0.15 and 0.25 Options



SOx Emissions of the Traditional and 0.15 NOx/SOx 50% Options (million tons)



Costs of Traditional vs Trading/Banking Approach to NOx and SOx ($Billions)



For More Information on The Acid Rain Program or CAPI

Visit our Acid Rain Home Page:
http://www.epa.gov/acidrain/ardhome.html

Visit our CAPI Home Page:
http://www.epa.gov/capi

Coal

Cornerstone of America's Competitive Advantage in World Markets

For
Center for Energy & Economic Development
National Mining Association
Western Fuels Association

By Mark P. Mills
Mills•McCarthy & Associates Inc.
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Chevy Chase, MD 20815

December 1996

Contents

Mills•McCarthy & Associates Inc.

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Opinions expressed herein may or may not reflect those of the sponsors.

Key Findings

Key Finding #1
Coal-fired electric generation is a major contributor to the U.S. dominance in the world's economy.

Study Support
- U.S. industrial and small business electric rates are among the lowest in the world.
- U.S. has world's largest fleet of coal-fired power plants. Majority (56%) of U.S. electricity is coal-fired.
- The central advantage for U.S. electricity consumers is that electricity producers pay less for fuel.
- U.S. manufacturers are 50% more productive than just two decades ago. Electric technologies fueled by low-cost electricity are a primary factor in this progress.
- Over the past two decades non-electric non-transportation energy use fell 10% while electric energy use rose 70%. This tracks productivity increases.

Key Finding #2
Coal-fired generation will supply a majority of the nation's growth in electric needs for the next 10-15 years.

Study Support
- A competitive electricity market will seek the lowest cost supply.
- Industry-wide forecasts show coal taking a 44 to 77% share of electric growth to 2010.
- GRI predicts 60% of future electricity through 2015 will come from coal use in existing plants.
- Over 85,000 MW of coal-fired capability exists without additional "green field" construction through the greater use of existing coal-fired capacity.

Key Finding #3
Low-cost electricity is crucial to the future productivity, competitiveness, and economic health of our nation.

Study Support
- Productivity is driven by technology. New non-transportation technology is dominantly electric in nature. Low-cost electricity accelerates these technologies.
- Productivity growth over the past two decades is projected to continue in critical industries and is highest in electric dominant industries.
- U.S. electric demand and GDP have grown together, over 60%, since 1975.
- U.S. spends more on electric energy ($200 billion annually) than any other commodity.

Key Finding #4
Emissions associated with coal-fired electricity will continue to decrease despite increased use of coal.

Study Support
- U.S. EPA projects a 24% increase in coal use, along with a 15% and 37% decline, respectively, in nitrogen oxide(NO_x) and sulfur dioxide(SO_2) emissions by 2010 from all coal-fired generation due to improvements in emissions controls.
- Taking into account total fuel cycle impact of electric technologies -- end-use emissions reductions from electric technologies -- there will be an even greater decline in critical smog precursors than projected by EPA.
- If 50% of new electric supply is coal-fired, the emissions reduction arising from the new uses of electrotechnologies will yield a net annual decline of about four million tons NOx and one billion tons CO_2 per year.

Executive Summary

The United States' competitive position in world markets will be determined by many forces. Two of the fundamental factors are the increased use of new technologies, and the availability of low-cost electricity to operate those technologies. The U.S. currently has and will likely continue to have market dominance in both these critical areas. Both of these factors are intimately related since the primary source of new technologies is electric in nature. And, because low-cost coal now dominates and will continue to dominate the electric supply system, and because the U.S. has both an abundance of coal and the world's largest fleet of coal-fired power plants, the U.S. will have an expanding base of low-cost electricity that will secure its current competitive advantage for years to come.

Electric technologies and, increasingly, computer-based technologies integrated with electric technologies are the primary sources of innovative advancement and economic growth. As a consequence, the growth in electricity, which has historically tracked GNP growth, is expected to continue. And, with the restructuring of the electric utility industry and the emergence of vigorous competition, prices are expected to decline as competition increases. The net effect of these forces will be to dramatically increase the use of electric technologies—and those sources of electricity that can provide low-cost electricity. The data show that coal, the primary source of new low-cost electricity, will supply between one-half and three-fourths of all new electric supply through 2010, at prices of about 3¢/kWh, and can do so without new power plant construction. Since the use of coal is expected to rise by at least 200 to 250 million tons/year over the current consumption of 850 million tons, and could increase as much as 400 million tons/yr, some have raised concerns about the emissions impact from the power plants. *This report also shows that the net effect of increased electric use, assuming coal dominance, will be a decrease in emissions.* This decrease will occur for two reasons: a) power plants are becoming increasingly clean, and b) the electric technologies that consume the electricity displace more emissions than are created at the power plants.

The bottom line for America:

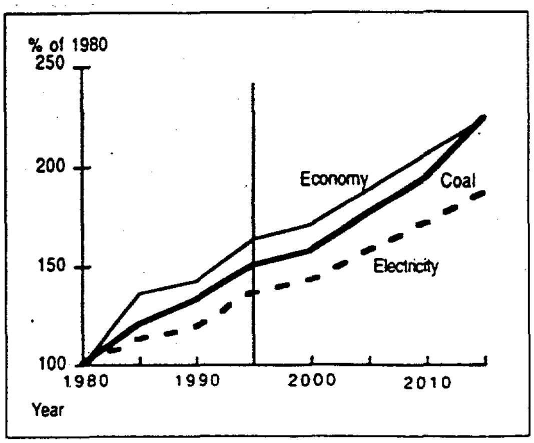
- **Improved economy**
  Lower cost electricity stimulates greater demand for electricity. Electric demand is a direct measure of the use of electric technologies, which will, through their productivity benefits, boost the U.S. economy.

- **Increased U.S. competitiveness**
  Electric technologies dominate the productivity growth of an economy. Low prices stimulate greater use of electric technologies. U.S. global economic power will be powerfully reinforced and protected by an economy with low-cost electricity.

- **Moderate inflation**
  When any commodity is projected to have stable and declining prices, economists predict low inflation. Since *electricity is the biggest commodity* bought and sold in our nation— three times the size of the second largest commodity—low and declining electric rates will moderate inflationary pressure for years to come, thereby protecting the integrity of savings and investments.

- **Reduce environmental impact**
  With the growing use of advanced electric technologies, the overall use of materials will decline. This will lead to declining use of hazordous chemicals, reduced land use, and reduced air emissions.

Growth in the Economy, Electricity and Coal Consumption



Data from DOE/EIA & EPA

Introduction

Competition. This word dominates discussions in and around the electric utility industry today. Understandably. Without regard to the effect on individual utilities, the pending changes to the regulations surrounding electric utilities have a potential impact at least comparable, over time, to those associated with or predicted to arise from the *Telecommunications Act of 1996*. This is true, if for no other reason than, because the electricity business alone has revenues equal to all of the major telecommunications activities combined; local exchange, long distance, cable, and cellular.

The focus of much of the discussion on the impact of legislative or regulatory changes leading to greater electric-sector competition has been on issues such as identifying the corporate winners and losers: tracking mergers and acquisitions; and—the most widely covered issue in the popular press—gauging the price consumers will pay for a kilowatt-hour. The popular and trade press, as well as state regulators and the U.S. EPA, have also focused on potential changes in power plant emissions.

All of these are important issues, but they all miss the central impact. Regardless of the form that regulations and legislation ultimately take, utilities <u>are</u> in a more competitive environment. The effect of this competition will be cheaper electricity for most customers, fewer new power plants being built (likely none for a while) <u>and</u> more coal being used to make electricity. Because of how, why and where electricity is used, profound economic implications from these changes are in store for the American economy that go far beyond receiving a lower electric bill. The changes underway in the electric sector will ultimately be seen as one of the single most important structural changes in our economy undertaken in decades. These changes presage a new age of enhanced and robust competitiveness on the part of the U.S. economy in world markets because of the central role that electricity and electric technologies play.

This paper summarizes the results of analyses and research undertaken over the past several years, including frequent presentations as expert testimony before many state regulators. In addition, this paper brings together the results of a new analysis regarding the potential future value of the nation's investment in coal-fired electric power plants.

Background

Coal: the cornerstone of America's competitive economic advantage? The 21st century is next door and the Information Age is dawning. How can coal be a cornerstone of anything but a monument to the historic achievements of the 20th Century? The answer can be summarized by a single word: connections. There are tight, demonstrable and critical connections between primary energy sources, electricity, new technologies, and the nation's economy. **This report is about those connections and the relevance of those connections to one of the largest industries in the nation, the electric utility industry.** This industry is undergoing changes now that are as dramatic and tumultuous as any time in this century. This report is about the relevance of those connections to businesses, jobs and **the American worker. And, critically, this report is about the relevance of those connections to coal, the primary source of fuel for the American economy.**

The seemingly tenuous connection between coal and our high-tech dominated economy is in fact fundamental. Basic inputs are connected to our day-to-day life, no matter how high-tech that life becomes. For example, soil and water—two of the oldest ingredients supporting life and civilization—are essential and hardly high-tech or 'modern'. They are nonetheless self-evident starting points for the food chain that leads to our dinner table, regardless of how exotic the meal. Basic energy sources are similar starting points in the "chain" that supports essentially everything in society. Like soil and water, coal and oil are the two primary starting points.

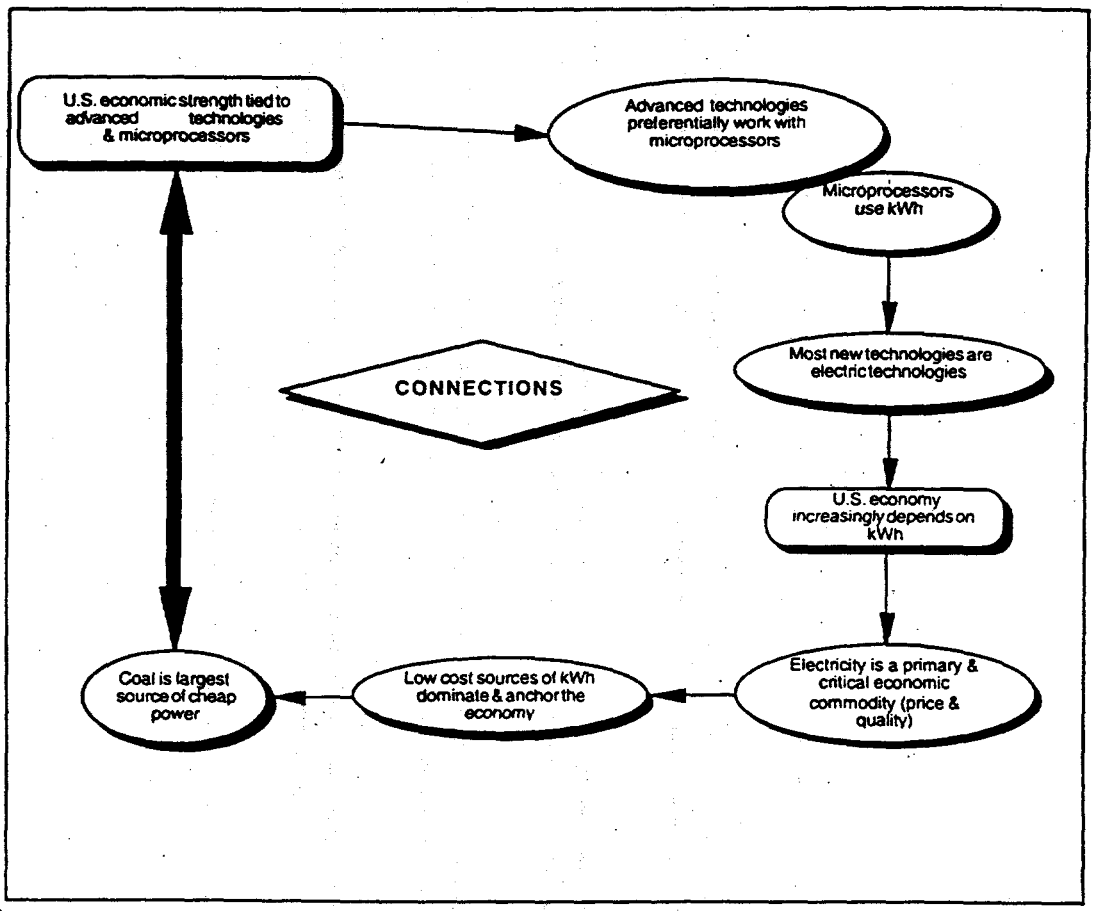
Changes in one part of a technology "food chain" can be felt rapidly throughout the economy. Economists talk about ripples through the economy from basic commodity price changes. The price of wheat, metals and other commodities do ripple through the economic system. The ripple of changes in energy commodities tends to move rapidly. Recently, the basic price and availability of crude oil changed and consumers quickly saw gasoline prices rise—and shortly start to fall again. When it comes to electricity—the biggest commodity in the economy—changes (when they occur) won't work like ripples, but will move at lightning speed through the economy and will have a larger effect.

This reality is the driving force behind the changes that are currently shaking the entire electric utility industry. As this report shows, neither gasoline nor oil, while important, are the underlying energy driving forces of the economy. Electricity, and specifically the technologies that use it, is the single largest factor supporting the economy. (Over three times as much money is spent each year on electricity as is spent on gasoline.)

If the direct linkage between coal and our high-tech economic well-being does lead to greater use of coal, as this report shows, will this linkage be bad for the environment—as some claim? This concern is also addressed in this analysis. The reason that this environmental concern is misplaced? Again, connections. ***The electricity from power plants, and thus the emissions from those plants, is directly connected to the emissions eliminated by electrotechnologies that use the electricity. The true net environmental impact can only be determined by comparing the two sources of emissions: emissions from power plants must be compared to, and are offset by, decreases in emissions from end-uses of electric technologies. This connection is real—and typically results in net reductions in emissions to the atmosphere.***

This report is structured in a conventional "building block" fashion, outlining key points and facts and then establishing the link to the next step in building the connections in the chain that anchors the nation's future as a high-tech economy with coal as the primary fuel support.

Connections in the U.S. Economy



There is a strong demonstrable chain of events and technologies that link coal to the health and strength of the U.S. economy.

Technology & Economic Growth

Economist Paul Romer is making waves in the theoretical field of economics with his model that establishes a clear linkage between knowledge, technology and economic growth. Romer's contribution is not the notion that technology growth drives the economy—this is common wisdom—but in providing a rigorous mechanism for observing and predicting the relationship, something economists have never been able to do. If Romer's modeling techniques hold up to scrutiny, some of his colleagues predict a Nobel Prize.

The link between technology and productivity, and its importance is evident in various basic indicators. This evidence is the first step in connecting the economy, through technology to electric technologies and to low-cost coal-fired electricity.

A common issue for policy planners seeking to spur the economy is to find ways to encourage companies to invest in new technologies. Spurring investment requires an understanding of how businesses can finance capital acquisitions and issues pertaining to integration of new equipment and processes into existing operations, training, maintenance, and reliability. Investment in new technology brings financial rewards for companies which become more competitive, and for employees—through the retention both of existing jobs as well as creation of new jobs—and, ultimately, growing income for both employer and employee.

Studies consistently show that machinery and equipment investment have a strong predictive value and relationship to economic growth. No other investment factor is as strongly correlated with economic growth. And, as *Table 1* shows, not only has capital investment in equipment (i.e., new technology) rebounded in recent years, but at the same time investment in computer-related equipment is soaring. As *Table 1* shows, the growth rate in spending on equipment is at a higher level than during any business expansion cycle of the past thirty years. Similarly, business investment in computer-related equipment is growing even more rapidly.

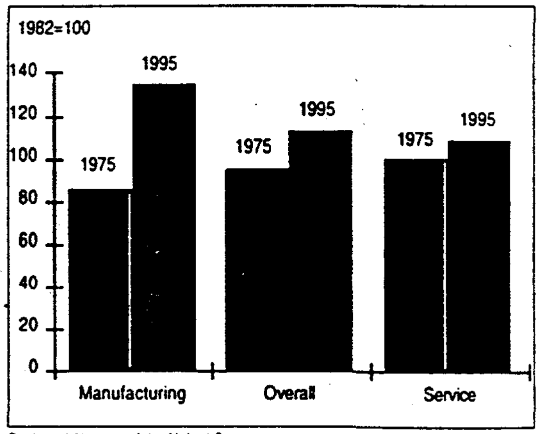
Table 1
Increase in Spending on Equipment
(During business expansion cycles)
(constant inflation-adjusted $)

Period	On Computer	All Equipment (excl. computer)
1962-66	34%	76%
1972-73	57%	34%
1976-79	170%	41%
1983-85	153%	21%

Fortune, April 3, 1995

The investments are often synergistic—that is, the computer-related equipment is used for or is an integral part of the "other" equipment. For example, more than half of all machine tool orders now incorporate a computer-driven control system, often one that can work on a computer/communications network. (*Fortune*, Dec. 13, 1994, "Welcome to the Revolution.") Both of these factors have direct relevance to the form of energy that businesses require, which is typically electrical, as we explore in the next section.

Figure 1
U.S. Productivity

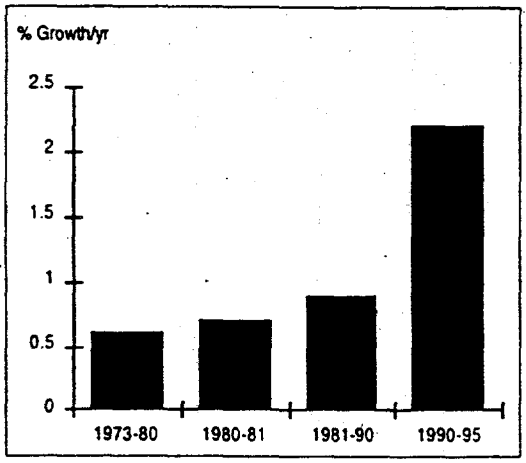


Statistical Abstract of the United States

The primary impact of new technologies on businesses is an increase in productivity. Productivity growth is what permits businesses to extract more value from the same inputs, and to increase wages while remaining competitive. In what amounts to a stealth revolution, U.S. manufacturing productivity growth has taken off over the past decade as businesses have adapted to new technologies. *Figure 1* illustrates the trends for manufacturing, the service sector, and the two blended as an overall U.S. trend. Manufacturing exports continue to be a critical part of U.S. competitiveness. U.S. manufacturing productivity is over 50% higher today than only two decades ago. This type of growth arises primarly from the use of new technologies.

The productivity growth trend is likely to both continue and to accelerate because U.S. firms in recent years have been spending more on capital equipment — new technologies — than at any time since the 1960s. (*Fortune*, April 3, 1995, p. 33). The U.S. already has the world's most productive economy. And recent events suggest even greater economic opportunity for the nation, as *Figure 2* shows.

Figure 2
Business Productivity Growth Between Business Cycle Peaks



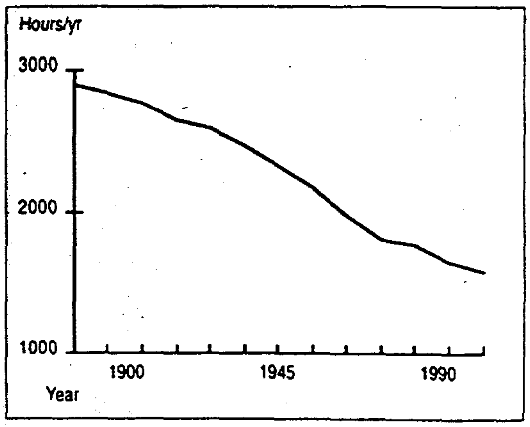
Business Week Oct. 9, 1995

Figure 2 illustrates the productivity growth rate measured during each of the productivity growth cycles of the past two decades. The most recent cycle, 1990-1995, has experienced unprecedented productivity growth at just over 2% per year, more than twice the growth rate of any previous business cycle of the past two decades.

The overall effect of new technologies and rising productivity is to increase the size of the economy and to increase personal wealth. **For example, if over the past decade the annual growth rate in productivity in the U.S. had been one-half of one percentage point higher per year, it would have yielded $1.5 trillion more in the economy, or $10,000 per household** (*Business Week*, October 9,1995 "Riding High").

Over time, new technologies and productivity growth also have the effect of reducing the amount of time the average person has to work to make a living. While everyone seems to instinctively understand this factor, the data are dramatic. *Figure 3* shows the trend of the past century during which average hours worked per year have been declining continuously. This means that people are on average earning more and working less, a trend that is made possible almost exclusively by increased productivity.

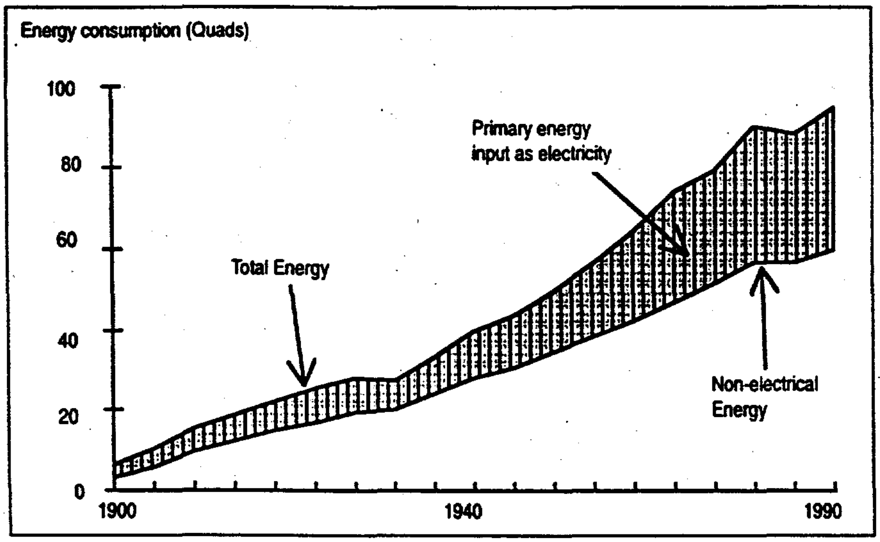
Figure 3
Average Annual Hours Worked in the U.S.



Ausubel & Gruebel, Technology Forecasting and Social Change, 1995

The relationship between growth in technologies and the economy is almost intuitively obvious. Perhaps less obvious is the role that electrotechnologies and, specifically, electricity have played in fueling this important economic and social trend. Considerable research has been devoted to demonstrating the important effect of electrification—increased use of electrotechnologies—on the American workplace. *Figure 4* suggests strongly that there is a linkage, one that is explored in greater detail in the next section. *Figure 4* illustrates that over the past two decades the nation's dependence on non-electric energy—i.e., on equipment that is combustion-based—dropped dramatically, while electricity use continued to rise.[1]

Figure 4
Historic Use of Electricity & Energy in the U.S.



DOE/EIA Annual Energy Review

1 To be sure, some of this effect is attributable to increased efficiency with which combustion fuels are used in equipment (conservation); but as the Technical Appendix outlines, improved efficiency of combustion equipment (notably cars) took place at the same time as improved efficiency of electric equipment (notably lights, refrigerators and motors), and furthermore, the combustion-conservation effect cannot account for the growing appetite for electric energy.

Electric Technologies: What Role in the Economy?

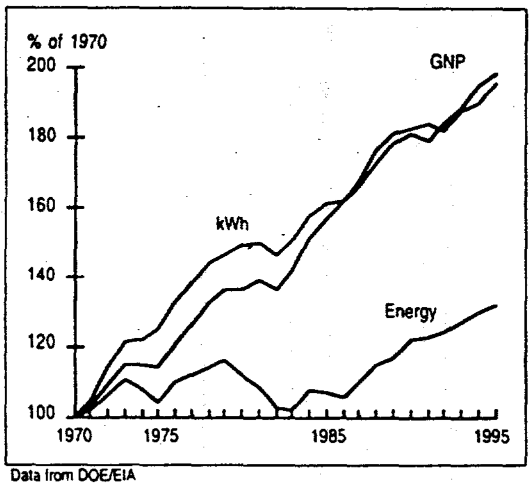
How significant are electric technologies in the context of all technology advancement? One obvious way to see the overall role of electric technologies as compared to fuel-based technologies is through the aggregate consumption of electricity. Clearly, significant increase in the use of electric technologies will appear as growth in consumption of electricity, and the extent to which electricity use tracks economic growth.

The kilowatt-hour and economic relationship, as a surrogate for electric technology growth, can be seen by looking at three data sets:

a) trends in the recent past,
b) current relationships, and
c) future projections.

Figure 5 illustrates trends of the **recent past** for the U.S., wherein it is clear that there is a close linkage between the growth in the economy and the increased use of electricity—which is fundamentally a direct measure of increased use of electric technologies.

Figure 5
U.S. Trends Excluding Transportation



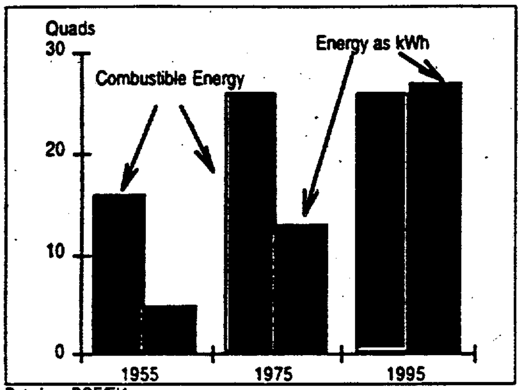
Data from DOE/EIA

Figure 5 excludes data relating to transportation energy use and the transportation sector's direct contribution to the Gross National Product. The reason for this is simple. Trends in transportation fuel use have virtually nothing to do with the electric sector. The transportation sector depends almost exclusively on oil—using over two-thirds of all oil, and less than 0.1 % of all electricity production. In addition, the transportation sectors direct contribution to the GNP totals under 10%. **Meanwhile, the other three major sectors of the economy—industrial, commercial and residential—account for 90% of the GNP, and consume 99.9% of all electricity.**

The continued growth in preference for electric-based technology, reflected in electric energy usage, can be seen by looking at the data in a slightly different way. In the past, the majority of equipment used in the economy has been in the form of combustible energy—primarily, oil, natural gas, and, earlier, the direct combustion of coal. As *Figure 6* shows, as recently as 20 years ago, nearly twice as much energy was purchased as combustible fuels than as in the form of electricity. This means that the majority of equipment being used in the marketplace (again excluding transportation) required combustible fuels—not electricity. Over the past two decades, a transformation has occurred. **Today, electricity provides for over one-half of all energy used by equipment in the industrial, commercial, and residential sectors.**

Not only have electric technologies been the primary source of new equipment purchases, but electric technologies must also have been replacing the use of existing fuel-based technologies over that two-decade period in order to lead to an energy transformation of this magnitude.

Figure 6
Uses of Energy by the Industrial, Commercial & Residential Sectors



Data from DOE/EIA

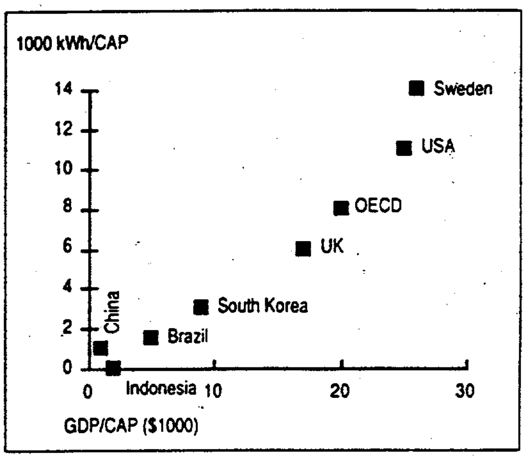
The linkage between electric technologies and economic growth was exhaustively documented in one of the most comprehensive explorations to date, undertaken a decade ago by the National Academy of Sciences (NAS). The NAS study, *Electricity in Economic Growth*, National Research Council, National Academy of Sciences, 1986, concluded:

"To foster increased productivity, policy should stimulate increased efficiency of electricity use, promote the implementation of electric technologies when they are economically justified, and seek to lower the real costs of electricity supply by removing any regulatory impediments and developing promising technologies to provide electricity."[emphasis added]

The close relationship between increased use of electric technologies (again, measured as rising kWh consumption) and the economy is not unique to the United States. As the graphs in *Figure 7* (next page) show, the relationship has been as strong, or stronger, in other industrial nations.

The present relationship
Just as the historic trends show a strong link between electricity and economic growth, so too do present data. This relationship is visible in current country-to-country comparisons. As *Figure 8* shows, a striking relationship exists between the per capita consumption of electricity among countries around the world today and the per capita income in those countries. The wealthier the citizens, the more electricity used per person. This, of course, is not a measure of electricity use per household, but total electricity use in the economy, measured per person. This is, in other words, a direct measurement of the effect of increased productivity providing greater individual wealth—productivity driven by technology, and technology that is dominantly electric in nature.

Figure 8
National Income & Electricity

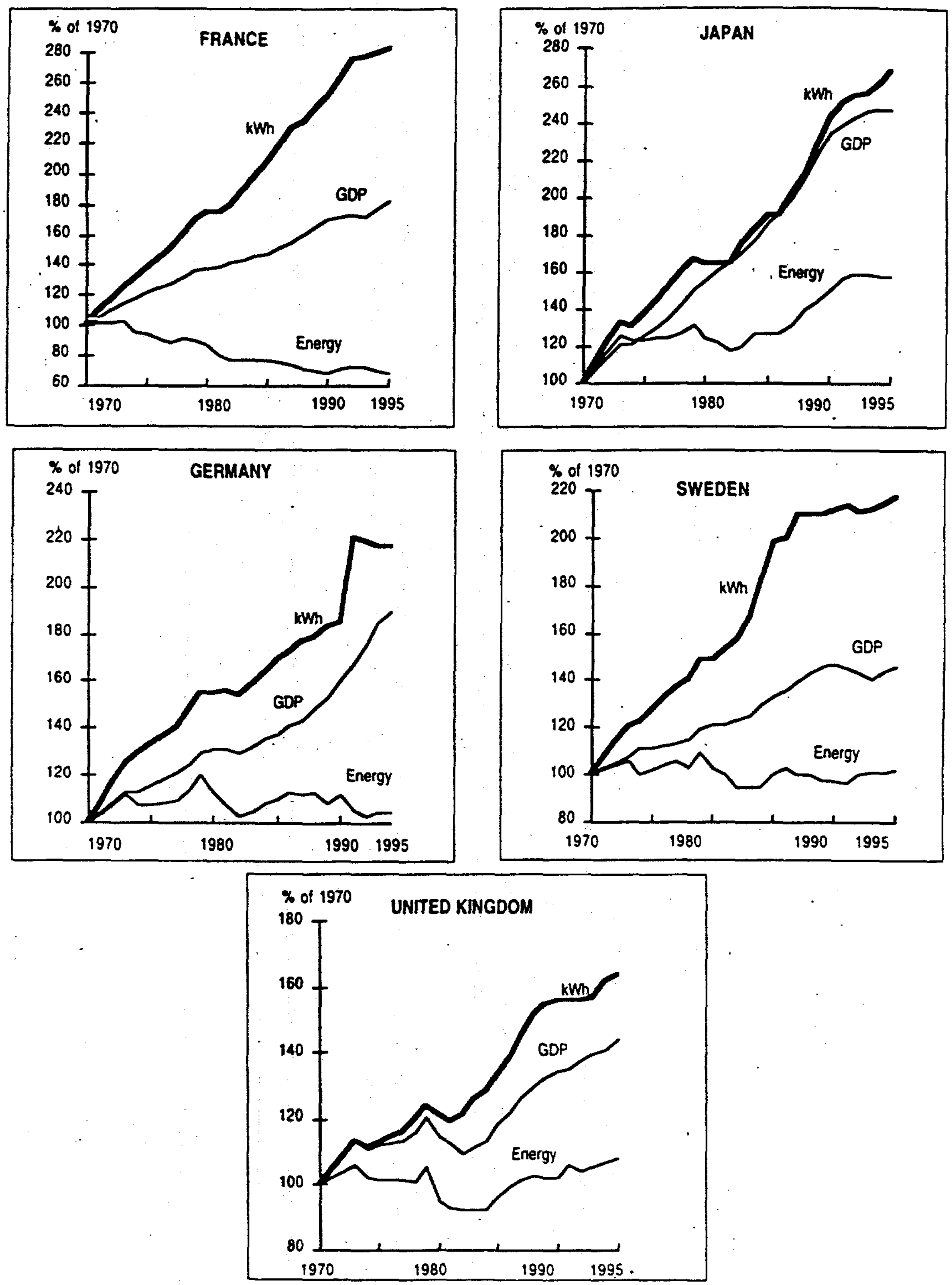


Data from OECD

Figure 9 is another way to look at the same overall effect—the role of electric technologies and their impact on the economy. *Figure 9* shows for various nations the growth in the size of the economies and associated growth in electricity consumption over the period 1960 to 1993. For that three-decade period, the United States experienced the largest increase in economic output, and the largest increase in the use of electric technologies—once again as measured by the use of kWh. During the same period, nations such as China, India, Brazil, and even the UK experienced far less total economic growth. Even Japan's economic juggernaut cannot compare to the U.S. performance—but the

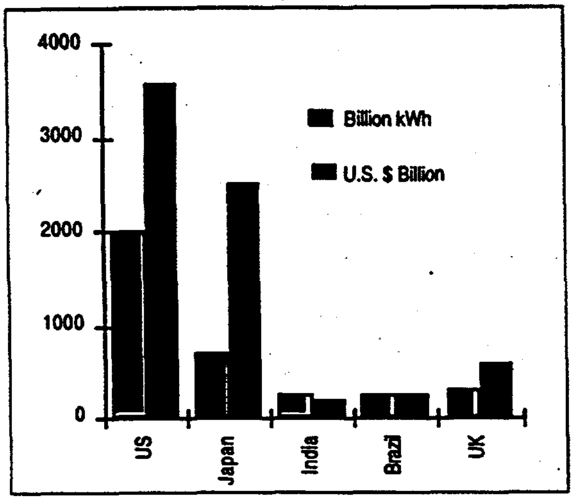
Figure 7
Trends in Other Industrial Nations

Data from OECD International Energy Agency



relationship between electricity and the economy is just as clear there.

Figure 9
Correlation between Economic & Electric Growth
[Total Increases between1960-1993]



Rainbow, The Electricity Journal, May 1996

The somewhat indirect measure of electric technology/economic trends illustrated in Figure 8 and 9 has been validated by a direct measurement. A recent U.S. Department of Commerce study of manufacturing technologies supports the conclusion that electric technologies are the dominant form of advanced/productive technologies being implemented. In a survey of advanced manufacturing technologies in over 6,000 manufacturing plants, the Commerce study concluded:

"Plants which utilize higher numbers of advanced technologies are less energy intensive and rely more heavily on electricity as a fuel source; use less energy per unit of output, but consume a higher proportion of electricity; plants over 30 years old are the most energy intensive and rely most heavily on non-electricity."

Energy Intensity, Electricity Consumption, and Advanced Manufacturing Technology Usage, M. Doms, T. Dunne, July 1993, Center for Economic Studies, U.S. Dept. of Commerce, Economics and Statistics Administration.

The Commerce Department study, in finding that more advanced manufacturing technologies lead to greater electricity use is a direct way of observing that those advanced technologies are primarily electro-technologies.

The Future Indicators

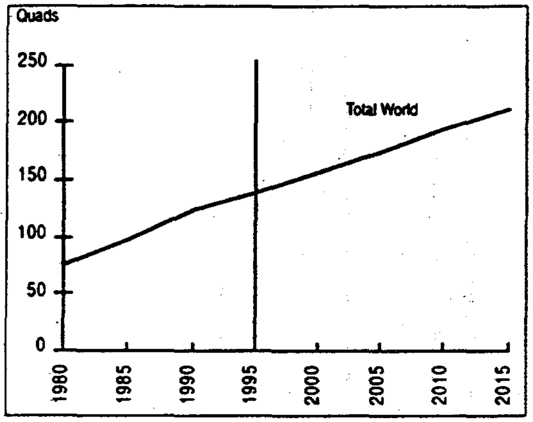
If, as is clearly the case, electric technologies have dominated the growth in new technologies, and currently dominate the market—what of the future? Do projections of future trends indicate an increase or decrease in their importance?

The clear answer from all available data is that electric technologies, measured as the consumption of electricity, will continue to dominate technological progress for at least the next two decades. Projections for both the industrial and developing nations show a clear pattern of increased use of electricity. As *Figure 10* shows, the use of electricity globally is projected to increase more than 50% over the next two decades.

Growth continues in all nations, and growth rates in developing nations are more rapid because they are starting from a much lower point of utilization of electric technologies. The point of departure for growth in some cases for developing nations involves many electric technologies (pumping of fresh water and sewage management for example, lighting, refrigeration, etc.) that are already commonplace and taken-for-granted in developed nations.

For the United States, in which many electric technologies have already reached maximum market penetration, a question arises with regard to the potential for additional growth in electric demand. Analysts agree that there is unlikely to be any growth in demand for electricity to meet future lighting and refrigeration and cooling needs. Even as the population grows, and housing and building stock grow faster than the population, driving significant demand for lights and chillers, the expected increased efficiency in these applications of electricity will more than offset increased use of the equipment. Indeed, most analysts expect

Figure 10
Projected Growth in Global Electricity Use



DOE/EIA International Energy Annual

demand for electricity in these applications to decline slightly.

Nonetheless, all projections still show a net overall increase in electricity demand. This outcome is a direct result of the increased use of electric technologies that are the anchor of economic growth, and especially growth tied to "high-tech" scenarios for the future of the nation.

The greatest uncertainty with regard to the future demand for electricity is associated with potentially larger, not smaller, growth. This arises from the fact that our understanding of technologies that reduce demand (so-called Demand-Side Management technologies) is more mature than our understanding of electric- and information-based technologies which accelerate growth in demand.

New electric technologies, of which there are hundreds, not only increase demand for electricity directly because of their specific use of kWh, but also because these new technologies contribute to productivity growth. The resulting economic growth generates a secondary—and sometimes larger—impact on electric needs because of the overall boost given to the specific industries and overall economy creating demand for electricity in other applications.

Electrotechnologies Dominate Growth

As the previous sections of this report have highlighted, advanced technologies tend to be primarily electric technologies, and these are the technologies that spur the economy. Some analysts have attempted to predict the effect. Table 3 below summarizes the outcome of one such attempt. Here the effect of a high-tech future (i.e, one strongly dominated by new technologies) is found to add nearly one-percentage point to the overall annual growth in the economy—a dramatic difference—and similarly increase growth in electric demand by over 0.5 percentage points a year. The difference represents about 500 billion kWh more demand by 2010—equivalent to the output of 250 power plants each generating 250 MW of electricity more per year than is currently projected.

Table 3
Differences Between Two Economic Futures
Average Annual Growth Rates 1995 to 2010

	Business as Usual	High-Tech Future
GDP	2.20%	3.00%
Per capita GDP	1.54%	2.66%
Electric demand	1.80%	2.40%

Electricity Futures: America's Economic Imperative, Edison Electric Institute.

There is strong evidence of the synergy between new technologies and electric technologies from another perspective. Recent projections for changes in productivity by sector provide additional insight. As *Table 4* shows, the greatest projected growth in productivity is expected to occur in three sectors: manufacturing, communications, and the electric sector. The first depends heavily and the second exclusively on electricity. And the third is the sector in which the electricity is produced to fuel the first two.

Table 4
Overall Projected % Growth in U.S. Productivity

Sector	1993-2000	2000 - 2020
Farming	6.7	23.9
Fish, forestry, agr	8.0	1.4
Mining	4.5	-6.9
Construction	9.3	15.5
Manufacturing	18.4	64.3
Transport	2.6	10.4
Communications	19.7	81.1
Utilities	7.6	29.7
Wholesale trade	6.5	27.5
Retail trade	1.4	19.3
Finance	4.3	19.3
Services	4.4	12.6
Government	4.4	12.6

"Future growth in worker productivity will be greatest in the communications and manufacturing industries." NPA Data Services, Washington D.C., American Demographics, June 1995

This synergy, and expectation for electric technologies to dominate the market place's appetite for new technologies, is also reflected in the projections by the natural gas industry—which understandably also views direct gas-to-electric competition for equipment as an important market-share battleground. The growth in demand for gas projected by ENRON directly reveals the kinds of new equipment dominating the future end-use market. As *Table 5* illustrates, ENRON projects that over three-fourths of all new demand for natural gas through 2010 will arise from fueling electric power plants. ENRON anticipates a greater market for gas in powering electrotechnologies than it does in providing gas at the point-of-use to displace electric technologies.

The ENRON view of the world is reflected, although less strongly, by the Gas Research Institute. The GRI projections for future natural gas use also show electric sector dominance, as shown in *Table 6.* GRI projects that at least one-half of all growth in gas demand will be to support the market's increased use of electric technologies. GRI's projections imply a greater confidence on their part that natural gas end-use technologies in the industrial sector will compete against electric technologies more effectively than ENRON projects. GRI is also less bullish about the overall growth rate in natural gas consumption—primarily linked to a lower expectation for electric demand growth (and thus by extension, a lower expectation for economic growth).

Table 5
ENRON projections
Growth in U.S. gas demand to 2010

Gas Demand for	Quads	Share of Growth
Power generation	5.8	77%
Industrial	0.5	7%
Residential	0.3	4%
Commercial	0.6	8%
Other	0.3	4%
Total	7.5	

Oil & Gas Journal, Oct. 23, 1995, p. 33.

Table 6
GRI projections
Growth in U.S. gas demand to 2010

Gas Demand for	Quads	Share of Growth
Power generation	3.2	53%
Industrial	1.5	25%
Residential	0.5	8%
Commercial	0.3	5%
Other	0.5	8%
Total	6.0	

1996 GRI Baseline Projection of U.S. Energy Supply & Demand to 2015.

The reason for electrotechnology market dominance

The reason that the marketplace has in the past preferred electric technologies on average over fuel-based technologies (and will continue to do so in the foreseeable future) is anchored in inherent productivity advantages. Considerable research has been devoted to studying the productivity gains attributable to electrotechnologies, many of which are summarized in the Technical Appendix to this report. *Table 7* summarizes the principal advantages of electrotechnologies:

Table 7
Typical Advantages of Electrotechnologies

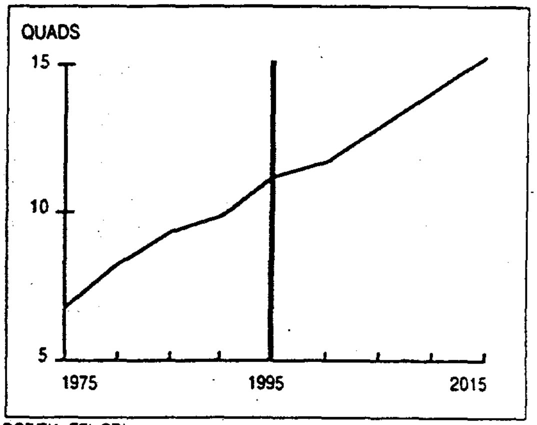
Faster PROCESS TIMES
Lower EQUIPMENT COST
Less SPACE
Greater FLEXIBILITY
Lower total ENERGY COST
Greater total CONSERVATION
Greater QUALITY CONTROL
Lower PRODUCT LOSS
Easier MAINTENANCE and higher RELIABILITY
Greater ADAPTABILITY
Lower ENVIRONMENTAL PROTECTION COST

Two examples illustrate the key differences between fuel-based and electric technologies (the Technical Appendix provides many examples).

Electric infrared (IR) paint drying directly displaces the use of natural gas heaters. The IR technology permits the use of smaller drying ovens, dries faster, and provides for greater uniformity, higher luster and fewer rejects (thereby reducing the time, expense, and environmental aspects of stripping paint and repainting). In addition, the IR technology dramatically reduces total energy consumption counting the combined efficiency of the IR lamps and the power plants used to make the electricity. IR drying is already in commercial application on automobile production lines, and is finding applications in painting and coating shops of all kinds.

Other examples can be found in the entire range of processes, new and emerging, based on microwave energy. Microwaves can be used to replace or enhance an almost limitless range of important manufacturing and processing operations. For example, microwave curing of rubber produces higher quality results in less time. Microwaves can be used to enhance chemical reactions, reducing energy use and waste. Microwaves have been successfully used to create synthetic diamond coatings on metal parts, thereby increasing their longevity and also reducing friction (with the related impact of improved energy efficiency). Microwave applications are showing up in an entire array of pollution control technologies. For example, it is feasible to use microwaves to clean up toxic spills in soils without excavation.

Figure 11
Projected Growth in U.S Electric Demand

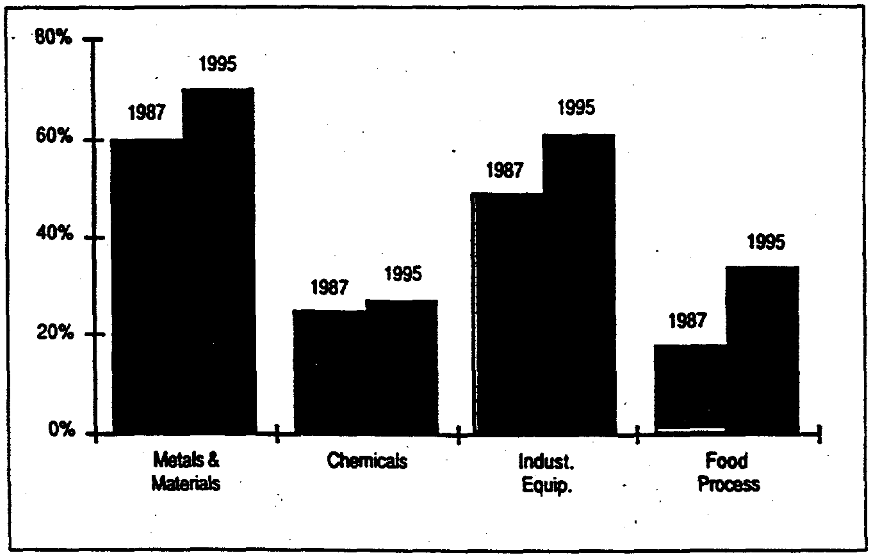


DOE/EIA, EEI, GRI

These examples are typical of the inherent advantages of many emerging electrotechnologies. The expectation that electrotechnologies will dominate new technology growth is reinforced by the outcome of a study of U.S. patents. The study focused on patents in aerospace, automobiles, chemicals, computers, electronics, food, fuels, health care, industrial products, machinery, metals and materials, and telecommunications. The study found that the share of all process (and manufacturing) patents has been rising, and that, overall, over 40% of all innovation in patent filings are electrotechnologies.

Since it is safe to assume that important new technologies will be patented, and since there is a lag time between patent applications and deployment of the resulting technologies, these results point to a strong and on-going growth in new and yet-to-be-realized applications for electricity. *Figure 12* summarizes the findings for the years 1987 and 1995.

Figure 12
Electrotechnologies as a Share of Total Process Technology Innovation Found in U.S. Patents

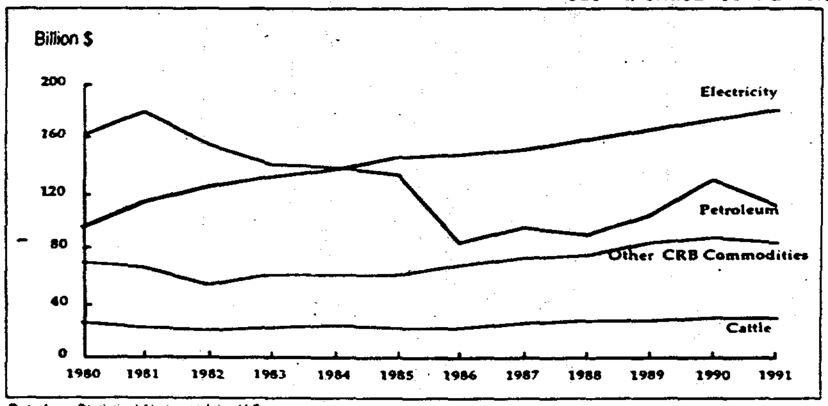


Data from The Role of Electric Technologies in U.S. Patents, CHI Research/MM&A, July 1996.

Demand for Electricity Drives Competition For Low Prices

Having established that electric technologies are directly linked to past and future economic performance, it would be entirely reasonable to expect that electricity itself would become the dominant energy commodity. Not only is electricity the dominant energy commodity, it is also the dominant basic commodity in the U.S. marketplace. As *Figure 13* shows, the purchase of electricity, when viewed against other commodities—not just energy commodities—is now the single largest commodity in the U.S. marketplace. The market consumes nearly $200 billion of electricity a year. As for other energy commodities, the totals are about $70 billion for natural gas and less than $60 billion for gasoline. The largest non-energy commodity is cattle at about $30 billion/year.

Figure 13
Total Annual U.S Commodity Purchases



Data from Statistical Abstract of the U.S.

The role of kilowatt-hours as a commodity is the underlying economic factor driving increased competition in the electric generating sector—and the creation of new markets and exchange systems to treat kWhs as a commodity. One obvious indicator of this new reality is the creation of formal commodity exchanges for electricity and the appearance of power marketing trade associations populated not just by electric utilities, but by traditional commodity-type brokers and Wall Street firms. (See the Technical Appendix for additional details on the commodity characteristics of electricity, and for details on the anti-inflationary indicators implied by declining electric rates.) The creation of a commodity business in electricity will have and is already having dramatic effect on the electric utility industry. The primary focus of interest from the perspective of regulators and popular media and legislative attention has been on the benefits to consumers of reduced electric bills. To be sure, competitive pressure promises to bring about declining electric rates, and lower electric bills for many consumers. In some regions of the country, the effect will be very significant.

However, a focus on the customer electricity bill misses the primary impacts of the increased role of electricity and declining prices arising from competition. The electric sector is not just about the bill at the end of the month—kWh and the technologies that use kWh play such a critical central role in the economy that the impact reaches far beyond that simple bill.

The important impacts of lower electric prices will be to:

- **Boost the economy**
  Lower cost electricity stimulates greater demand for electricity. Greater electric demand is a direct measure of the greater use of electric technologies, which will through their productivity benefits, boost the U.S. economy.

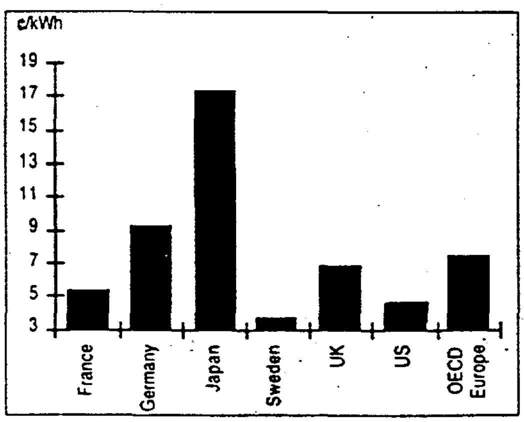
- **Moderate inflation**
  When any commodity is projected to have stable and declining prices, economists predict low inflation. Since electricity is the nation's biggest commodity—three times the size of the second largest commodity—low and declining electric rates will moderate inflationary pressure for years to come thereby protecting the integrity of savings and investments.

• **Increase U.S. competitiveness**
Electrotechnologies dominate the productivity growth of an economy. Low prices stimulate greater use of electric technologies. The U.S. position of world economic dominance will be powerfully reinforced and protected by an economy with low-cost electricity.

Given the fierce and growing competition in world markets, this last factor may be the most important effect. Because of the direct connection between electricity/ electrotechnologies and the cost of electricity, the potential for continued dominance of the U.S. economy in world markets is directly related to the relative price of a kilowatt-hour.

Figure 14 shows that even before the effects of the competitive environment take hold, the U.S. already holds a dominant position in low-cost electricity for the industrial sector. Of the major industrial countries in the Organization of Economic Cooperation and Development (OECD), only Sweden has lower industrial electric rates than the U.S. This competitive advantage is reinforced by the importance of and growth in electric-based equipment, as illustrated earlier in *Figure 6*. Low-cost electricity not only leads to lower operating costs for electric-equipment-dominated businesses, but also encourages investment in new highly-productive electric equipment. Compared to the OECD Europe overall (a collective economy about the same size as that of the U.S.), U.S. industrial customers pay nearly 40% less for electricity.

Figure 14
Industrial Electric Rates

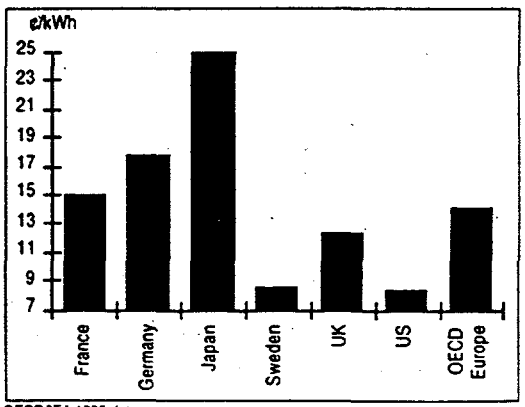


OECD/IEA 1995 data

In some respects, electric rates are more important for small businesses and homes. In the U.S., the 381,000 small manufacturing establishments produce over one-half of all U.S. manufacturing output. [Modernization Matters, May 1996, The Modernization Forum.] And manufacturing exports make up over 60% of all U.S. exports. Thus, as small manufacturing becomes more dependent on electric technologies and electricity, their electric rates become increasingly relevant to international competitiveness of the nation overall.

As *Figure 15* shows, only Sweden is close to the U.S. in providing low-cost electricity to the small business (and residential) sector. Unlike the rates for large industrial customers (shown in *Figure 14*), Swedish small business rates are slightly higher than U.S. rates. Compared to overall OECD Europe, the U.S. small business sector pays 41% less for electricity.

Figure 15
Small Business & Residential Electric Rates



OECD/IEA 1995 data

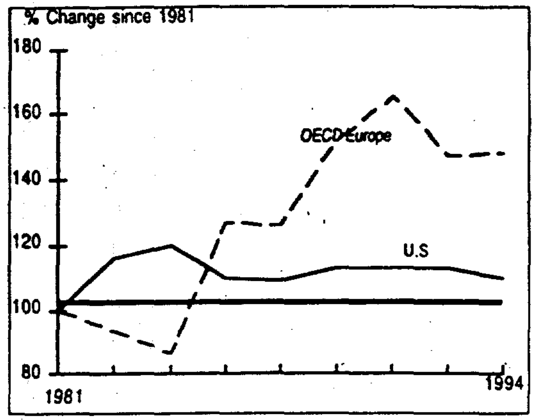
The current advantage that the U.S. enjoys in low electric rates is likely to continue and indeed will very likely grow, with recent trends showing the change in electric rates over the past decade (see *Figure 16*) with the U.S. far lower than OECD Europe.

One reason the U.S. enjoys such a large and important advantage in electricity is related to how electricity is produced, and the low cost of the fuel used to make that electricity.

It is not a technology issue. From an engineering perspective, the U.S.'s industrial competitors clearly have the ability to build comparable power plants (indeed, the manufacturers of major power plants are multinational). The central advantage for U.S. electricity users is that electricity-producers pay less for fuel to make electricity. (The reason that Sweden is able to meet or beat the U.S. is that over one-half of all Swedish electricity comes from relatively old, low-cost hydroelectric facilities.)

Of the 10 lowest-cost electricity power plants in the U.S., all are coal-fired. None of the power plants with the 10 best heat rates (i.e., best combustion technology) made it onto the list of 10 lowest cost producers. While there are obviously other factors which have an impact on the cost of electricity, the primary factor is unquestionably cheap fuel. *Table 8* shows that coal is a primary fuel source for electricity production in four of the six major industrial nations in the OECD. *Table 8* also shows that the U.S. cost for coal is about one-third that of competing nations.

Figure 16
Changes in Electricity Costs



OECD/IEA

Table 8
Largest Source of Electricity & Cost of Fuel for that Source

Contry	Fuel	Share	Cost ($/toe) Fuel
France	Nucl.	78%	-
Germany	Coal	57%	$227
Japan	Coal	19%	$152
	Oil	20%	$200
	N.Gas	21%	$161
Sweden	Hydro	51%	-
UK	Coal	52%	$113
US	Coal	54%	$57
OECD	Coal	39%	$80

toe= tons-of-oil-equivalent

Data from OECD

Low-Cost Power Anchored by Coal

It is easy to see that the primary reason the U.S. enjoys stable low-cost electricity is the dominance of coal-fired power plants. Over one-half of all current electric supply comes from coal-fired plants. The prospect of continuing to have low and lower cost electricity is thus primarily related to the future of coal prices and the future use of existing coal-fired power plants. These two factors, as the chain of connections in this study shows, are thus also a major determinant of the competitiveness of the U.S. economy in world markets.

The factors that relate to the role of coal in this story of connections are straightforward:

- Coal is the dominant source of electricity today
- Coal-fired power plants dominate low-cost electricity supply
- Coal fuel is the cheapest fuel and trends show costs declining further
- There is lots of coal available in the United States
- There is lots of additional coal-fired capacity available—with no new construction of power plants

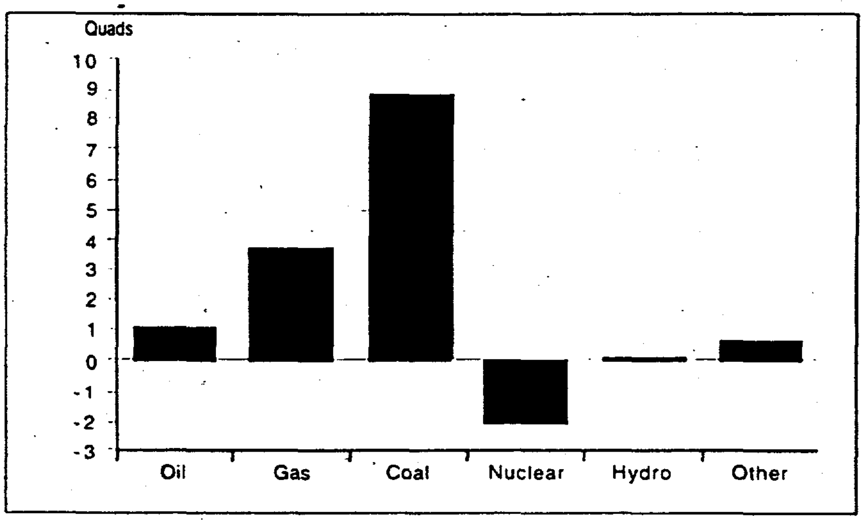
This last point is the dominating factor for assessing what sources of electricity will meet future demand. According to the Gas Research Institute, over 60% of all *new* electricity will come from coal-fired power plants. See *Figure 17.*

The GRI projection states:

"The major share of increased electricity demand over the next 20 years will be met by increased generation from existing plants, not the construction of new ones."

Since the major share of generating capacity is coal-fired, this is a direct affirmation of the increased use of existing coal-fired power plants. There is a clear

Figure 17
Sources of Additional U.S. Electricity through 2015



Data from GRI

economic advantage from increasing the utilization of existing 320,000 MW of coal power plants, compared to the capital expenditure associated with building new power plants.

This view is counter to a common piece of wisdom that has made the rounds in the utility industry for years: as the age of the majority of the dominant coal-fired power plants exceeds 30+ years, the plants will be retired and new power plants of some kind will be needed. **If coal units over 40 years old were actually retired, by 2015 there would only be one-third of the capacity, or 137 GW, of the current units still on the system. This is certainly not the view of GRI, nor is it the conclusion reached in this study.**

It is clear from all current forecasts that analysts implicitly assume that significant increased use of coal-fired capacity will occur to meet demand for electricity. *Table 9* summarizes data from recent forecasts. In all cases, coal is expected to account for about one-half of all increased need for electricity.

Table 9
Projected U.S. Electricity Growth & Coal Share of Total Supply Increase

Forecast	Total Growth to 2010 (billion kWh)	Share of New Supply From Coal %
EEI base case	970	44
EEI "high tech" case [1]	1125	44
EPA base case	740	48
EPA "high emissions" [2]	890	77
GRI	390	53
MM&A potential [3]	1500	50

[1] Data from EEI "Electricity for the American Economy 1995"
[2] Data from EPA "Revised Forecast of Electric Generation and Air Emissions Under the Clean Air Power Initiative," June 1996. The "high emissions" case assumes an enhanced price advantage for coal over natural gas, and thus higher electricity consumption growth and greater use of coal to meet that growth.
[3] Projected potential electric demand arising from demand stimulated by rapid price decreases (AD 2010 average price of 4.5¢/kWh) arising from competition and new technologies.

The Role of Existing Coal-Fired Units

In this study, we sought to validate the projection of increased use of existing coal-fired power plants from two perspectives:

1) Do the engineering fundamentals support the expectations that existing power plants, including very old ones, can be used more extensively and for much longer?

2) Based on a realistic assessment of the status and characteristics of existing coal-fired power plants, how many of them are likely to be able to operate at competitive electric rates for the next two decades?

After undertaking a literature search study, and interviews with leading engineering experts in the field, we found that the answer to the first question is clearly yes. Importantly, the answer to this question is based on the economically viable extension of the use of existing coal-fired power plants. Details on this exploration are contained in the Technical Appendix.

The answer to the second question was sought by undertaking an exhaustive analysis of the amount of total existing coal-fired capacity that could be available through life-extension and refurbishment, such that the resulting power plant would be competitive.

As an economic benchmark, our analysis used 3¢/ kWh as a maximum target price. Based on current and projected wholesale rates and contracts, a 3¢ benchmark represents a competitive price. For the analysis of coal power plants undertaken for this report by Resources Data International (details in the Technical Appendix), only those power plants that could meet or beat this benchmark were counted. In this way, the analysis identifies the magnitude of the additional coal-fired generation (i.e., post-refurbishment, life extension, or repowering) available as a competitive benchmark for 'green field' construction.

The analysis considered all coal units based on a 3¢/kWh maximum price as the acceptable delivered power to the bus bar following any capital expenditure to extend the life of or repower old units. The analysis incorporated all of the critical performance criteria of the existing plants (e.g., age, size, heat rates, O&M trends, etc.) *Table 10* summarizes the results of the analysis. (Details are available in the Technical Appendix.) After completing the model and sorting all of the data by the key criteria, the analysis found that without building any new power plants of any kind, about 270 GW more coal-fired capacity could be operating in 2010 - 2015 than under a scenario of retiring units more than 40 years old. Furthermore, the technical capability exists to have the equivalent of 85 GW more coal generating capacity than is actually in use now, at a cost below 3¢/kWh, without breaking ground for a "green field" unit. This capacity establishes a powerful, low-cost benchmark since it represents about 50% of all the growth in supply projected to be required by 2010—and confirms the macro-economic projections or expectations in the GRI and other data presented earlier in this report.

Table 10
Total Potential Coal-Fired Capacity

CATEGORY	CAPACITY GW in 2015	
Life Extended	353.8	
Under Construction	3.6	
Return to Service	2.2	1996 Capacity
Possible Fuel Conversions	46.3	Total
Total	405.9	320 GW

Data from Resource Data International, 1996

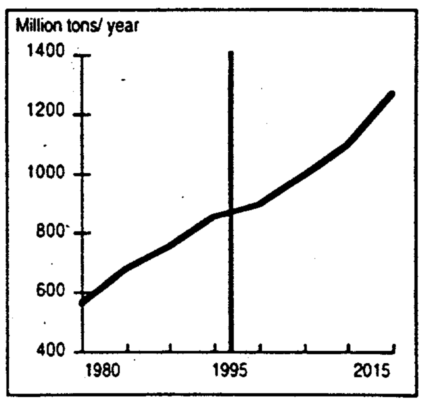
Technical note
(Fuel conversions are estimates of the potential for converting essentially unused oil-fired power plants to coal. The conversion potential in the model is based on the economic incentive to use existing capital plant with low cost fuel (coal) while achieving the model's benchmark 3¢/kWh goal. Note that any decisions to implement such conversions will clearly be dictated by plant-specific and company-specific economics. But the technical/ economic capability establishes a benchmark for competing generation sources of all kinds.)

The availability of the additional electricity generating capacity from a source (existing coal-fired power plants) at a price of less than 3¢/kWh will establish for the United States a continuing dominant role in providing low-cost electricity to the manufacturing and business sectors.

In addition to providing an abundant low-cost electric supply benchmark, the outcome of this analysis points to the probability of substantial increases in the amount of coal mined and burned. *Figure 18* illustrates the historic and projected coal consumption for electric generation.

Table 11 summarizes the increased coal consumption associated with the various electric growth scenarios included in this analysis. Without regard to which scenario

Figure 18
Projected Increase In Annual U.S. Coal Consumption
(Assumes all new generation <3¢/kWh)



ends up accurately anticipating the trends, all project a substantial growth. It is instructive to note that economic scenarios which envision higher economic growth are associated with electric projections leading to greater use of coal-fired generation.

Table 11
Projected Growth in U.S. Electricity & Coal Consumption

Forecast	Total Growth to 2010 [billion kWh]	Total Additional Coal Use in 2010 [million tons/yr]
EEI base case	970	215
EEI "high tech" case [1]	1125	250
EPA base case	740	205
EPA "high emissions" [2]	890	400
GRI [3]	390	250
MM&A potential	1500	400

[1] Data from EEI "Electricity for the American Economy 1995" Both cases assume only 22 billion kWh/year decline in nuclear generation.
[2] Data from EPA "Revised Forecast of Electric Generation and Air Emissions Under the Clean Air Power Initiative," June 1996. The base case assumes 106 billion kWh/yr decline in nuclear, the "high emissions" case assumes 135 billion kWh/yr decline by 2010.
[3] GRI assumes no significant decline in nuclear generation by 2010, but a 200 billion kWh/yr decline by 2015.

Using More Coal Reduces Emissions

While it is clear that economic forces will lead to greater coal use, a natural public policy concern is the associated potential for increases in power plant emissions. Addressing this concern, the U.S. Environmental Protection Agency has undertaken forecasts of power plant emissions arising from a competitive environment that will (in their projections, too) promote rising coal-fired power plant use. As it turns out, EPA's projections show a decline in total power plant emissions of critical regulated smog-related pollutants, even with a 25% increase in coal combustion. The EPA outcome, shown in *Table 12*, is a consequence of the improvement in the technology of combustion and emissions control.

Table 12
EPA Projected Changes in U.S. Coal Emissions to 2010
[Assumes coal use increases 25%]

Emission	Change
Nitrogen oxides	-15%
Sulfur dioxide	-37%
Carbon dioxide	+34%

From EPA June 1996 Revised Forecast of Electric Generation and Air Emmissons Under the Clean Air Power Initiative

However, while EPA does project an increase in the emissions of carbon dioxide (CO_2) from power plants-the principal gas implicated in the global warming theory there is more to consider.

Without regard to the merits of the global warming theory, the facts suggest that proponents of that theory need not worry. The effect of using more of the nation's electric infrastructure will be a net ***reduction*** in CO_2 emissions and even greater reductions in smog-related emissions than are currently projected. This reduction will occur because the increased use of electrotechnologies eliminates more emissions at the point-of-use than is created at power plants.

Details on this phenomenon are contained in the Technical Appendix. The calculations show that every 1,000 kWh used by an electrotechnology typically creates a net reduction in total societal air emissions of about nine pounds of nitrogen oxide and 3,000 pounds of carbon dioxide—the former a critical smog-related and regulated emission, and the latter a politically important unregulated and controversial emission.[1] This calculation assumes that coal provides 50% of the increased generation.

Table 13 summarizes the average results of the calculations. The emissions associated with electricity generation are comparatively uniform. For fuel-based technologies, however, there is a very wide variation in emissions from different equipment. The data in the table represents a low-weighted average. NO_x emissions for combustion-based technologies can range from as little as 0.5 lbs to over 50,000 lbs for equivalent amount of performance as achieved by an electric technology using 1,000 kWh (and emitting 1.5 lbs of NO_x).

Table 13
U.S. Emissions Reductions from Electrotechnologies
[Assumes coal provides 50% of electric supply]

Source	NO_x emissions (lbs)	CO_2 emissions (lbs)
Operate electric technology -use 1,000 kWh—power plant emissions	1.5	1,300
Operate equiv. combustion tech. to accomplish same task as above -burn fuel at point-of-use—emissions	(10.5)	(4,300)
Net decline	**9**	**3,000**

Data from "Total Fuel Cycle Implications of Increased Use of Electricity" Feb. 2, 1996, MM&A

Emissions reductions from increased electrification are evident from a systems, or total fuel-cycle perspective. The essence of this concept is the need to balance the emissions associated with producing electricity with the emissions displaced when electricity is used at a customer's site to power zero-emissions electrotechnologies.

Familiar to everyone is the electric vehicle (EV) trade-off: zero emissions electric cars (or mopeds, forklifts, tractors, etc.) lead to lower-than-gasoline-vehicle emissions at power plants for the same distance traveled. But EVs, while exciting, represent only a small part of the story.

Electrotechnology Emissions Advantage

There are literally hundreds of new and emerging electric technologies with thousands of applications in every sector of the economy.

For example, ozone-based laundry systems use electrically-generated ozone to both eliminate chemical detergent use and the associated energy/emissions from chemical processing, and dramatically reduce hot water consumption with its attendant energy costs. The energy needed to make the electricity is less than that displaced by the ozone technology.

Another example, electric induction forging of metals is emerging as a preferred technology, eliminating point-of-use combustion emissions. A more subtle example: water-jet paint stripping (achieved with powerful electric pumps creating extremely high-pressure water jets) completely displaces the use of chemical strippers as well as the energy needed to make, transport and dispose of the chemicals and the associated hazards of this process. Similarly, the growing array of electric destruction technologies for medical waste directly displaces the use of trucks that formerly carried the waste to landfills or incineration.

In many cases the energy/emissions benefits from electric technologies arise from reduced material waste because of increased precision of operation. For a manufacturer this is a clear economic benefit. From an environmental perspective, reduced material use also reduces the energy/emissions associated with both producing the wasted material, as well as disposing of it as waste.

In general, the electrotechnology offers the inherent efficiency advantage of electric phenomenon compared to combustion processes. Returning to the automobile example: internal combustion engine efficiency is less than 20% and small non-road engines are generally less than 10% efficient. And while power plants are 'only' about 40% efficient (new designs can exceed 50%), the electric motor at the customer site is 90% efficient. Thus, even counting power plant losses, the total fuel-cycle efficiency of (for example) an electric motor is about 40%, compared to a gasoline engine at less than 20%. This leads to real, not theoretical, environmental benefits.

Some examples of typical emissions reductions from switching to electrotechnologies are shown in *Table 15.*

Similar results illustrated in the table can be calculated for many other electrotechnologies. Such results can be used to roughly extrapolate an overall national outcome, as shown in *Table 14.*

Table 14
Potential Net U.S. Emissions Changes by 2010

Source	NO_x (tons)	CO_2
Emissions from generating 1,500 billion additional kWh	1 million	3 billion
End-use combustion emissions eliminated by the electrotechnologies using the 1,500 billion kWh	(5 million)	(4 billion)
Net decline in emissions	**-4 million**	**-1 billion**

If low prices (driven by competitive pressures and advancing generation and transmission technologies—

see Appendix for details) lead to an increased demand for electricity of about 1,500 billion kWh by 2010, and if 50% of that growth were met by coal, there would still be a net decline in emissions due to the offsetting impact of the electrotechnologies. The net total U.S. emissions reductions by 2010 are likely to be:

- **over one billion tons of CO2/yr,** [250 million metric tons of carbon] **and**

- **nearly four million tons of NOx/yr.**

Such results are consistent with an earlier Electric Power Research Institute report which projected some 600 billion kWh of new demand arising from 15 selected electrotechnologies with emissions reduction of 400 million tons/yr by 2010 because of those electrotechnologies and end-use emissions benefits. (Reductions that also take into account power palnt emissions.)

Earlier in this report we summarized coal use and emissions data from EPA's recent projections arising from increased competition in the electric sector. EPA concludes that power plant emissions of NOx (a smog precursor) and SOx will decline even as coal use rises.

Table 15

Net Emissions Reductions for Selected Electric Technologies Replacing Comparable Fuel Technologies

(Typical reductions per year per single use of technology.)

Technology	lbs NO_x	lbs CO_2
Automobile, electric	6	2600
Clothes drying, heat pump	1	700
Cold vaporization	10	8500
Commercial cooling	100,000	1,200,000
Commercial laundry, ozone	20	17,500
Copper melting	180	140,000
Electric moped	10	5,000
Electric steel mill	4,000	3,000,000
Fax	<1	150
FlashBake cooking	40	54,000
Forging, induction	170	95,000
Freeze concentration, dairy	50	40,000
Gas-line compressor	65,000	50,000,000
Heat pump, geothermal	6	9,700
Irrigation pump	300	27,000
Magazine ink drying, ultraviolet	20	16,000
Medical waste, Medaway	46,000	3,600,000
Microwave oven	<1	200
Mower, cordless electric	<1	60
Paint curing, infrared	50	44,000
Painting, super critical CO_2	330	92,000
Pasta drying, microwave	10	10,000
Powdered coating, infrared	45	38,000
Telecommuting	6	8,000
Train, high speed electric	23,000	17,000,000
Water-jet paint stripping	40,000	3,800,000
Welding of tube, resistance	12	9,700
Zamboni	945	60,000

Data from "A Cleaner Economy" Jan. 1995, MM&A for Edison Electric Institute

This will arise from improved combustion and control technologies. EPA also correctly notes that total CO2 emissions from power plants will rise because of substantial increase in coal combustion.

However, net national CO_2 emissions will not rise, since the additional electricity produced by the power plants will be used by end-use electric technologies that are associated with zero emissions displacing end-use combustion technologies. *Table 16* amends the EPA results to reflect the true total net fuel-cycle impacts. (Note that the net additional reductions in NO_x associated with end-use electrotechnologies are not included here.) **As the table shows, at the assumed and calculated average end-use emissions reductions of typical electrotechnologies, the net effect of the increased use of electricity will be a total reduction in carbon emissions—not an increase. Even if the effect of electrotechnologies at the point-of-use is one-half that found here, the effect of increased coal use will be to have no net increase in carbon emissions.**

[Note that these calculations do not account for trends in total carbon emissions in the transportation sector]. Electrotechnologies also frequently reduce a range of other environmental impacts, including a variety of chemical wastes, landfill use, waste water, and various of the emissions identified under the air toxics provision in *Title III* of the *Clean Air Act* amendments. For example, a new chemical-free dry cleaning technology based on super-critical carbon dioxide gas, which entails greater use of electricity to produce the CO_2, eliminates the use and emissions of perchlorethylene (PERC) the dry cleaning chemical that is highly reactive and a *surprisingly large contributor to urban pollution.* A cold vaporization process used by Kodak (and other firms producing low concentrations of toxic metals in a waste water stream) achieves the goal of zero waste and recovers such valuable materials as platinum and silver. The output of the cold vaporization process is drinking quality water.

Importantly, the kinds of environmental benefits outlined here will be driven by the market's appetite for the economic rewards of electrotechnologies.

Table 16
<u>Net</u> Projected Emissions Impact From Electricity Generation & Electrotechnology Use (2010)

			[million tons C /yr]		
EPA Forecast	Electric Growth [billion kWh]	Coal Share Total Growth	Increased Power Plant Emiss. [1]	End-Use Emissions From Electric Tech. [2]	Net Reduction.
Base case	160	48%	+162	-370	-200
High emissions	240	77%	+240	-443	-200

(note: previous tables and data are expressed in short tons, and measure carbon dioxide; the EPA data are in metric tons of carbon.)

[1] Power plant emissions from EPA analysis
[2] End-use emissions reductions are typical maximums from Technical Appendix; average of 4 lbs carbon dioxide per kWh of electrotechnology use; converted to one metric ton carbon/2,000 kWh.

[1] CO2 is the principal gas discussed in the global warming theory. Its inclusion in these calculations is <u>not</u> an endorsement of the theory. The research summarized here shows that for those concerned about reducing CO2 emissions, the easiest and most economically-beneficial (as opposed to financially damaging) strategy is to <u>promote</u> increased electrotechnology use; in other words, to support increased electrification and lower electric rates.

Conclusion

The consensus of opinion in expert circles, and the evidence found in this study, clearly point to the fact that competitive pressures in the electric utility industry will lead to increased use of coal-fired electricity. The increased use of coal as a low-cost source of electricity is driven by economic forces that arise from the direct relationship between electricity, electrotechnologies and the health of the national and regional economies. The importance of low-cost electricity derives from two key facts: first, electricity is the largest commodity, not just energy commodity, in the economy; and second electrotechnologies dominate the growth in business uses of new technologies.

In simplest terms, the nation, states and businesses thrive in an economic environment that has and that promotes access to low-cost electricity. Coal has played and will continue to play the anchor role in supporting the vital position electricity has in the economy.

This study also illustrates the fact that increased use of coal-fired electricity will be associated with decreased emissions. Critical regulated emissions reductions are expected due to factors: first, improved emissions controls on power plants will lead to reduced overall generation emissions even as the use of those generating assets increased; and second, the electricity produced by coal-fired power plants is consumed by a wide range of electrotechnologies that replace combustion-based processes, and in so doing, eliminate at the point-of-use more emissions (on average) more emissions than are created at the power plants.

Addendum

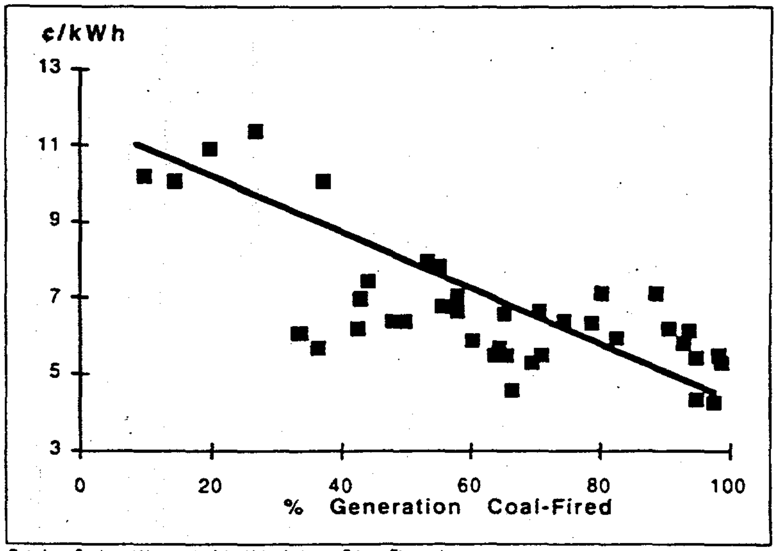
A State Perspective on Coal and Electric Rates

The graph below illustrates that there is a strong relationship between the average cost of electricity and the use of coal to generate power in a state. The data in the graph is a simple plot of the average cost of electricity in each state, and the share of that electricity which comes from coal-fired generation for that state.

The price of electricity is one of the major determinants in the competitiveness of businesses. There are two principal reasons that electric rates play an important role. First, at the fundamental level, electricity is the largest single commodity consumed by a state's economy. Changes in electricity costs thus have a larger impact on overall inflation pressures than do, for example, comparable increases (or decreases) in gasoline costs. Secondly, at the broad technological level, new electrotechnologies have come to dominate the growth in manufacturing innovation. Thus the cost of electricity has become an increasingly important consideration in helping stimulate, or depress, business interest in committing to an increased use of advanced technologies since those advanced technologies are frequently electricity-consuming electrotechnologies.

It has become a truism that manufacturers and businesses in states compete not just with neighbors in other states, but increasingly with other countries. Thus, the price of electricity in a state has a direct bearing on the global competitiveness of that state. And, again as the graph below shows, the cost of electricity is directly related to the share of state-wide electric generation that is coal-fired. From this type of evidence, and the more detailed exploration of these relationships in the preceding report, one may draw two obvious conclusions: i) higher dependence on coal improves the competitive posture for a state both compared to other states and other nations, and ii) any policies that have the intentional or inadvertent effect of reducing the use of coal-fired generation will negatively impact a state's economy.

Relationsip between share of state electricity generated by coal and average cost of electricityin each state



Data from Statistical Yearbook of the Utility Industry, Edison Electric Institute
[Note: data are for 41 of the contiguous states and exclude the six states with 0% coal generation, ME, Vt, RI, DC, ID, CA, and four states with >50% generation from old hydro units, WA, OR, ID, SD]

These tables show the share of a state's electric generation from coal, along with the average cost of a kWh by state.

State Rank by cost of electricity

List in ascending order of average state-wide cost of kWh (EXCLUDES 5 states with >1/3 of generation from hydro)

State	% Coal Gen.	Avg. ¢/kWh
Wyoming	98	4.23
Kentucky	95	4.26
Tennessee	70	5.23
West Virginia	99	5.25
Utah	95	5.36
Indiana	99	5.44
Wisconsin	71	5.46
Alabama	66	5.48
Nebraska	64	5.49
Minnesota	65	5.63
South Carolina	36	5.67
North Dakota	93	5.78
Oklahoma	61	5.84
Iowa	83	5.92
Mississippi	34	6.05
Louisiana	33	6.05
Colorado	94	6.08
Ohio	91	6.19
Virginia	43	6.2
Missouri	79	6.28
Arkansas	50	6.35
Nevada	75	6.35
Texas	48	6.39
Georgia	66	6.57
Kansas	71	6.61
North Carolina	58	6.63
Delaware	56	6.78
Florida	43	6.96
Maryland	58	7.03
Michigan	81	7.11
New Mexico	89	7.11
D.C.	0	7.12
Illinois	44	7.41
Pennsylvania	56	7.84
Arizona	54	7.92
Vermont	0	9.21
Maine	0	9.63
California	0	9.78
Mass.	37	10.01
New Jersey	15	10.06
Connecticut	8	10.19
Rhode Island	0	10.24
New York	20	10.91
New Hampshire	27	11.32

OTHER NATIONS		
Japan	-	25.0
Germany	-	17.8
France	-	15.0
United Kingdom	-	12.3
Sweden	-	8.5

Alphabetical listing of states

(* indicates state with >1/3 of generation from hydro)

State	% Coal Gen.	Avg. ¢/kWh
Alabama	66	5.48
Arizona	54	7.92
Arkansas	50	6.35
California	0	9.78
Colorado	94	6.08
Connecticut	8	10.19
D.C.	0	7.12
Delaware	56	6.78
Florida	43	6.96
Georgia	66	6.57
Idaho*	0	4
Illinois	44	7.41
Indiana	99	5.44
Iowa	83	5.92
Kansas	71	6.61
Kentucky	95	4.26
Louisiana	33	6.05
Maine	0	9.63
Maryland	58	7.03
Mass.	37	10.01
Michigan	81	7.11
Minnesota	65	5.63
Mississippi	34	6.05
Missouri	79	6.28
Montana*	67	4.51
Nebraska	64	5.49
Nevada	75	6.35
New Hampshire	27	11.32
New Jersey	15	10.06
New Mexico	89	7.11
New York	20	10.91
North Carolina	58	6.63
North Dakota	93	5.78
Ohio	91	6.19
Oklahoma	61	5.84
Oregon*	10	4.6
Pennsylvania	56	7.84
Rhode Island	0	10.24
South Carolina	36	5.67
South Dakota*	36	6.19
Tennessee	70	5.23
Texas	48	6.39
Utah	95	5.36
Vermont	0	9.21
Virginia	43	6.2
Washington*	12	4.02
West Virginia	99	5.25
Wisconsin	71	5.46
Wyoming	98	4.23

Technical Addendum

Electricity as a Commodity & The Relevance to Inflation

At the wholesale level, electricity is a commodity, and it is the single largest and thus primary commodity in the U.S. economy. This reality has two broad implications: 1) as a commodity, market forces are powerfully oriented towards demanding low prices, and 2) the lower the prices the greater the downward pressure on inflation. (A corollary: any activity that either increases, or slows the decrease in, the price of electricity would be inflationary and broadly harmful to the economy.)

Changes in commodity prices are considered a key indicator of inflationary trends. Despite the fascination with oil (and its unquestioned importance in the transportation sector and international markets), it is not the pre-eminent energy or general commodity indicator.

When the commodities "basket" was created in the 1950s, electricity was a small input to the nation's economy; in fact, the U.S. economy spent twice as much on oil as electricity in 1950. Since 1950, demand for oil has increased 2.5-fold; electric demand has grown 10-fold.

Trends in overall commodities prices are monitored for their pressure on inflation. The Commodity Research Bureau (CRB) index of futures prices incorporates 21 commodities (cattle, hogs, bellies, gold, silver, platinum, coffee, cocoa, sugar, orange juice, crude oil, cotton, copper, unleaded gas, heating oil, lumber, corn, wheat, soybeans, soybean oil, soybean meal).

The table below lists the typical national annual expenditures on these various commodities, with electricity and natural gas added to the list for comparison. The current CRB commodity index does not include either electricity or natural gas. Note that electricity is the largest commodity with over three times as much money spent on kilowatt-hours as gasoline or natural gas, and six times as much is spent on electricity as on the largest non-energy commodity (cattle).

Typical Total U.S. Annual Commodity Purchases
(1995 data from Statistical Abstract of the United States)

Commodity	Billion $
Electricity*	190
Natural Gas*	75
Unleaded Gasoline	60
Crude oil	50
Cattle	30
Corn	20
Soybean	12
Pork bellies	10
Sugar	7
Coffee	7
Heating oil	6
Wheat	6
Lumber	6
Cotton	5
Copper	4
Gold	3
Cocoa	1
Silver	<1
Platinum	<1

The CRB establishes an overall price index for the entire basket in order to measure basic inflationary pressure exerted by changes in commodity prices. Relatively small changes in the index are believed to have a large multiplier effect on inflationary trends in the economy. It is possible to reformulate the index to include electricity, and thus how kilowatt-hours impact the inflation-predicting commodities index.

Recasting the CRB price index to include electricity yields some dramatic results. (The analytic techniques and assumptions for this modeling are described in *Does Price Matter? The Importance of Cheap Electricity for the Economy,* Mills•McCarthy & Associates Inc. for Western Fuels Association, January 1995.) Using an electricity-modified CRB index, one finds the inflationary impact is the same for each of the following individual price increases (all other prices held constant):

0.4¢/kWh of electricity
32¢/gallon of gasoline
$2/bushel of soy beans (over a $5.60 base)
$323/ounce of gold

Technical Addendum

Analysis of additional generating capability of existing coal-fired power plants.

The results in this analysis come from a joint effort of Resource Data International and Mills•McCarthy & Associates Inc. RDI served as a data provider, compiler and analyst with analytical direction provided by Mills•McCarthy & Associates, Inc..

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The purpose of this investigation is to assess the overall supply impact arising from life extension of existing coal-fired power plants. A forecast for the year 2015 is presented here that reflects the maximum potential amount of additional electricity generation available from existing coal-fired generation.

Approach to Analysis

The general approach employed operating performance and cost data as well as design characteristics for every existing coal-fired unit. The critera examined include age, size relative to the system in which the unit is dispatched, average annual heat rates, operating and maintenance costs, and capital costs.

Using a filtering technique, each unit was categorized based on one of the following actions which appeared most feasible:

- Retirement - Unit is retired sometime between 1995 and 2015.
- Extended Use - Existing coal unit which could be run more intensively, raising its capacity factor up to 80%,
- Simple Life Extension - Unit continues to operate with minimal O&M increases and efficiency decreases beyond 30 years of age.
- Low Cost Refurbishment - Unit is maintained and overhauled as required to increase its service life and efficiency.
- Capital Intensive Repowering - Replacement of boiler usually to a fluidized-bed or combined cycle technology.
- Return to service - Units in cold standby or out of service, but may be re-activated with some expenditure to update or retrofit the equipment.
- Fuel conversion - Most oil steam units are capable of burning some type of pulverized coal or slurry. Existing idle and operating capacity are examined for possible conversion.

To estimate the potential capital expenditure for each unit associated with any of the above actions, a market clearing price of 3.0 ¢ /kWh is assumed. By estimating 2015 production costs, the difference between the market clearing price and the production cost forecast represents an amount which can be used for capital costs associated with life extension activities.

Overview of Findings

The analysis finds some 406 GW of potential coal-fired capacity for the year 2015 (see Table below), compared to 329 GW available today. The 'new' coal capacity arises from life extension of all but the smallest and oldest coal units, re-activation of idled units, and conversion of other existing steam units to coal. No planned or forecasted capacity additions are included; only units now under construction are counted.

Potential Coal-Fired Capacity (2015)

CATEGORY	CAPACITY GW
Life Extended	353.8
Under Construction	3.6
Return to Service	2.2
Possible Fuel Conversions	46.3
Total	**405.9**

Explanation for categories of coal capacity

Life extension: The belief that large coal-fired power plants 30-40 years old are due for retirement is based on a flawed assumption that an amortization or planned operating life is a determinant of an actual physical or engineering life.

Most highly engineered facilities have a large degree of design margin built into them, mainly for reliability and safety reasons. Under normal operating conditions, this means that many of these components and systems have the capability to operate well beyond the economic life of the facility. Other components and systems may have to be replaced, but at substantially lower cost than building a new facility.

The consensus of expert opinion found in the literature and in interviews undertaken for this study is that utilities will have a wide variety of options to further use the fully amortized, and high-value installed coal-fired capacity.

Return to service: The return of 2.2 GW to service is a potential source of additional coal capacity, although it is difficult to assess the cost effectiveness of this because of a lack of cost and operational data on these units.

New capacity: In order to portray a conservative estimate with regards to new capacity, only units under construction in 1995 have been included.

Fuel conversion: Fuel conversion of steam units to coal-firing is technically possible at a reasonable cost in many combustion systems. All of the non-coal steam units are candidates for fuel conversion should the relative price of coal and the cost of conversion imply lower average production costs over the life of the plant.

Data Sources used for this analysis include:

EIA Form 767 : Steam Plant Design and Operation.
EIA Form 860, Generator Unit Reference File.
NERC Form OE-411, Coordinated Bulk Power Supply Report.
EIA 759, Monthly Power Plant Report
FERC 423, Monthly Report of Cost and Quality of Fuels for Electric Plants
REA 12, Annual Operating & Financial Report (Rural Electric Utilities)
EIA 412, Annual Report of Public Electric Utilities
FERC Form 1, Annual Report of Major Electric Utilities, Licensees, and Others
EIA 860, Annual Electric Generator Report
FERC Form 1 (for investor-owned utilities)
RUS (formerly REA) 12 (for cooperatives)
EIA 412 (for municipal utilities).

Key Assumptions

Capacity factors: All units are assumed to operate at 80%. This is done to represent a maximum technically feasible generation level for coal-fired capacity.

Heat Rate: This are assumed to remain constant throughout the period. Obviously if some of the performance improvements were to be made the heat rates would drop correspondingly.

Costs: Fuel prices are RDI's 1995 plant-by-plant delivered coal price forecast. These are based on a particular demand for coal at each plant.

Capital Costs: These are based on the 1994 book value of the plant. For plants less than 30 years old, a capital charge is included in the 1994 busbar cost.

Operating and maintenance costs: These are assumed to be constant in real terms out to 2015. It is possible that many plants' O&M costs will increase with age as more maintenance and materials are needed to operate older units, although some refurbished plants will experience a decline in their O&M costs. For those companies which do not report plant costs, an O&M cost of 1.5 cents/kWh has been assumed.

Discount rate: This along with the cost of capital is assumed to be 10%.

Estimated Allowance for Capital Investment: This is based on a market clearing price of 3.0 cents/kWh in the year 2015. The difference between the market clearing price and the 2015 busbar cost represents the potential capital portion. The $/kW amount is estimated assuming an 80% capacity factor and that any capital expenditures would be amortized over a 20-year period at the discount rate stated above.

ENVIRONMENTAL ISSUES AFFECTING CCT DEVELOPMENT

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Legislative Assistant to
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U.S. House of Representatives
Washington, DC

Legislative Issues Relating to CCTs

While no final legislative schedule has been set for the new Congress two issues with strong environmental ramifications which are likely to affect the coal industry seem to top the list of closely watched debates in Washington - the Environmental Protection Agency's proposed new ozone and particulate matter standards and utility restructuring.

EPA's Proposed New Ozone and Particulate Matter Standards

Background

On November 27, 1996, the EPA proposed new encompassing air quality standards for ground-level ozone (smog) and particulate matter (soot), based on evidence of harm to human health and the environment.

Compared to the existing standards, these new standards are much more stringent. The EPA believes these new standards are necessary in order to meet the Clean Air Act's requirement that air pollution not adversely affect public health.

EPA and a board of independent scientists have reviewed 86 particulate matter related health studies, covering millions of people, that showed harmful effects from breathing particles at the current standard. Another 185 of the latest ozone-related studies on human health were also reviewed. All of them showed harmful effects from ozone at the current standard, including 1.5 million incidences a year of significant respiratory problems.

The proposal is based on a thorough review of the best available science and the EPA expects to hear from a wide range of interested parties, from scientists and environmentalists to industry experts, small business owners, doctors and parents, in order to receive the broadest possible public comment and input on this important issue. Stricter limits for urban smog and soot would prevent as many as 20,000 premature deaths each year and relieve the suffering of millions of Americans afflicted with asthma and respiratory diseases.

Public Comment

There will be a 60-day formal comment period for each of the rules being proposed. The purpose of the comment period is to reach out to all stakeholders in order to obtain the best information available for determining the appropriate final standards. There will also be an EPA sponsored public hearing.

Congressional Review of Regulations

Once a final regulation is issued, it will be among the first major environmental rules reviewed by Congress under the new Small Business Regulatory Enforcement and Fairness Act. Under this legislation, enacted in March 1996, federal agencies promulgating major rules must submit to each House of Congress and the Comptroller General a copy of the rule and the cost benefit analysis of it. Before the rule can take effect, Congress is given 60 legislative days to pass a joint resolution of disapproval. A resolution of disapproval would prevent the EPA from implementing the new standards or from issuing them in substantially the same form. Such resolutions are subject to the presidential veto power and it would take a two-thirds majority in each chamber to prevent the implementation of new standards. Basically, Congress gave itself veto power over new regulations. Many stakeholders are opposing the new standards, claiming they are expensive, unnecessary and hurtful to the economy. Already stakeholders are making appeals to Congress to intervene. Aggressive and expensive lobbying efforts are in place.

Other Legislative Options

As the administrative rulemaking process proceeds, Congress can conduct oversight and consider use of the appropriations process to influence the EPA. The FY97 appropriations conference report for the EPA contained language expressing the committees misgivings concerning new particulate matter standards even before the EPA proposal was released. Congress could also revisit the Clean Air Act and enact amendments to it that target the ozone and particulate matter standards. That process would occur in the authorizing committees - Senate Committee on Environment and Public Works and House Committee on Commerce.

EPA has reached out to Congress to get their views on the proposed rule. Briefings have already been held on Capitol Hill with staff and it is expected that the EPA will continue to be forthcoming during this process. All comments by stakeholders will be addressed and since this is a very complex process it could take some time. It remains to be seen whether or not the entire matter can be resolved during the 105th Congress, particularly in light of the symbolic legislative changes pertaining to promulgating federal rules.

Utility Restructuring

The House Commerce Committee and the Senate Energy and Natural Resources Committee are both involved in another intense debate in Washington - Utility Restructuring. At issue is the right of every consumer to choose their own provider of electric power. Some people contend that competition in the electric power industry is coming, just as it has for the telecommunications industry.

The House and the Senate have both been working on legislation that gives consumers choice of electric service. The Clinton administration began holding hearings around the country on competition and is currently drafting legislation. Many states have already announced plans to implement some degree of consumer choice.

Democrats strongly believe we should develop our energy resources in ways that will not cause harm to the environment, the consumer or the taxpayer. Conservation is a critical element of our energy policy.

According to the Senator Dale Bumpers of Arkansas the ranking member of the Energy and Natural Resources Committee, "Properly handled, greater competition in the electricity industry should lead to greater customer choice and lower electricity prices -- just as competition has in the long-distance telephone business. Improperly handled, it could lead to higher prices for some customers and the loss of some customer services."

The bottom line is that any legislation Congress passes must benefit the public as a whole and not just the utility companies and their largest industrial customers.

Barbara Wainman
Assistant to the Chairman
Interior Appropriations Subcommittee
U.S. House of Representatives
Washington, DC

First a little background about myself. I have been with Mr. Regula since 1981-- some of you have been working on these issues since the 70's, but to have been on the Hill 16 years is a very long time. So, I have seen a variety of approaches to our energy policy over the years.

Anyway long enough to have been around during the last Speaker of the House that had problems, Jim Wright. Speaker Wright used to tell a story about energy and how one of his constituents came up to him and says "Jim, I'm really worried about energy, we really have to worry about it." He says, "You know we can't keep burning coal, coal is dirty. It's not a good thing to keep burning coal. We can't keep using oil, because oil is in the unstable Mid-East, and I'm worried about that. We can't keep sending our troops over to fight to protect oil. Nuclear's just not safe, we can't use nuclear." So the Speaker said well Joe, what do you think is the answer. His answer: "We just have to use more electricity."

Well that would be funny, if it wasn't pretty reflective of what a lot of people know about our energy policy. A lot of people unfortunately have a limited amount of knowledge about energy and the issues that all of us in this room care about. Some of them are of our Congressman and their staff and it's not that they're not interested, but Congress really tends to be crises oriented and there is currently no energy crisis. There hasn't been in recent memory. So it's not something that's really on the congressional radar screen. And if you look at this Congress, speaking about staff being younger, I start looking every year to see how many members are younger than I am. And this is a very young Congress. Young in terms of experience and a lot of them young in terms of age, and there are many people up there who may not remember well the crises of the 70's. I remember the energy crises of the early 70's, because I had just gotten my drivers license and I always got to take the family vehicles on the odd days when you could get gas depending on license plates odd or even and filled them up. And some of these guys weren't even driving, they don't even have that exposure.

So we really have a job to do in terms of trying to focus on how do we deal with the energy issue, absent a crisis. Congress is looking at budget crises and Medicare crises and those kinds of things, and their philosophy is "if it ain't broke then don't worry about it." So we have to think of how we are going to deal with the Congress in that context.

I think that to some degree what it means is the way we're going to deal with energy policy is going to be incremental. I don't think we're going to see big sweeping energy policy acts or even utility deregulation in the next two years. I think it's going to be an incremental process.

Now what does that mean for all of us. I think it means that what every one of us in this room, what you all need to be doing--and those of us like Maura and I who are more familiar with these issues, need to be helping you to do--is "Education." I think it's very important that you get out and start talking to your Congressmen and your Senators and their staff about what issues are important to you. Talk to them in ways that they can understand. Make it relevant to their State, their district, and their constituents

I've learned a lot today, but there's a lot that I hadn't a clue what was being talked about, and I'm pretty familiar with these issues, so I think you need to get out there and talk about these issues so that those of us who don't spend our whole lives working on this, which is most of the Congress, can really understand and understand why it's going to be important to them. Why it's going to affect their district. Tom and I were talking at lunch, about, the impact if you throw half of this country into non-attainment. You're going to have a real crisis. But most members don't know that, they don't know what non-attainment is and so you need to be starting now. Get out and really start the education process because we're going to be dealing with these issues, not next week, not next month but over the next period of years, and it's very important to not just go and say here's what I want you to do for me, but here's what I want to tell you about this issue. I think that's very important and it's never to early to begin this education process.

What does all this have to do with the impacts for clean coal technologies. I really find that I agree very much with what Linda said earlier. When we established the Clean Coal Program, I can say we because I was around at the birth of the Clean Coal Program so I'm very interested in how it finishes up. But I remember what I call the "3 E's." The program was founded because it was going to make these technologies more *economical*, it was going to make them more *efficient*, it was going to make them more *environmentally* friendly. I think right now two of those issues are very central to current debates and that is economics and the environment. The two issues of utility restructuring and changes in the whole Clean Air Act will both affect the future of the clean coal projects, but I don't think that necessarily has to be negative. I think that we should not look at these changes as "stumbling blocks" but as "stepping stones", and how can we use these to make the Clean Coal Program the true success that it can be. I think it is very important that all of you continue very aggressively to work on deployment, to have the most options to respond to whatever Congress comes up with in terms of new regulations or deregulations. You can't sit in this room and know what Congress is going to do. I think these issues, like you said, are going to be necessarily dealt with in the 105th Congress, maybe the 106th or 107th, and we don't have a clue as to what those are going to look like. We just have to be ready with the best suite of options.

A classic example of where an industry failed to do that is one that we're dealing with in another area of DOE. When some groups saw a Republican Congress elected, they thought "heck" now we can go in and not worry about getting our appliances more efficient. I'm glad to hear refrigerators are really efficient, because that helps the company that I'm interested in, but DOE thinks they need to be more efficient. So, a lot of the industry just sort of sat back thinking the Republican Congress is going to save us from having to make these refrigerators more efficient. Now they are scrambling to meet anticipated new standards. So you don't want to sit back trying to anticipate the lay-of-the land, because the lay-of-the-land can change every two years. It's important to get out there and keep working on getting these technologies into the market, get them sold, get them demonstrated and be very aggressive on that front. Because we don't know what Congress is going to do. We can't predict from day-to-day. But I think we need to look at these issues as positive opportunities and to be working to have the most options available for the coal industry to make sure that coal continues to play the important role in our economy and environment that we all know it can.

Thank you very much.

Panel Session 4

Issue 4: CCT Deployment From Today Into the Next Millennium

A Utility Perspective on the Deployment of CCTs Into the Next Millennium

Michael J. Mudd
Principal Engineer
AEP Energy Services

ABSTRACT

The successful Clean Coal Technology projects which are being discussed in this conference are all a testament to the positive advancements that can be made with environmentally superior technologies when the government and industry cooperate in the context of a properly funded and a well thought-out program. Many of the technologies developed in the Clean Coal Technology Program have taken a competitive position in the marketplace, and many others are on the verge of being competitive in the marketplace. Based on the success of the Clean Coal Technology Program, one would expect that they would be ready for full deployment in the marketplace as we approach the next millennium.

This is not happening. There are several hurdles that impede their deployment. Some of those hurdles, such as the higher first-of-a-kind cost and technology risk factors that accompany not-yet mature technologies, have existed since the initiation of the Clean Coal Technology Program. However, several new hurdles are impeding the market penetration of Clean Coal Technologies.

Those hurdles include the radically different marketplace due to the restructuring of the electric utility industry, a soft market, the difficulty in financing new power plants, low natural gas prices, and lower-cost and higher-efficiency natural gas combined cycle technology.

I. INDUSTRY RESTRUCTURING

The restructuring of the electric utility industry is being reviewed in detail at other sessions. Therefore, I will not discuss that aspect in detail here. However, at the same time, it is important to acknowledge that the restructuring of the industry from cost-based prices to market-based prices will have a great impact on the commercialization of CCTs in the domestic electric utility industry. This is because the pending change in the electric utility industry has resulted in the deferral of construction of new plants in the United States into the next decade or beyond. Until the rules of the newly restructured marketplace are known, electric utilities are not likely to add new base-load coal-fired capacity.

II. MARKET FOR NEW PLANTS

The market for new base-load, coal-fired plants in the United States is stagnant. Sales of coal-fired plants are few and far between. The load growth of electricity is lower than was projected twenty years ago when the electric utility industry was adding significant capacity to the grid. As a result, there is ample base-load capacity to serve our nation's electric system in most areas of the United States. Currently, the average capacity factor of the 720 GW of generating capacity installed in the United States is 49.6%. Most of the projected load growth for the next 10 to 15 years can be absorbed by increasing the capacity factor of existing power plants, decreasing reserve margins, and by life extension of existing capacity. It will not be met by adding base-load solid-fuel power plants.

III. FINANCING OF NEW PLANTS

In a regulated environment, utilities based decisions to erect new facilities on prudency, life cycle costs, and the regulatory compact, whereby utilities were allowed to recover the cost of prudent investments provided the facilities were used and useful, and a reliable source of electricity was provided to the ratepayers. In the deregulated environment, the key to building a new power plant is financing. One of the keys to financing is to obtain a Power Purchase Agreement. A Power Purchase Agreement is dependent on the ability of the generator to provide reliable power at competitive prices. The utility, (or GENCO or IPP or any producer of electricity by any other name) would seek a Transmission Company, Distribution Company, customer, or power broker to sign an enforceable long-term contract for the electricity produced by the new facility.

Absent a Power Purchase Agreement, the plant would be a "merchant" facility (eg. the plant is built without any assured purchaser of the power) which entails considerable financial risk. Usually, it is difficult, if not impossible to finance such a facility with project financing (using lower-cost debt to finance the project). A merchant plant would likely be financed with mostly equity (which typically is more expensive than debt).

Let's look at whether or not a Clean Coal Technology Plant could provide competitive power in today's market. Most studies which project the market price for power in the 2000 to 2005 time frame point to an average market price for energy in the range of 20 to 25 mil/kWh, and 30 to 35 mil/kWh when capacity is included in the cost. With natural gas at less than $2.00/million BTU, a Natural Gas Combined Cycle Plant can be competitive with that price level. Most new solid-fuel plants, whether a conventional or a Clean Coal Technology Plant, cannot provide power at that price. The reasons for that follow.

IV. NATURAL GAS

Since 1988, approximately 75% of new generation has been gas fired. The dominance of natural gas in recent years can be attributed to economics associated with the price differential between natural gas and coal, the efficiency of natural gas combined cycle plants, and the decreasing capital cost of combustion turbines.

Natural gas has historically commanded a price-premium factor of 2.5 to 3 (on a BTU basis) over coal. That premium reached a low of 1.25 within the past five years, and has remained well under 2 over the past several years. It is because of this historical price premium that coal-based technologies have been competitive with natural gas technologies despite their higher capital cost. With the lower price premium, coal-based technologies tend to lose out in an economic comparison. Will natural gas prices increase in the future relative to coal prices? Current conditions do not indicate such a trend. Known natural gas supplies have increased by 30% over the last decade. The abundance of reserves, coupled with advances in extraction technologies and competition in the natural gas industry, have reduced natural gas prices by 15% in real dollars in the past five years.

At the same time, the efficiency of gas turbines has been steadily increasing. The efficiencies of the latest fleet of high-temperature gas turbines is approaching 40% for a simple-cycle configuration, and 50% for a combined-cycle configuration. The DOE projects efficiencies of 60% in advanced turbine systems by the next millennium.

Finally, the capital cost of gas turbine combined cycle plants has declined dramatically. The current cost of a Combustion Turbine Combined Cycle Plant (on a $/kW basis) is about one-half the price of a pulverized coal-fired plant.

The combination of lower fuel prices, higher efficiency and lower capital cost has resulted in lower projected life-cycle costs for NGCC Plants compared to coal-fired plants -- both conventional designs and Clean Coal Technology designs.

There are many other issues which impact the evaluation of whether or not a utility should build new generation, and what type of generation should be used. Some of them include environmental considerations, location of plant relative to the availability and cost of fuel, system stability requirements, system needs (peaking, intermediate, or base load) to name a few. There will be selected niche markets where a coal-fired plant is the economic choice. However, in the short term, I believe that natural gas will dominate new plant construction.

V. CLEAN COAL TECHNOLOGIES

Where does this leave CCTs in relation to the domestic electric utility industry? I do not believe that there will be a viable wide-scale market for solid-fuel, base-load power plants -- whether clean coal or conventional in the United States until the need for base-load power reenters the marketplace, and coal can reestablish its competitiveness compared to natural gas.

At the same time, CCTs continue to be good technologies. They have cost advantages, efficiency advantages, and environmental advantages compared to conventional technologies which must not be sold short. They have the potential to provide the higher efficiency and lower capital cost to bring coal back to the forefront for new electric generation. But before CCTs can be competitive with natural gas, they must complete their path along technical and cost maturation curves.

In the long run, coal-based generation must continue to be a viable and important part of our nation's future generating needs. Coal is a natural resource which must not be ignored. Coal is an important aspect of our country's energy security. I believe that the dominant market for new generation in the foreseeable future will be in smaller-size generating stations. Fluidized-bed combustion boilers, especially CFBs, can continue to serve this important market niche, especially where low-grade fuels and alternate fuels (such as pet coke and biomass) are economically available. At the same time, this smaller-size market is where the competition between coal and natural gas will be the greatest. Both PFBC and IGCC technologies could be the "swing" choices for new generating facilities, which could allow coal to capture a large share of the intermediate-size power generating stations in the future.

If PFBC and IGCC can continue down their paths of commercial demonstration and cost reduction, these technologies should offer the opportunity to use coal in medium-size facilities which might otherwise be fired with natural gas. The challenge remains to continue the development of these important technologies despite the fact that the near-term market for new generation, especially coal-fired, is bleak. This is why, absent opportunities in the domestic market, it is so important to continue to focus on developing these technologies overseas.

VII. INCENTIVES

The Clean Coal Technology Program has been the model of the type of incentives that were required in the mid 1980's to assist in the commercialization of CCTs. I believe that the incentives should remain in effect to allow those projects to be completed. At the same time, it is important to acknowledge the context in which the CCT program was initiated. Natural gas prices were declining relative to coal prices, however it was expected by many analysts that would be a short-term situation. The Clean Air Act Amendments were being discussed, but were not yet enacted. Deregulation was being talked about, but it was far from a reality. The cost-sharing provided by the federal government was often tied to enhancing the cost-recovery of the project by the utility through rate consideration.

As previously discussed, conditions are significantly different now. At the same time, incentives are still required to assist the completion of the commercialization of Clean Coal Technologies. Proper incentives are still required to ensure that not-yet-mature CCTs are commercially deployed as opportunities become available. Those incentives must make these not-yet-mature CCTs cost indifferent to the customers. If the only market for CCTs is overseas, and if incentives are required to ensure that Clean Coal Technologies can be proven in this market, then it is better to pursue an international cost-sharing program than to simply claim that we should not spend CCT funds on overseas projects, and lose the momentum gained through the CCT Program.

VIII. CONCLUSION

Our nation has invested a lot of effort and money in the development of Clean Coal Technologies -- in excess of $7.5 billion. Electric utilities have played a major role in that development, having been involved in a significant percentage of the Clean Coal Technology projects. This is a testimony to the importance that electric utilities place in the development of Clean Coal Technologies. Our industry and our customers cannot overlook the environmental, efficiency and economic benefits of Clean Coal Technologies. Industry and government must continue to work together to ensure that Clean Coal Technologies are ready to be used in the next fleet of power plants by being an economic choice compared to other alternatives in the future.

A CHICKEN IN EVERY POT
A NEW BOILER IN EVERY POWERPLANT
A NEW POWERPLANT AT EVERY INDUSTRIAL SITE

Robert D. Bessette
President
Council of Industrial Boiler Owners (CIBO)
Burke, Virginia

For those of you who do not know, the Council of Industrial Boiler Owners (CIBO) is a broad-based association of industrial boiler owners, architect-engineers, related equipment manufacturers, and university affiliates consisting of over 100 members representing 20 major industrial sectors. CIBO members have facilities located in every region and state of the country. We have a representative distribution of almost every type boiler and fuel combination currently in operation. CIBO was formed in 1978 to promote the exchange of information within industry and between industry and government relating to energy and environmental equipment, technology, operations, policies, laws and regulations affecting industrial boilers. Since its formation, CIBO has taken an active interest in the development of technically sound, reasonable, cost-effective energy and environmental regulations for industrial boilers. One of our prime objectives is to support and promote the industrial energy base of our country, a foundation of global competitive power.

What you do and are talking about at this conference is directly in line with our objective to promote the industrial energy base of our country. In that context, I want to begin with a quote from Jesse Jackson's remarks to the Democratic National Convention in Chicago:

"What is our vision tonight? Just look around.

This publicly financed United Center is a new Chicago Mountaintop. To the South, Comiskey Park, another mountain. To the West, Cook County Jail, with its 11,000 mostly youthful inmates.

Between these three mountains lies a canyon.

Once Campbell's Soup was in this canyon. Sears was there, and Zenith, Sunbeam, the Stockyards. There were jobs and industry where now there is a canyon of welfare and despair.

This canyon exists in virtually every city in America."

If we look at where the companies which once thrived in the canyon have gone we may not like the answers we find. When we talk about boilers which support the companies which produced these jobs, they are not being built in this country today. When is the last time you saw a major new manufacturing plant being built or considered for any major city or non-attainment area? They are not. The canyon of welfare and despair will never be revitalized without a rebuilding of American industry. Even Mr. Jackson knew this, as he ended his speech at the convention with the following:

"In the Canyon, we must have a plan to rebuild and redeem our cities, to reinvest in America.

I suggest we have at least as much sense as a honey bee, which knows enough to repollinate her flower.

After World War II, we helped rebuild Germany-- the Marshall Plan. We helped rebuild Japan - the MacArthur Plan.

Now we must rebuild America."

Today I want to share with you my thoughts on a problem which all but prevents us from doing this. This problem has increased the complexity for the individual or business to create its own future. There is a perception, throughout the country, which binds our hands as we look to create a better future for our children -- whether they are in the city or suburb.

What is this perception? "Energy Awareness!" There is "no" energy awareness! We as a people take energy for granted. We forget it takes energy to do anything, to provide any product or service. I challenge you to touch something in this room, or where ever you happen to be, which doesn't have energy connected to it in some way. Even touching takes energy.

As we look to the future, our nation's energy awareness will be the determining factor in how and what we are able to do. I do not know what that will be. Right now we have great "Environmental Awareness." To balance the future, we must have an equally strong "Energy Awareness." In a sense, it is now backwards. I believe people, in general, feel energy happens (made by God, used by man), and environment is created (made by man, used by God). When you think about it, in reality, the environment happens and energy is made. Everyone agrees we must be environmentally conscious as we build our future. However, without energy there is no future as we think of it today.

If we stop and take a look at where we are today, to say the "times-are-a-changin" may be an understatement. EPA's regulatory activity is at its highest level in recorded history. Utility deregulation and competitive sourcing are opening new alternatives resulting in new complexities (including additional environmental complexities), for our day-to-day operations and long-term development considerations. Corporate re-engineering is changing the face of every industrial company in the United States, if not the world. What we see two years from now will not be anything like what we saw two years ago.

Each industry grows, or changes, as a result of the pressures it experiences. If you are to be successful you have to look at what these pressures are and how to address them.

What are the pressures on the industrial boiler owner today which will affect how he meets his energy needs?

- CHANGES IN OPERATOR KNOWLEDGE AND EXPERIENCE
  Retirements and Loss of Naval Training

- INCREASING ENVIRONMENTAL REGULATIONS AND COMPLEXITY
  NAAQS Integration, ICCR, FERC, OTAG

- INCREASING GLOBAL COMPETITION
  Cost of Goods Sold, Regulation Difference, Profitability

- DEMANDS FOR INCREASED ENERGY EFFICIENCY
  Global Climate, Cogeneration

- DEGRADATION OF FUEL SUPPLY QUALITY AND CONSISTENCY
  Waste Fuels

These pressures have created a new environment in which the industrial power plant must operate. The ability of the industrial company to compete has been seriously complicated. The goods and services which are produced to maintain our standard of living and to provide the social benefits to the people of the United States are becoming more expensive primarily due to the increasing burden of regulations, environmental and others. Talking primarily about environmental regulations, these regulations are generated without significant positive benefit. We forget it takes energy to clean up the environment or do anything.

As a result of these pressures, especially the environmental regulations, we see some major trends which may be indicative of what the future will hold.

- Industrial development is now mostly in other countries and not in the United States.

- There are very few people who know how to burn coal or fuels other than natural gas in an efficient, environmentally acceptable way.

- The question of who should own my powerplant is given serious consideration. As more companies proceed down this path, the financial plant, definition and labor problems will be worked out for others to follow.

- Staff reductions and travel curtailments are commonplace to meet the ever increasing globally competitive pressures and the demand for short term profits by investors and management. Capital for powerplants vs. production.

- Environmental regulations have forced rapid development of technologies without a plant operation infra-structure.

- Regulations emanating from the implementation of the Clean Air Act Amendments of 1990 are being generated on all fronts at the same time without sufficient time to determine the true costs and benefits. However, all affected parties are beginning to talk to each other.

- We are beginning to see a trend where savings are being generated through team efforts. There is a greater acceptance of owner/vendor/engineer groups working together. A new way to work out projects.

- Natural gas is the primary industrial fuel of choice.

The single most important question to come out of our annual meeting in October was: "what is the future of industrial energy needs in a deregulated utility market?" We are going to try to work this out and develop a program to specifically address this issue over the next year.

Today's situation is one of complexity and multiple energy/ environmental issues forcing companies to look at the increasingly complex solutions with increasingly smaller staffs.

I must say, I do not believe there is anyone in this room who does not want a clean and safe environment for our children and our grandchildren. This has become a top priority in everyone's mind. It is like buckling seat belts when you get into a car; where once there was resistance, now there is a natural acceptance.

Where do I think the industrial powerplant will be in the next 10 to 20 years?

- The industrial powerplant may not necessarily be owned or operated by the users of the steam and power. The powerplant will be considered a profit center.

- Powerplants will be built to generate electricity based on a process steam load to capitalize on the system efficiencies. The "steam only" system may become extinct.

- There will be a drive for effective and efficient increased consumption of any waste which can be used as fuel, if not completely banned by the EPA, under a radical combustion strategy and maximum achievable control technology (MACT). Large Wholesale Electric Generation's (WEG) will be located at mine sites or where there is low cost fuel.

- The next generation of electric powerplants will be smaller (40 to 240 MW) systems located at or near the major industrial energy users, taking advantage of the increased efficiencies of cogeneration.

- Environmental regulations will be generated with real and valued input by all interested parties. These may provide a sense of realism and benefit for the costs incurred. The Industrial Combustion Coordinated Rulemaking (ICCR) and Ozone Transport Assessment Group (OTAG) are examples of this.

- The environment will be cleaner; and people will be better educated. They will not be scared like "Goosy Lucy" listening to "Chicken Little" when they hear words like endocrine disrupters, ozone hole, alar and radon.

- Clean coal tehnology programs will have a more important place in everyday decision making.

The above projections are based on a sense of optimism that there will be sufficient energy awareness to balance the environmental awareness which exists today. If this happens we will be able to replace our aging industrial energy base and provide the support for an increased national productive capacity. If it does not happen, I am afraid to consider the possibility that we will become a nation of service providers to the world and importers of goods. Of course, this is what some would like to see -- a return to the primitive times.

"In Order to be Successful, Technology Must Adapt to the Changes in the Marketplace"

James C. Houck
General Manager
Alternate Energy Department
Texaco, Inc.

First, let me tell you how proud Texaco is to be a part of the team which contributed to the success of the Polk Power Station IGCC -- the cleanest coal power plant in the world. I also want to commend our friends at Tampa Electric Company for their vision, their energy and their spirit that were critical to bringing this plant on line -- and on schedule. Finally, I want to thank our DOE hosts for organizing this fine conference.

Texaco has been in the gasification business for more than 50 years, and the only "constant" we have seen in the marketplace is change. The marketplace is no longer a set of neat and distinct boxes. It is hard to discern the lines between the utility and non-utility sectors; and between the power and the refining and chemical sectors.

In the same way that marketplace distinctions have evolved, technology distinctions have evolved. In adapting gasification to the marketplace, we have learned not to view gasification as strictly a "power" technology, or as strictly a "coal" technology. It is, however, a "popular" technology because it is so many things to so many people. Thus, the emphasis of my remarks are on "technology that meets marketplace needs," not on "clean," or "coal."

A little perspective on where we've been and what we've learned will help us understand where we're going. Gasification was first used in the late 18th century to "cook" coal to produce gas for street lamps. Over the next hundred years it was primarily used to produce town gas. During the 1920's gasification was first used by the chemical industry to synthesize chemicals. During World War II and for several years thereafter, gasification was used to produce liquid fuels from coal and natural gas.

Texaco entered the gasification market during this time period, and we licensed our first commercial plant in 1946. At the start, the gasification technology appealed to the chemical industry, followed later by the refining industry, where it was used to produce hydrogen from oil and natural gas.

With the energy crises of the 1970s, America decided to become energy self-sufficient and since our most abundant energy resource was coal, it was clear that coal-based, energy self-sufficiency had to be balanced with environmental concerns. Hence, the creation of the Synfuels Corporation and later the Clean Coal Technology Program. As has been thoroughly documented at prior CCT conferences, it is important to note that these programs did indeed contribute to advancement of technology, including commercialization of technology, in the power sector. (And Texaco is proud to have played an important role in the Clean Coal Technology Program.) It is equally important to note that some of these technologies have been, and continue to be, adapted from other, more traditional, marketplace applications.

The lessons we learned from history is that the gasification of 1996 is a far cry from the gasification of 1796. In fact, the only point of commonality is the name itself.

The marketplace, both here and abroad, has changed dramatically since the Clean Coal Technology Program was first legislated. In the United States, the Electricity Market is undergoing the most profound change since Edison first invented the light bulb. Overseas, the electricity markets are growing at a much more rapid pace than total energy demand.

We believe gasification can play a key role in the marketplace competition for power generation. National privatization and regional imbalances in projected supply/demand scenarios have created opportunities where gasification has successfully competed. Markets where the demand for power is combined with the lack of inexpensive, indigenous fuel (for example in India, Taiwan and Japan), or where the ability to use a variety of low value and/or waste feedstocks in combination with coal feedstocks, have also created opportunities where gasification has successfully competed. An interesting result from our successful efforts in the area of low value and waste feedstocks has been the importance of not necessarily characterizing gasification as a "clean coal" technology. Rather, it is a "clean, versatile" technology, with an emphasis on both "versatile" and "clean."

Against the backdrop of the recent gasification successes in the marketplace, it is important to ask "What are the challenges to future commercial success?" Let me share our thinking on a few:

1. Government -- The old attitude was that regulations must become more strict in order to foster an environmental in which gasification can succeed. The new attitude should be that government should step aside and let the market figure out how best to make this technology succeed. And that is by recognizing that a technology is only as versatile and flexible as the laws which regulate it. Gasification can do many things, and solve many problems, but only if the lawmakers are willing to advance their regulations as quickly as industry advances the technology. The EPA and other countries' environmental agencies should recognize this, as should the World Bank.

2. Perceptions -- Most of the technologies showcased at this conference are fully commercial. Gasification certainly is. So let's stop referring to these projects as "demonstration," let's stop talking about these efforts as R&D, and let's stop suggesting that these technologies need special incentives to deploy them. Similarly, let's recognize that as commercial technology, it has met the marketplace requirements for reliability and availability. Too often, as we develop technology for new marketplace applications, we are tempted to emphasize the "learning curve" issues and not give credit when those issues have been clearly addresed.

Gasification is Commercial. The commercial lending community recognizes this, as evidenced by the successful projecting financing of two IGCC projects in Italy. And the Utility market recognizes this, as evidenced by the winning bid put forth by GSK in Tokyo Electric's IPP solicitation.

3. Cost - Although gasification has enjoyed recent commercial successes, the major factors contributing to the overall costs of projects still need improvement. In particular, installed capital cost of a gasification facility continues to be perceived as a barrier to widespread commercial acceptance. The techniques for capturing and implementing reduction in cycle time, along with improvements and standardization in engineering designs are known and being used to make improvements. With the continued efforts of many of the world class technology suppliers and engineering/construction companies represented here today, we are confident this barrier will be eliminated. Overall costs can also be reduced through multiple product facilities where incremental capacity additions to accomodate more than one product result in economies of scale.

What will be the model gasification plant in the next millennium? That's tough to predict, but our current successes would illustrate the folowing trends:

1. Multiple feeds -- The feedstock versatility of gasification mentioned earlier will be more and more common. The kinds of materials we wouldn't have imagined just 20 years ago (for example petroleum coke; municipal wastes and sludges; industrial and hazardous wastes; biomass) are frequently included in project considerations. The Texaco gasification projects at the STAR Delaware City refinery in Delaware, the Texaco El Dorado refinery in Kansas, the Ube Ammonia facility in Japan, and the Quantum Chemicals facility in Texas are examples of this.

2. Multiple products -- As the walls that used to neatly define industries come down, single facilities making multiple products will become more common. With gasification's primary output being syngas, the potential for achieving greater project economies by producing fuel, hydrogen, chemicals, steam and power from syngas is significant. Texaco gasification has long been operating in the multiple hydrogen/chemicals environment. Building on the success of the SARLUX refinery based project in Italy to produce hydrogen and power, the Texaco gasification technology is now under final evaluation for several refinery/chemical facility applications, including the Shanghai Coking and Chemical Plant in China. This facility is developing a "trigeneration" project, of which two of the three legs are already operating. This single plant is designed to convert coal into methanol, electricity and town gas -- meeting three very distinct market needs -- cleanly, efficiently and with the flexibility to adapt quickly to changing market requirements.

3. Facility Integration -- Again, with the flexibility afforded by gasification's multiple feeds and multiple products potential, the ability to locate a gasification facility adjacent to, and therefore integrate the facility with, another facility (such as an existing refinery chemical plant or power plant) provides a significant opportunity for capital cost reduction and additional revenue steam generation.

4. Facility Financing -- Just as the applications for gasification technology are expected to become more complex, the methods of funding such projects are expected to be more sophisticated than the traditional model of corporate balance sheet financing. The financial community has already demonstrated its level of comfort on recent Texaco gasification power projects. Included in this success story are the financial closure of two refinery-based "project financed" transactions and one refinery-based "operating lease" transaction. Texaco is proud of its role, which included both technical assessment and commercial performance guarantees, in supporting the financial community in achieving these breakthroughs. And we clearly stand ready to continue this support for future projects.

5. Strategic Partnering -- It should come as no surprise that if the applications are expected to become more complex and the financing more sophisticated, there will need to be an evolution from the traditional project roles of owners/suppliers/etc. Teamwork among project sponsors to better manage the risk/reward profile for a gasification facility will become a must. Texaco's strategy, for example (and we know similar strategies are being initiated by other world class companies represented at this conference) emphasizes joint venture partnerships, and includes the active participation by Texaco in roles beyond the traditional perception of Texaco as technology supplier. The additional responsibilities we are pursuing when becoming an owner include responsibility for fuel supply, for operations/maintenance supervision, for establishment of maintenance programs, and for the supply of selected gasification technical support and equipment fabrication/supply. And we recognize that each of these roles must be performed to competitive standards and to bankable, contractual requirements.

The underlying theme to the facility of the future is its versatility -- using different, and multiple feedstocks to produce a host of products for different industry segments. Adapting technologies to these applications which are fully commercial will provide the most economic and efficient means of making these products from these materials, as well as being environmentally superior.

Thank you very much.

CONSOL'S PERSPECTIVE ON CCT DEPLOYMENT

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ABSTRACT

The principal focus of government investment in Clean Coal Technology must be to serve the interests of the U.S. energy consumer. Because of its security of supply and low cost, coal will continue to be the fuel of choice in the existing domestic electricity generating market. The ability of coal to compete for new generating capacity will depend largely on natural gas prices and the efficiency of coal and gas-fired generating options. Furthermore, potential environmental regulations, coupled with utility deregulation, create a climate of economic uncertainty that may limit future investment decisions favorable to coal. Therefore, the federal government, through programs such as CCT, should promote the development of greenfield and retrofit coal use technology that improves generating efficiency and meets environmental requirements for the domestic electric market.

I. INTRODUCTION

The CONSOL Coal Group, jointly owned by Rheinbraun and DuPont, produces about 72 million ton per year of steam and metallurgical coal and has reserves in most of the U.S. coal basins. Our mining operations are located in Canada, Kentucky, Illinois, Ohio, Pennsylvania, Virginia, and West Virginia. Domestically, CONSOL coal markets are east of the Mississippi River. Foreign sales include the Far East, the Middle East, and Europe. Because of the locations of our mines and our markets, we are particularly interested in environmental control technologies, including many of those being developed as CCTs.

Why is CONSOL qualified to speak about CCT deployment? CONSOL has supported coal-related research and development. We are the only U.S. coal company that supports a privately-funded coal research program. We have been active in supporting the DOE coal R&D program, including participating in four CCT projects: The Edgewater Boiler Limestone Injection and COOLSIDE Process Demonstration, The Milliken Clean Coal Project, the Micronized Coal Re-Burning Project, and the Piñon Pine IGCC Project. Our involvement includes financial contribution, direct participation to develop and evaluate process performance, and, in some cases, as a fuel supplier. As a coal-supplier, our goal in participating in the CCT program is to increase coal's market share of the electric generating market. The development of new technology may gain increasing importance as the deregulated utility market seeks the lowest fuel cost and capital cost for its electric generating systems. In addition to uncertainties due to deregulation of the electric utility industry, the generation-capacity owner, technology developer/marketer, and fuel supplier are facing uncertain environmental regulations. These environmental issues will create the potential for development and deployment of new CCTs.

Before proceeding, I would like to define what CONSOL means by Clean Coal Technology. Our definition includes retrofit and greenfield environmental control technology (wet scrubbers, low NO_x burners, Selective Catalytic Reduction, and wide-plate-spacing ESPs), retrofit technology to improve cycle efficiency at existing plants (e.g., heat pipe air heater), and new power generation systems (e.g., PFBC, IGCC, advanced supercritical boilers, and the Kalina cycle) for greenfield or repowering applications.

During the remainder of my presentation, I will cover three main topics:

- Future of the power generation Industry
- Impediments to commercialization of clean coal technologies
- Need for government-industry partnerships

II. FUTURE OF THE POWER GENERATION INDUSTRY

The future of the power generation industry is uncertain. Utilities are buying and selling generating assets. The role of the IPP in the electricity generation market is unclear. Despite these uncertainties, one constant in any future utility scenario will be a focus on fuel price. The market will reward the low-cost producer and punish the high-cost producer. This will affect competition among coals, and particularly between coal and natural gas as the primary fuel for new electric capacity. Three issues drive the competition between natural gas and coal. They are:

- The efficiency of natural gas combined cycle units vs coal-fired systems
- The availability and price of natural gas
- Current and future environmental regulations

The natural gas combined cycle (NGCC) generating systems have significantly improved cycle thermal efficiency compared to simple cycle and first generation NGCC units. On a high heating value basis, the advanced NGCC generators have achieved 52 to 55% cycle efficiencies (at sea level and in new condition). The NGCC cycle efficiency is a function of elevation above sea level (cycle efficiency decreases by 0.3%/100 ft elevation), ambient temperature and age. The installed coal fired capacity in the United States has a cycle efficiency between 35 and 37%.

CONSOL R&D developed the CONSOL Coal Quality Cost Model (CQCM) to evaluate the break-even price of coal and other fuels. The break-even price is the delivered natural gas price at which the bus bar power cost is identical for natural gas and coal. For the cost comparison, a new 500 MWe pulverized coal- fired power plant, complying with the NSPS for utility boilers and having a thermal efficiency of 36.2%, was compared to an NGCC plant complying with the Gas Turbine NSPS and having a thermal efficiency of 45.6%. Life cycle costs were estimated for different coal and gas prices, depending on the real inflation rate for gas prices. Figure 1 depicts the relationship between the break-even natural gas price (expressed as dollars per million Btu), the real inflation rate for natural gas, and the delivered coal price. For example, at a n NGCC cycle efficiency of 45.6%, a current delivered natural gas price of $2.75 per million Btu, and a natural gas real inflation rate of 1%, the break-even coal price is $40 per ton. The impacts of NGCC and coal-fired cycle efficiency on the break-even coal price are illustrated below.

Effect Of NGCC Cycle Efficiency On Break-even Coal Price

NGCC Cycle Efficiency, % Cycle	Coal-Fired Efficiency, %	Break-Even Coal Price, per ton
45.6	36.2	$40.00
52	36	$34.00
52	42	$37.50

Assuming a 1% real inflation rate for the natural gas price and natural gas base price of $2.75 per million Btu, increasing the NGCC cycle efficiency by about 6% absolute reduces the break-even coal price by $6.00 per ton. Increasing the coal plant cycle efficiency from 36% to 42% at 52% NGCC cycle efficiency will increase the break-even coal price to $37.50/ton. The current average delivered coal price is about $33/ton.

This short discussion illustrates how NGCC and coal-fired boiler cycle efficiency, and the natural gas and coal prices will affect generation fuel selection.

Another topic that is being discussed is the rate of growth of utility generation. Many expert s predict the future...most are wrong. That said, we will provide some estimates of future electrical load growth. Based on EPA telephone contacts with boiler owners and state regulatory offices, the projected 1996-2000 planned capacity addition is 5189 MWE[1]. The Energy Information Agency[2] estimates that electrical load will expand by 50,000 to 60,000 MWe through 2010. The increased demand for electricity will be filled by increased utilization of existing capacity , purchase of electricity from Canada and Mexico, repowering of existing units, and construction of new power plants. Repowered and new power plants could provide the markets to deploy CCT demonstrated generating systems (PFBC, IGCC, etc.).

III. IMPEDIMENTS TO DEPLOYMENT OF CCT TECHNOLOGIES

As I mentioned earlier, CONSOL markets coal worldwide. While our primary interest is the domestic market, CONSOL supports the worldwide deployment of CCTs to expand foreign markets. Expanding domestic and foreign markets will stabilize coal prices, increase the volume of coal exported, increase the volume of U.S. industrial exports, and help to maintain U.S. technological leadership.

I will now focus on domestic CCT installations and impediments to deploying CCT technology. As a coal producer, we are interested in retrofit CCT's which will be deployed beyond 2000 and in new, greenfield power installations for the post-2005 period. CONSOL believes that there will be three main impediments to deploying CCT technology. They are:

- Uncertainty concerning environmental regulations
- Uncertainty concerning power industry
- Coal-supply implications of new technology.

The U.S. power industry is facing a period of high uncertainty concerning the future of environmental regulations. EPA is considering the following environmental regulations:

Pending Environmental Regulations

National Ambient Air Standard for SO_2
National Ambient Air Standard for Ozone
Revised New Source Performance Standard for Utility Boiler NO_x Emissions
NO_x Emission Limits Due to the Ozone Transport Assessment Group
NO_x Emission Limits Due to OTC Regulations
Nation Ambient Air Standard for PM (2.5 μm Particulate Matter) $_{2.5}$
Utility Air Toxics Regulations

The three ambient air standards could require utilities to reduce NO_x and SO_2 emissions from existing utility boilers through the State Implementation Plans. If the cost of compliance is not excessive, these regulations could create a market for the retrofit CCTs. For example, the CCT program demonstrated the performance and economics of the Pure Air , Chiyoda, and SHU FGD processes for SO_2 control; of the NO_xOUT, Selective Catalytic Reduction, and low NO_x burners for nitrogen oxide control; and wide-plate spacing ESPs for particulate control. The OTC and OTAG processes could create a market for NO_x control technologies capable of achieving emissions of 0.15 pounds-per-million-Btu. Clearly, EPA's actions will either expand the market for CCTs or, if the environmental regulations are too severe, they could reduce coal-fired generation and the demand for CCTs.

I have been informed that the utility deregulation legislation being drafted by DOE may include an environmental compliance title. It was reported that EPA is seeking significant SO_2 and NO_x emission reductions beyond Title IV Acid Rain Control levels. DOE and EPA are discussing a concept termed "environmental comparability". While the definition of "environmental comparability" is not clear at this time, it could mean that existing SIP-regulated boilers become subject to the New Source Performance Standard after a certain operating life. There is much economic uncertainty due to deregulation. Adding an uncertain environmental burden only increases this uncertainty.

Not on the list of pending regulations is greenhouse gas control. A program to limit greenhouse gas emissions without including the entire community of nations is doomed to failure. Several countries have already stated that they will not participate in greenhouse gas emission control. Many third world countries are purchasing the standard 2400 psi, 1000 F/1000 F boiler. The third world is where the growth in greenhouse gas emissions will occur. China is currently the world's leading coal consumer. The Chinese are purchasing the standard boiler package and have stated that they will not agree to greenhouse gas limitations. Reducing CO_2 emissions will limit coal and, for that matter, any fossil fuel usage. Increasing power plant efficiency will reduce CO_2 emissions per kilowatt generated, but may not reduce the total CO_2 emissions if there is compensating growth in generating capacity.

Regardless of the post-deregulation future of the power generation industry, there will be a shakeout period. As stated above, the low-cost power producer will be the winner. The role of CCTs in this market is not clear. The uncertainty in the nature of the generation business will limit capital expenditures over the short term. The initial impact of deregulation is to minimize capital investment. Only absolutely needed generation will be purchased. The initial choice will focus on low capital cost systems with short payback periods. As the future becomes clearer, the generation owners will begin to focus on least-cost, life-cycle processes. In this market, coal will continue to be an important player. CCTs can capture a portion of the new generation capacity market (2005 to 2015) if they can demonstrate cost-effectiveness, reliability, and generating capacity flexibility.

The impact of coal quality specifications on CCTs has not been clearly defined. Will all coals perform equally well with a given CCT? What are the impacts of ash fusion temperature, coal chlorine content, ash content, volatile matter, etc., on CCT process performance? These issues have not been resolved for all economically attractive coal basins.

IV. NEED FOR CONTINUED FEDERAL ASSISTANCE

CONSOL believes that government involvement in the development of technology should be minimized. However, the combination of regulatory and environmental uncertainty caused by past and potential future federal actions has changed the private sector risk analysis. Typically, when a company evaluates a development project, it evaluates the market size and the cost and performance of current technology. For example, Intel knows the cost and performance of both its current generation and the competitors' microprocessors. Developing a new microprocessor has risk, but the market size and new performance requirements can be estimated with some accuracy. Compare this to developing power systems. What is the performance requirement? The EPA can alter the performance specification by imposing additional requirements that are out of the control of the process developer. If the developing design includes a 90% NO_x removal but

EPA regulations require 95%, then the development effort may be in vain. A significant uncertainty is greenhouse gas emission reduction. What is a minimum acceptable boiler efficiency that might satisfy EPA requirements? No one can answer that question.

When regulatory uncertainty introduced by the federal government has such significant impacts on technology development, then the government has a responsibility to assume a portion of the development risk. The Clean Coal Technology Program was an example of a private sector-federal program which achieved some success. Some have complained that this was a welfare program for industry. This is far from the truth. For example, CONSOL, Babcock & Wilcox, DOE, and EPA developed low capital cost, moderate SO_2 removal processes. When the Clean Air Act Amendments of 1990 were passed, Title IV (Acid Rain Control) did not favor these technologies because of the utility-wide emission allowance and trading programs. The private sector and federal investments were made obsolete by the Congress and EPA's implementation of the Act. This situation continues to exist today and probably will continue to exist in the foreseeable future. If the United States is to remain a leader in power systems development, continued federal assistance will be required to domestically deploy CCT-demonstrated NO_x and SO_2 controls and more efficient coal-based power systems such as PFBC, IGCC, the advanced supercritical boiler, the Kalina cycle, and others.

One final point. Ultimately, the decision about federal investment in energy technology should reflect the goal of providing power to the domestic consumer at lowest cost consistent with environmental objectives. In this sense, the success of the CCT program should be judged by how well it speaks for the energy consumer. The objective of the CCT program is to demonstrate lower cost, environmentally-compliant technologies to increase the use of inexpensive, abundant coal, and to leverage the government investment through private-sector cost sharing. A successful CCT program keeps the cost of electricity low, which benefits industrial, commercial, and residential users. I believe the CCT program can stand on its record in addressing the two demands of the energy consumer: low-cost electricity and environmental protection.

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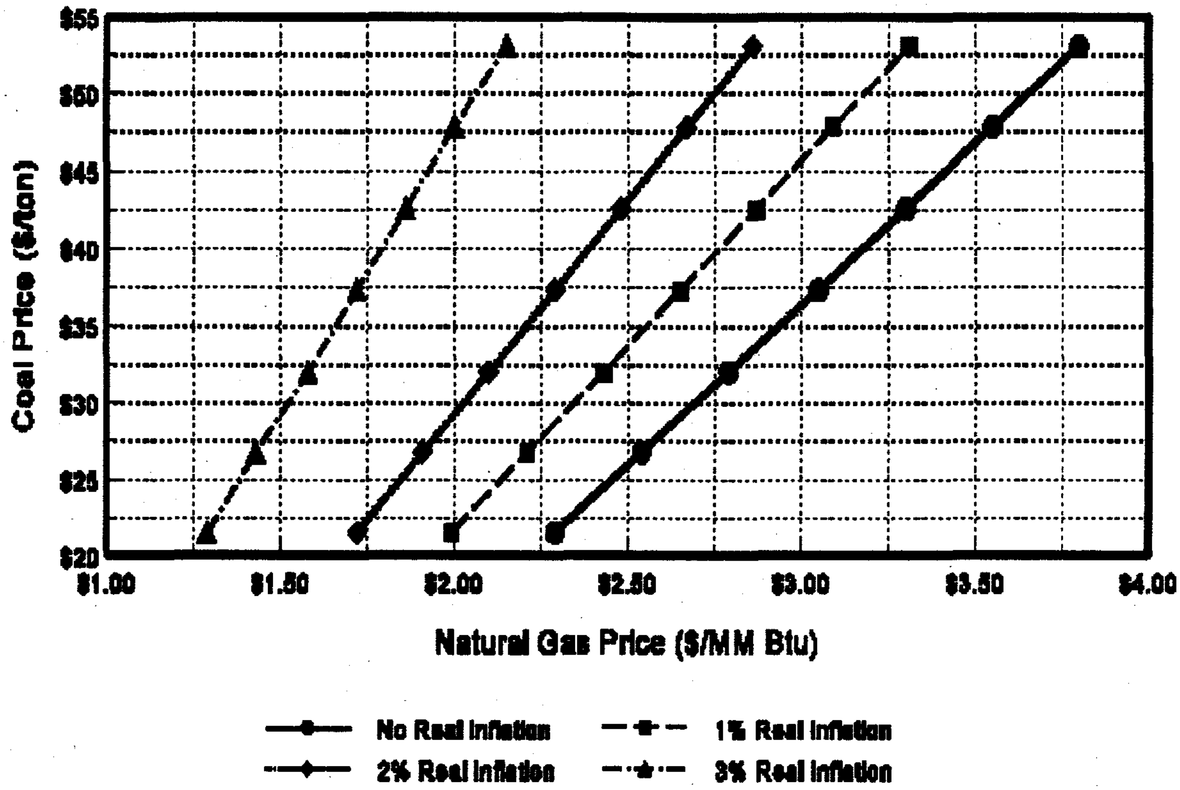
Break-Even Fuel Prices
New 500 MW Power Plant (Today's Efficiencies)
Coal @ 36.2% HHV -- Natural Gas @ 45.6% HHV



STATE PERSPECTIVES ON CLEAN COAL TECHNOLOGY DEPLOYMENT

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ABSTRACT

State governments have been funding partners in the Clean Coal Technology program since its beginnings. Today, regulatory and market uncertainties and tight budgets have reduced state investment in energy R&D, but states have developed program initiatives in support of deployment. State officials think that the federal government must continue to support these technologies in the deployment phase. Discussions of national energy policy must include attention to the Clean Coal Technology program and its accomplishments.

I. INTRODUCTION

I'm pleased to be a part of this panel to represent the states' perspectives on the future of Clean Coal Technologies. Before I begin, I would like to thank all of the state officials who took time to talk to me about their views and activities.

States have been active partners in the Clean Coal Technology Program since its beginnings. Of the 40 projects funded through the program, 15 received support from state governments or state universities. The states of Alaska, Ohio, Pennsylvania, Indiana, Illinois and New York and the universities of Georgia and North Dakota all have participated in Clean Coal projects. Ohio alone was a funding partner in six projects, and Illinois and Pennsylvania supported two projects each. States provided only about 3% of total program funding, but their participation was crucial in building political and funding support for many of the co-funded projects.

It's always been clear that the participating states perceive they have something to gain from the commercial development and deployment of Clean Coal Technologies. The states' role in Clean Coal Technology development has been a parochial one, aimed at fortifying specific economic strengths as well as providing long-term energy and environmental benefits to their citizens.

When the Clean Coal Technology program began in 1985, there was a very different culture in states than the one that exists now. At that time, a typical debate in my state legislature involved which tax to raise, how to come up with a dedicated funding stream, how much more bonding authority to approve -- basically, how to get the money to pay for more and bigger programs.

Coal development programs enjoyed strong political and funding support in a number of states even before the federal Clean Coal Program was established. In Illinois, for example, we had already cofunded several technology demonstration projects by 1985. We were embarking on a series of industrial-scale demonstrations using advanced fluidized bed combustion systems. We were developing a demonstration of the Chiyoda scrubber at the University of Illinois. We had just received funding for a major coal R&D effort, in addition to participating in the national Clean Coal Technology program. Clean energy was a real priority in state and national programs and policies.

Ten years later, states are still interested in clean coal technologies, but there have been some fundamental changes in the type and amount of support that states provide. I'm going to briefly discuss some of the challenges states face and how they have influenced state activities.

II. CHALLENGES

Many speakers over the last few days have cited the challenges facing Clean Coal Technology deployment: emerging environmental issues, electric utility deregulation, the current excess capacity in domestic utility markets, the dynamic relationship between coal and natural gas, the costs and status of technology deployment, et cetera. All of these factors have undoubtedly influenced the decisions of all of the participants in the Clean Coal Program in some respect.

The unique differences between states make it difficult to talk about a "generic" state outlook or response. From the state perspective, it makes sense to look at these challenges in a kind of aggregate way, and you can boil them down to two central forces: The first is a kind of "uncertainty factor," related to all of the regulatory and market issues that other panelists have discussed. The second is related to the budget problems that states are experiencing. These forces together have changed how states see their role in any future technology deployment initiatives.

Everyone here understands the regulatory and market issues. As of June 30, 1996, regulatory commissions in 44 states had adopted or were evaluating utility deregulation alternatives, according to a study by the General Accounting Office. There are at least 12 deregulation bills in the works in Congress, although it's still unclear whether legislation will advance during this session. Illinois' Office of Coal Marking and Development has produced a white paper on the effect of utility restructuring on our state, with specific attention to impacts on the coal industry. The paper predicts several major changes in utility operations, including consolidation, a switch to performance-based regulations, and the development of regional power pools. It also predicts that with an emphasis on efficiency, existing coal-fired power plants will increase production in the short run due to their lower marginal generation costs. Over the longer term, however, the older, less efficient plants will be retired and replaced with or converted to natural gas. Other states have similar predictions, although there is an emerging body of experts who believe that gas-fired, highly efficient "micropower" plants will supplant utilities as we know them by the end of the next decade. In either scenario, the outlook for new coal use technologies is uncertain.

The impacts of change in environmental regulations on the coal industry are well documented. In 1985, the FOB price of Illinois coal was $30.80/ton; a decade later, the price had fallen 29%, to $21.80/ton. Mine employment dropped 67% over the same period. Electric utility purchases of

Illinois-mined coal fell 25%, from 54.5 million tons to just over 41 million tons. Ohio, Pennsylvania, Indiana, and Kentucky -- the states traditionally most active in coal research and development -- all experienced similar decreases. Meanwhile, exports to the Midwest from the Power River Basin reached an all-time high. Still to come, of course, are the impacts of Phase II of the Clean Air Act. In the environmental arena in particular, uncertainties are driven by forces that are external to state government and it's difficult for states to formulate meaningful technology policy in response.

Then there's the fiscal challenges to states. Over the last decade, states have increasingly had to cope with a structural imbalance between the rate of growth of state revenues and the rate of growth of expenditures. This imbalance has affected every state in some way and it's almost all due to increases in the costs of Medicaid, which pays for health care for the poor and elderly. From 1990 to 1995 these costs -- which are mandatory entitlements -- grew by almost 20% per year, while state revenues increased by about 5% a year.

Today, these Medicaid costs make up 20 to 30% of our state budgets. In Illinois alone, the tab is $6 billion a year. It's impossible to argue that this is not a priority, yet every single other state initiative -- education, child welfare, prisons, mental health, law enforcement, as well as energy and environment and economic development -- has been affected. In the 1990s, states have stopped looking for new ways to spend money, because we are told how we **must** spend it.

Governors and state legislatures have not been inclined to raise revenues to make up the difference. In fact, according to the most recent *Fiscal Survey of the States*, a report produced annually by the National Governor' Association and the National Association of State Budget Officers, 35 states actually decreased taxes in some way last year, continuing a trend that started in the early 1990s.

The regulatory and market uncertainties combined with serious fiscal constraints have led, directly or indirectly, to changes in state programs. In August 1996 *Governing* magazine reported that many states had closed or restructured their energy offices. In fact, Washington, New York, Pennsylvania, Illinois, Mississippi, North Carolina and Tennessee have all recently consolidated their energy programs into larger departments. In the last 6 years, the number of employees in state energy offices has fallen by an average of 14.5%, according to a survey by the National Association of State Energy Officials.

State funding for energy R&D has also declined. In 1995, the General Accounting Office looked at changes in electricity-related R&D for technologies cited by a Secretary of Energy task force as having high and medium long-term potential for meeting national energy goals, including fuel cells, coal gasification and advanced turbines as well as alternative energy technologies. The report noted that "of the 11 large (R&D) programs in the nine states reviewed, 7 have been reduced in the last three years." Overall, the GAO study found a 30% reduction in state funding for advanced power generation R&D, from $83 million to $58 million, over the two year period surveyed.

I should also note here that the federal government and electric utilities also reduced R&D funding over the same period. Overall tight budgets and the increased competition expected from utility deregulation were cited as the principal reasons for declining support.

III. STATE ACTIVITIES.

The good news is, even though programs have been downside and restructured, there is still a significant amount of state activity and interest in the support of coal and clean coal technologies. The state energy officials that I interviewed consistently cited a sharpening of goals in their programs and a feeling of greater accountability in setting economic development priorities.

In those states that have traditionally pursued clean coal technologies and coal development, the approach today appears to have shifted from big incentives for major development projects to more pragmatic, focused actions such as exploration of niche markets, promoting export opportunities, technical assistance and education.

There is one notable exception to this generalization. Mississippi, one of a handful of states projected to need new generating capacity, is undertaking a major lignite development project that will likely use an advanced, clean technology. Last year, the Mississippi state legislature expanded the scope of general obligation bonding authority and earmarked $30 million toward the development of a 400 MW lignite-fired generating plant and associated industrial complex, diverting bonding authority previously earmarked for the Strategic Petroleum Reserve. A coal company, electric utility and the state and local government are partnering in the project, which is still in its developmental stages.

In Kentucky, a state with a long history of support for coal research and technology projects, state officials have made a decision to focus their efforts on education at the elementary school level. Bill Grable, director of the Kentucky Coal Marketing and Export Council, plans to personally visit public schools throughout the state to bring students the message of the importance of coal to the state economy and the opportunities for environmentally sound coal use.

Pennsylvania has restructured its energy office and put it in the state Department of Environmental Protection. The Pennsylvania Energy Development Authority no longer exists as an active R&D organization. The new Department of Environmental Protection has become business-friendly, according to state officials, and has created the Office of Compliance Assistance to work with companies on pollution reduction. This would include assistance in planning for advanced technology retrofit projects.

In Ohio, the state is exploring niche markets for coal, including industrial projects. Ohio appears to be the only state where programs are specifically configured to promote Clean Coal Technology deployment. The Ohio statute allows state funding for up to three replications of a first-of-a-kind technology. Other states might consider such a statute to allow for participation in the deployment phase.

Illinois has a number of major projects ongoing. The state has also undertaken specific activities relevant to the deployment of Clean Coal Technologies, including the development of an interactive, computer-aided design package for State of the Art Power Plants using advanced technologies. Illinois is also supporting a series of workshops to bring together technology manufacturers and electric utility operators to share solutions to changing environmental standards. In addition, Governor Edgar has recently announced a multi-million dollar plan to expand markets for Illinois coal and improve the state's coal transportation, export and delivery systems. Our Lieutenant Governor, Bob Kustra, has formed a Coal Strategy Group to explore ways to improve the economic viability of Illinois coal. The group is made up of leaders of the Illinois Coal Association, the United Mine Workers of America and several state agencies. The Coal Strategy Group has been active in development of legislation to support the state's coal industry.

IV. THE NEED FOR LEADERSHIP

Realistically, individual states will not make much of an impact on Clean Coal Technology deployment in the near term. State energy officials are highly supportive of deployment, and they think that these technologies merit continued federal support and leadership in the deployment phase. Federal tax incentives, expedited permit protocols, targeted export assistance and graduated support for successive replications were some of the ways that states suggested to help promote commercial deployment.

It's interesting to note that one regional organization, the Southern States Energy Board, has established an effort to promote the increased use of U.S. coal and the transfer of Clean Coal Technologies. SSEB's activities include participation in major coal forums to serve as a focus for state interest in Clean Coal Technologies, facilitating discussions of market development and penetration potential for these technologies, and identifying institutional barriers to their use. Other states might want to join forces with SSEB or organize their own regional effort.

State officials also stressed the importance of raising the profile of the program at the national level. The Clean Coal Technology program has not received nearly enough credit for what it has accomplished. I'm not being critical of the federal Clean Coal program leadership, because they've done an admirable job of keeping interested parties informed about its accomplishments. States are concerned, however, about the lack of attention to this program in national policy, and beyond that, the lack of attention to any coherent policies that incorporate realistic energy goals.

Our national political leaders seem to spend a lot of time hyping things like public-private sector cooperative efforts, development of emerging markets for technologies, export opportunities, building national excellence, and promoting environmental quality. These are all attributes of the Clean Coal Technology program. It should be recognized as a model initiative and the embodiment of important national policy goals. We are taking a lot of rhetorical and actual pride in our ability to get things done, but, as far as energy is concerned, there is very little attention given to what it is we should do and why we should do it.

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Closing Plenary Session

Powering the Next Millennium: CCT Answers the Challenge

COMPLETING THE CCT MISSION: THE CHALLENGE OF CHANGE

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I. INTRODUCTION

Thank you for the opportunity to provide some insight on the future of clean coal technology and how the CCT mission might be completed in a restructured electricity industry. A few years back, I spoke at this conference when it was held in Cleveland. At that time I was a regulator and before that a legislator. I hope to draw upon those prior experiences, add a perspective from my current role as an energy industry association executive, and suggest some ways in which we can all work together to meet the challenge of change consistent with the theme of this meeting.

First, I hope you will indulge me the opportunity to tell you a little about the Illinois Energy Association. Our organization is relatively new, having been formed in January 1994. We have eight member companies who are investor-owned energy utilities doing business in the State of Illinois: Central Illinois Light Company, Central Illinois Public Service Company, Commonwealth Edison Company, Illinois Power Company, Interstate Power Company, MidAmerican Energy Company, Mt. Carmel Public Utility Company and Union Electric Company. Our members run the gamut from a heavy concentration of nuclear generating capacity to exclusive use of coal for generation. Each year we use millions of tons of coal, both high-sulfur Illinois Basin and low-sulfur. The member companies of the Illinois Energy Association are not only interested in the future of clean coal technology, we have a huge stake in its viability.

My personal involvement in clean coal technology spans my changes in career. As an Indiana State Senator representing a coal belt district, I was deeply involved in pro-coal legislation and was an author of Indiana's 1989 statute promoting the use of clean coal technology. When I left the legislature and became Chairman of the Indiana Utility Regulatory Commission in May of 1989, one of my first tasks was to interpret and implement that very law which I had just authored. That case resulted in construction of the Pure Air on the Lake project at Northern Indiana Public Service Company's Bailly Generating Station. Later I was involved in approval of construction for PSI Energy's Wabash River Coal Gassification Repowering Project. Since leaving the Indiana Commission in 1993 for my present position, I have been involved in helping my member companies monitor clean coal technology developments. I was born and raised in Sullivan County in Indiana's coal belt, and much of my public and private career has been devoted to promoting coal and clean coal technology.

Permit me also to say a word about coal and the State of Illinois. We are deeply involved in coal development for many reasons, but especially because of the fact that there is more energy in Illinois coal deposits than in the oil reserves of Saudi Arabia and Kuwait combined. From the earliest days of the state, coal has not only fueled the homes of Illinois residents and the state's economy, but it has been woven into its social fabric.

The State of Illinois and the state's coal mining industry have long acknowledged the problems inherent with mining and burning coal. But, more importantly, they are actively and vigorously seeking new technologies to ensure that coal plays an important role in Illinois' future.

Long before clean air and acid rain become important public issues, Illinois was leading the way toward the development of new technologies to burn coal more cleanly, more efficiently and less expensively. Illinois, in fact, is a leader in the development of clean coal technologies.

Coal is mined on an immense scale in our state. Altogether, some 54 million tons a year are recovered from beneath the rock and soil of Illinois. Both surface and underground mining are done on a scale that astonishes those who view it for the first time.

Unlocking the secrets of clean coal technologies is done on the other end of the scale. It begins with the molecular structure of coal. Researchers probe the basic organic nature of this fossil fuel to help other scientists — and later, utility and coal industry engineers — understand how to make coal a cleaner fuel for the 21st century.

The search for answers on how to burn Illinois coal, which is naturally high in sulfur, without releasing unacceptable levels of sulfur dioxide into the air has been going on for decades.

The effort is under way in the laboratories of major Illinois universities, in the demonstration projects managed by the state's utilities and large industries, by researchers working for the state's coal companies and through special programs operated around the state. This massive effort is coordinated by the Illinois Coal Development Board and the Illinois Department of Commerce and Community Affairs, which administers the state's research, development and demonstration programs. In 1984, the Illinois General Assembly established the Coal Technology Development Assistance Fund to speed the transfer of successful laboratory experiments into full-scale demonstration projects. To date, the Board has approved nearly $42 million for laboratory research through the Illinois Clean Coal Institute.

Since 1975, the Illinois General Assembly has authorized $183 million in Coal Development Bond funds for the Illinois Coal Demonstration Program, of which the Board has committed $138 million on 18 clean coal technology projects. The state money has been matched with nearly $662 million in public, private and federal funds for these projects.

Illinois believes that coal is a fuel for the 21st century, both by necessity and by technology. From the standpoint of necessity, coal is our most abundant natural resource, giving America literally hundreds of years of supply.

From the technological perspective, advances in research — fostered by the Illinois Coal Development Board, the Office of Coal Development and Marketing and the Illinois Clean Coal Institute — are proof of the reality that coal's bright past is but a prelude to coal's bright future.

II. CCT AND INDUSTRY RESTRUCTURING

The thrust of my remarks today is this: In order to "complete the clean coal technology mission" it will be necessary to determine CCT's role in the restructured electricity industry and develop a strategy to promote that role. First, we must understand where the industry is headed and how clean coal technology fits into that future. Then, we need to develop a strategy for getting from here to there, from where CCT is today to where it must be in five, ten or twenty years to be a viable option for decision-makers.

Trying to determine the details of where the nation's electricity industry is headed is an especially difficult task at this point in time. In fact, it has developed into a real growth industry if the number of conference and seminar brochures which arrive daily at my office are any indication. But one need look no further than the halls of the state legislatures and the Congress to find guidance. For the first time in nearly a century, the fundamental order of the industry is being changed by those who set it in place originally, our elected representatives. In Illinois, as in California, Rhode Island and any number of Statehouses, the General Assembly is beginning to take up industry restructuring legislation as we speak. The Congress is also poised to take up the subject. The laws which are passed in Washington, Springfield and elsewhere will provide the statutory roadmap which leads eventually to a fully competitive electricity industry where every customer has the power to choose his or her or its electricity supplier. While important, the timing of this move is not nearly as critical as the fact that it absolutely, positively will occur.

One of the most critical parts of my job is to demonstrate to people at my member companies who have been in the industry for many, many years that this change is coming, it is positive and that it will fundamentally alter the way their companies operate. The phrase I often use in a shorthand way to try to describe this sea change is that we will soon become an industry where the bottom line is actually the bottom line. That concept has lots of implications for every stakeholder in the industry but it has particular implications for those of us interested in promoting clean coal technology. When I say that we need to determine how clean coal technology fits into the future of a restructured industry I mean above all how does it fit in terms of "cost." Because that little four-letter word "cost" will soon play the same role in our industry as it does in every other competitive industry, a role which it has really never before played for us. We can talk all day long about the abundance of coal and how using coal to fuel the next generation of power plants would be in the common good, but believe me all the strong policy arguments won't amount to much if clean coal technology is not cost-competitive with other sources. When we say that CCT will be a superior technology at the time these decisions are made, we must include superiority from a cost-effectiveness standpoint in that definition.

Clearly, clean coal technology does not meet that standard today. How, then do we get from here to there? What is our strategy as promoters of clean coal technology as the power source of choice for the next generation? Who does our strategy target in terms of decision-makers? Perhaps, this final question is the place to begin because the answer on a long-term basis will be quite different than it has ever been for the industry. For the first time in its history, the electricity industry itself will be required to assume the risk and make such decisions. And all without any of the old, reliable safety net found in the regulatory model. In the coming market economy, electricity industry decision-makers will find that the market itself will set the parameters of their decisions and that those parameters, as in all competitive industries, will be largely based on costs. It is nearly impossible to underestimate the change in industry corporate culture needed to digest this shift in priorities.

Thus, the crux of any strategy for promoting clean coal technology as a viable choice for industry decision-makers must lie in making CCT cost-competitive with other potential power sources. Reaching such a goal will not be easy but it is not impossible. It can be accomplished by forging a collaborative effort on the part of the stakeholders who would benefit from use of clean coal technology: electricity consumers, federal and state governments, electricity suppliers of all stripes, CCT developers and vendors, and those directly involved in the production and sale of coal itself. And in this latter group I would certainly include those whose jobs either directly or indirectly depend on coal. One of the increasingly vocal stakeholder groups in the electricity industry restructuring debate is that representing the utility workers. Coal miner representatives must be a vital part of any clean coal technology collaborative effort.

Together, these diverse groups have a great deal of political clout if they will only work in a coordinated fashion to use it for this purpose. Various types of incentives which would help to spur research and development of clean coal technology can be achieved at both federal and state levels if we all work together toward that goal. To be cost-competitive in the long run when decisions will be made regarding new sources of generation, clean coal technology must have already progressed through the testing stage and the application stage of development so that it is approaching maturity status as a market. Only then will it pass the kinds of cost-effectiveness tests which will be used by the market to make final choices. Clean coal technology must be ready when the time is right; it cannot afford to be late, because as my industry is about to learn, in a market economy as in politics, timing is everything.

Policy decisions which benefit the development of clean coal technology will not be made in a vacuum and they will not be made out of altruism. They will be made by down-to-earth policymakers engaged in a political process which is the lifeblood of our society. If we who favor deployment of clean coal technology sit back and wait for policymakers to discover the wonder of our product by their own devices, it will be a very, very long wait. We must mobilize our considerable resources and actively promote our agenda if we have any hope of success for CCT.

III. CONCLUSION

Coal makes sense for the United States. It makes sense for several important reasons not the least of which is its abundance here — we are the Persian Gulf of coal. It also makes sense in terms of its economic impact on large areas of our nation. And if coal makes sense, especially economically, then clean coal technology makes even more sense because of its potential to capitalize on this abundant resource in an environmentally friendly manner. But I am here to testify that after nearly thirty years of involvement in the political world at all levels from Washington, D.C. to Washington, Indiana, I have learned the hard way that "common sense" does not always, or even often, carry the day in the policymaking process. I believe that the future of clean coal technology hinges on our ability in the next few months and years to mobilize all those who favor that technology to move forward in a cohesive and coordinated effort to affect the policymaking and political process and thereby promote and accelerate CCT development. If we can do so, then we are well on the way to completing the clean coal technology mission and meeting the challenge of change.

INTERNATIONAL MARKETS: SEIZING THE OPPORTUNITY

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Chairman, before I get started on my presentation I would like to congratulate the US Department of Energy for having the considerable foresight in establishing the clean coal demonstration programme when it did.

While many speakers over the past few days have highlighted the challenges of bringing forward the take-up of clean coal technologies, without the US Department of Energy Clean Coal Demonstration Programme the challenge would be near impossible to reach and the long term consequences on the environment substantial. In addition the guidance and inspiration it has given to more modest clean coal programmes overseas cannot be underestimated. I know from personal experience that the UK Department of Trade and Industry and UK industry has found our contacts with the programme invaluable.

To start off my analysis of the presentations, I would like to highlight some of the key facts and figures mentioned in a number of papers this week, together with a summary of the perceived market barriers.

Firstly, a number of presenters have referred to the expected continued rise in coal demand for power generation and other uses for the foreseeable future - certainly well into the 21 century. Forecasts by the International Energy Agency highlighted in John Ferriter's presentation on Wednesday indicate a substantial increase in world coal demand to 2010. Rising from around 3.5 billion tones at present to over 5.3 billion tones by 2010. As we heard from David Gallasby yesterday, most of this increase is in Asia, where coal demand in China alone is set to increase from 1 billion tonnes to over 2 billion tonnes and in India from 250 million tonnes to 500 million tones by 2010. These figures demonstrate the substantial economic growth expected in Asia over the next few years and perhaps indicates where much of our effort to promote clean coal technology should really be focused.

There is a clear consensus on what the barriers to bringing forward any significant amount of advanced clean coal technology at the present time. These are:

- uncertainty associated with a deregulated electricity industry and a highly competitive market place

- increased availability and competition from natural gas
- in many countries the electricity utilities have only just been privatised and are particularly risk adverse
- lack of commercially demonstrated performance and perceived cost competitiveness, particularly for IGCC and PFBC
- the public and political perception about coal
- the concern about even tighter environmental constraints
- the financial constraints and technology risk premiums

A number of presenters have touched on the issue of coal being perceived to be a "problem fuel" associated with global warming and local pollution acid rain and particulates. This is despite the wealth of publications and information about the benefits of clean coal technologies produced over the past few years by various public and private agencies in the US and overseas.

The increase in coal use should not be seen only as an environmental problem to solve, but a major market opportunity for exporters of technology, components and know-how - in both the United States and internationally. A recent study by the IEA Working Party on Fossil Fuels has shown that the potential market for clean coal technologies exceeds $800 billion over the next few years to 2010. 90% of which is related to power generation. This $800 billion forecast is close to the trillion dollar figure quoted by Mrs Patricia Godley on Wednesday.

Seizing this huge market opportunity is the real challenge. If we are successful (I say we for this market is large enough for everyone to have a share),it would make a substantial difference to the environment of the certain increase in coal use over the next few decades.

It is also important here to understand that clean coal technologies can also mean "state of the art" conventional plant. Such plants offer substantial improvements in both efficiency and environmental performance when compared to many existing plants in both the United States and the rest of the world.

We should not necessarily be too pessimistic about not being able to speed up the deployment of advanced clean coal technologies as fast as some speakers this week would like. In my view the worst possible outcome for advanced clean coal technologies such as IGCC is if a technology is sold to a utility or IPP on the basis of certain performance criteria and it fails to deliver. While this is obviously a major problem both financially and technically for the technology supplier, it is also immensely damaging to other clean coal technologies approaching commercialisation. As Larry Papay of Bectel mentioned during his luncheon address on Wednesday, some technologies will inevitably fall by the wayside; what we must not do is make some of them fall off the road because we pushed them to quickly.

The Coal Industry Advisory Board study which John Wootten outlined on Thursday provides an invaluable status report on where we are with deploying clean coal technologies. In particular, it set out the policies and measures that might be deployed to overcome some of the barriers.

The presentations from John Wootten and David Gallasby, did indicate to me a considerable interest by utilities to take up more advanced clean coal technologies if manufacturers could deliver on price, availability, and reliability etc. As Ian Torrens presentation highlighted, the fact we have 350 supercritical units operating or planned throughout the world now, and that some utilities are prepared to take the risk and become involved in first of a kind plant both here in the United States and in Europe, Japan etc., albeit with some public funding in one form or the other, is very encouraging. Clearly it would be immensely beneficial both to the environment and to industry if the more advanced technologies could be taken up commercially at a faster pace both at home and overseas.

Having listened to, and read the papers presented on Thursday, I believe there are a number of positive things we can do to smooth the path of encouraging the deployment of clean coal technologies over the next few years. It will require careful planning, and a willingness of all those with an interest in seeing clean coal technologies adopted as the energy technologies of choice in the 21st century, to work together much more closely than at present. Many of the activities could turn out to involve little if any additional work and may even lead overall to less effort if there is a commitment to work together.

Firstly, we need to be much more focused and concentrate effort in a few key growth areas such as China and India. The UK for example is focusing its export activities on clean coal technology on India and just one or two provinces in China.

Secondly, there is growing evidence that a number of countries have been confused by the conflicting information and advice they have received about clean coal technologies. This confusion and lack of knowledge also persists in those countries leading technology development. I have met for example a number of senior energy company executives in the United States who were unaware of the breadth of the US Clean Coal Demonstration Programme. Mrs Patricia Godley has quite rightly emphasised the importance of educating key players in the United States together with the general public.

There is always a danger we produce information only for ourselves, It is vital we remember key decision makers at home and abroad and the public have their own, often very specific information requirements. The importance of preparing appropriate information and disseminating it effectively was emphasised by John Wootten in setting out the CIAB's recommendations on policies and measures to overcome barriers.

These CIAB recommendations' emphases the importance of the private sector and government working together to disseminate technical and economic information about clean coal technologies including supercritical and ultra supercritical technology.

I would strongly endorse this but recommend this is done under the auspices of the International Energy Agency as part of the World Bank clean coal initiative. I would also recommend we make particular use of the IEA Clean coal Centre (formerly known as IEA Coal Research) for this work.

Thirdly, there is a need for a consensus on what are the main barriers to technology deployment within individual countries and prepare a strategy to overcome them collectively. Again, this could form part of an international collaborative activity under the auspices of the IEA.. It cannot be effective and efficient to try and open up new markets to deployment and reduce tariff charges etc., in a random way as currently undertaken.

Three final points. There are clearly no easy solutions to overcome some of the perceived impacts of deregulation, privatisation and competition to the take up of clean coal technologies. As David Gallasby reminded us on Thursday, what is most important is market pull, assisted to some extent by improved information dissemination on benefits of clean coal technologies.

The US Department of Energy may wish to consider for its next conference to have a specific session devoted to reporting progress on overseas demonstration projects. This would allow within the scope of one conference for us to see the "state of the art of world development of clean coal technologies., and further demonstrate the commitment of the United States, Europe and Japan etc., to work together to enhance information dissemination.

Finally, accepting market pull is essential to the future deployment of clean coal technologies, the US Department of Energy should consider inviting representatives from the key market areas - decision makers, technical and financial advisers etc. to tell us what information they require with respect to clean coal technologies. Such action should greatly assist the US Department of Energy in focusing its future activities more effectively.

ROLE OF CCTs IN THE EVOLVING DOMESTIC ELECTRICITY MARKET

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I. KEY POINTS AND ISSUES

(1) Panel considered the effects of deregulation of electricity markets on CCTs, with CCTs defined as greenfield and repowering technologies, in the medium to long term

(2) Full fledged consumer choice likely won't occur for at least five years, perhaps more, but there are at least two important impacts today for CCTs:

(A) Uncertainty: don't know what costs can be recovered in long run, so even more incentive (e.g., in addition to present overcapacity) to minimize new construction

(B) Huge incentive to cut costs everywhere: *any missed opportunity to reduce costs in new, deregulated environment automatically translates to lost profit (or losses instead of profit)*. Main impact of deregulation on CCTs is probably pressure to reduce construction costs

(3) Impediments to CCTs being cheapest option:

(A) Natural gas prices are low and projected to increase only slowly (EIA projects about 1% annual increase in excess of inflation through 2015);

(B) Capital costs for CCTs (and coal generally) are too high; and

(C) CCTs are still perceived as riskier than more commercial technologies, and thus may bear a risk premium

(4) Uncertainties that could affect demand for CCTs

(A) Natural gas prices can be quite variable, and uncertainty; may be mostly on the high side: despite EIA projections (and those of others) that gas wellhead prices will still be about \$2.50/MMbtu in 2015, Frank Burke graphics in Panel 4 showed late December price spike at Henry Hub in Louisiana, and futures prices for natural gas in similar time frames, at about \$4.75

(B) Capital costs may well be lower in deregulated environment: according to Bob Edmonds of Duke Power, Duke recently built a new coal unit for just over $1,000/KW in South Carolina (the Cope unit), several hundred $/KW less than present expectations: Edmonds cited cost-cutting lessons learned in Duke's recent experiences abroad

(C) Higher demand growth could spur need for new units, everything else equal: Mary Hutzler of EIA stated that an increase in demand growth from 1.5% to 2.0% from 1995 to 2015 would trigger a need for about 100 GW of new units, about half of them coal

(D) Lower prices due to deregulation could spur new electricity demand: Bob Edmonds stated that Duke projects internally that prices could drop between 5% to 30%, depending on treatment of stranded costs

II. SUGGESTED SOLUTIONS TO BRINGING PRECOMMERCIAL CCTs TO MARKETPLACE

A wide range of potential solutions was offered, some involving some government role or incentive, some involving only industry

(1) Solutions involving Government roles

(A) States currently undergoing, or looking at, the transition to deregulation are examining new ways to continue supporting "favored" technologies. These could include:

(I) a nonbypassable "wires" charge (such as implemented by California) to collect $ to be used to fund renewables, conservation, and R&D

(ii) a "portfolio standard" which would a require that sellers obtain a certain percentage of their power from favored technologies

(iii) regulatory requirements favorable to certain technologies, such as a requirement that nuclear units must be allowed to run anytime they are available

(B) Financial incentives, such as proposed by Dwain Spencer

(C) Incentives for overseas deployments of CCTs, in order to demonstrate them adequately by the time they are needed domestically

(D) Work with state regulators to develop some types of incentives

(E) Recognize in some way the fuel diversity benefits of coal

For any of these incentives, coal industry involvement above and beyond that of today was urged, because other entities might have other priorities than developing CCTs.

(2) Industry solutions

(A) Co-production (including tri-generation of electricity, heat, and chemicals) will bring price of electricity down

(B) Co-firing with "distressed fuels"

(C) Develop standardized plant, modular production, use cookie cutter approach to lower capital costs

(D) Coal sector should work together to produce an integrated project, just as the gas industry abroad has developed new gas fields in conjunction with identified power plant projects (parallel to mine-mouth units domestically?) To gain synergies

III. OUTLOOK FOR POSSIBLE ACTIONS

(1) Given the difficulty of obtaining financing from federal or state sources (due in part from rising budgets for social costs such as health care, according to Terri Moreland), it may be up to the private sector, possibly in conjunction with non-financial incentives such as portfolio standards and line charges, to bring CCTs to commercial fruition

(2) If there is to be government involvement, need to get private industry and different levels of government together to decide on a course of action. Right now, there appear to be many ideas, but little leadership.

(3) If there is to be government involvement, the lone remaining major opportunity is likely to be the legislation that will likely go forward in states the U.S. Congress to put electricity deregulation into practice

SUMMARY OF PANEL SESSION 3
ENVIRONMENTAL ISSUES AFFECTING CCT DEPLOYMENT

BY KARL HAUSKER

The panelists discussed a variety of environmental issues that affect CCT deployment, and more broadly speaking, power development in general. The issues were both international and domestic in nature. I summarize below the issues discussed and possible solutions.

ISSUES

International Issues

James Newman of Golder Associates described the environmental guidelines and requirements facing developers of power plants abroad. The guidelines and requirements can come from the financing entity, the host country, or the internal policy of an independent power producer (IPP). The financing entity may be a multi-national, regional, or national development bank and/or a private bank, finance company, or trading company. The guidelines or requirements may be procedural in nature (concerning environmental impact assessments, management, monitoring, public participation in planning) or operational in nature (limits on emissions or impacts on natural resources). Adherence to ISO 14000 may become an important procedural requirement.

These guidelines and requirements may pose a confusing web for a developer. However, many finance entities defer to World Bank guidelines. This can simplify the situation, but those guidelines are, themselves, in a long process of revision, creating considerable uncertainty.

Domestic Issues

Considerable uncertainty exists with respect to domestic environmental requirements as well. Brian McLean of the U.S. Environmental Protection Agency discussed current and proposed EPA regulations that affect power plants. The 1990 Clean Air Act Amendments are still being implemented in stages as directed by the legislation. For example, Phase I of the NOx and SO2 programs are underway, with Phase II coming in 2000. Other programs in the pipeline include the utility air toxics MACT and regional ozone programs. In addition, in November 1996, EPA made proposed revisions to the National Ambient Air Quality Standards for ozone and particulate matter. These standards could result in significant additional requirements for emission reductions from power plants.

Climate Change

The issue of climate change spans the domestic and international agendas. Linda Silverman of the Department of Energy discussed the latest developments in the Framework Convention on Climate Change (FCCC). The signatories to the FCCC are in the process of negotiating a binding agreement on quantified emissions limitations and reductions for the post-

2000 period. This would be a major step beyond the current non-binding agreement on limiting greenhouse emissions in the year 2000 to 1990 levels (which most countries will not achieve). The U.S. position is to support an agreement that contains verifiable, medium-term emission targets that are realistic, achievable, and allow maximum flexibility. If an agreement goes into force, it would undoubtedly require limitations or reductions in fossil fuel combustion. Mark Mills of Mills, McCarthy, & Associates presented an analysis of electro-technologies that I discuss below under "SOLUTIONS".

Uncertainties Loom Large

There is little doubt that international and domestic policies will demand improved environmental performance by the electric power sector in the future. The presentations of these speakers and two Congressional staff also indicated the large uncertainties that exist over just what these future environmental requirements will be for CCT and other fossil fuel generation. Uncertainties flow from the internal decision processes of institutions such as the World Bank and EPA, the outcome of international negotiations on climate, and the impact of Congress on Administration policy proposals.

SOLUTIONS

My summary will highlight ideas from the panelists that could be characterized as solutions to the demand for improved environmental performance and the surrounding uncertainties. I will also offer some personal comments and observations

International Issues

Mr. Newman urged project developers to work hard to identity all the entities that might affect the environmental aspects of a power project, and determine their guidelines or requirements. Stay in close and frequent communication with these entities. Define the project early with close attention to site selection, baseline data and monitoring requirements, and public participation. I would add that, in addition, his presentation suggests that developers should press the World Bank to finalize its guidelines in order to eliminate that source of uncertainty.

Domestic Issues

Mr. McLean described the "Clean Power Initiative" under development at EPA: an effort to rationalize the current complex web of requirements and timelines, and to develop an integrated strategy for achieving the goals of the Clean Air Act with respect to the power industry. Such a strategy would employ more cap-and-trade approaches, more flexibility, and more banking. It could reduce the cost of compliance and provide more continuity to help business planning. I think there is great potential in such a strategy: it would build on the success of the SO2 trading program and is very much in the spirit of other regulatory reinvention activities underway at EPA. I would add that the more sources that EPA can include in cap and trade programs (not just utilities and IPPs), the greater the cost savings. EPA may also want to consider regional or airshed-based boundaries for trading systems if that is appropriate to the nature of the pollution problem. Finally, using an electric utility analogy, the Agency should explore "peak-shaving" approaches to some problems such as ozone. Temporary measures to address temporary peaks in pollution are under-utilized in the current system, and, in combination with permanent measures, can be cost-effective.

Climate Change

Ms. Silverman described some of the Administration's positions aimed at addressing the climate change problem in a cost-effective way. Policies should address comprehensively all greenhouse gases. Emission targets should be multi-year, rather than single-year, thus allowing nations more flexibility. Any agreement should involve a time horizon long enough to allow normal, rather than premature, turnover of capitol stock. Any agreement should allow emission trading and joint implementation. She also stressed that the U.S. opposes harmonized policies and measures because these could lead nation's away from least-cost solutions.

Mr. Mills presented analysis indicating that a multitude of technologies are emerging that substitute electricity for direct fossil fuel combustion (e.g., microwave drying for heat drying), or for another factor of production (e.g., ultrasound cleaning or chemical cleaning). In many cases, the net impact of this substitution is to decrease CO2 emissions, even if the electricity is generated by coal. I believe this phenomenon reinforces an important lesson for any effort to limit greenhouse gases: least-cost policies must recognize the complexity of the economy, and the many trade-offs that can be made. For example, a cap on electric utility emissions alone would not be as cost-effective as a cap on all emissions. The former might prevent cost-effective net reduction in emissions resulting from a increase in utility emissions coupled with a large decrease in industrial emissions made possible through electro-technologies. Similarly, a cost-effective climate policy might result in an increase in kWh production coupled with decreases in direct fossil fuel use by industry.

The Role of Education

Maura Reidy and Barbara Wainman, staff to members of the House Interior Appropriations Committee, stated that Congress is paying a lot of attention to the issues raised here. They also stressed that Congressional members need plenty of education, especially given recent turnover and the influx of relatively young members. This is consistent with the comments from many attending the conference on the importance of education in general.

CCT DEPLOYMENT: FROM TODAY INTO THE NEXT MILLENNIUM

ISSUE 4 RAPPORTEUR REPORT

ALL SECTORS REPRESENTED: Utility, Industrial, Fuel Supplier, Technology Supplier, State Government.

ALL EXPRESSED CCT FACES MANY UNCERTAINTIES: Barriers, Hurdles, Problems

1. Electric Deregulation -
   - Postpone Capacity Additions (49.6%CF)
   - Soft Market (load growth in US lower)
   - Need for Smaller Generation
2. Capital Expense-
   - Higher
   - Seen as Demonstration vs. Standardization
3. Competition-
   - Gas Price Low
   - Natural Gas Generation Technology Advancing (Eff. 50-60%)
   - Known Natural Gas Supplies Increasing (30% in last Decade)
   - Global Competition for Industry
4. Environmental-
   - Can go to far (CCT not enough)

	Can Discourage Retrofitting (Updating may Trigger NSPS)
	Uncertainty of Regs. Even 2 & 3 Years From Now (NOx 60% today 80% tomorrow)
5. Government Dollars-	Fewer Federal & State (30% Reduction of state funds in 2 years)
6. CCT Energy Awareness-	Stigma of Coal in General

Public attitudes toward coal remind me of a resent political survey that ask Americans on the Street, "What is the bigger threat to our Democracy - Ignorance or Apathy?" The overwhelming response was, "I don't know and I don't care!"

First, for CCT to be excepted (like natural gas) it must be KNOWN!

Second, We must not be APATHETIC about the promotion of our product! The positive societal changes CCT can bring to the world are dramatic.

FOR EACH PROBLEM THERE IS A SOLUTION!

1. Electric Deregulation-	Legislation may Include Environmental Requirements that promote Retrofit Tech.
	Legislation may carry provision to encourage use of domestic resources and reliability provisions
2. Capital Expense-	CCT no longer Demonstration (TEXACO) Commercialization/Standardization Facilities
	Financial Commitment is there!

(IGCC Texaco, CFBC Phillips Coal Miss.)
JOINT VENTURE PARTNERS
RISK MANAGEMENT

3. Competition-	Increased generation efficiencies
	Standardizing the fuel - coal blending
	Natural gas prices are unstable
	O & M expense cut with "smart" operating systems
	Duel-Fuel generating capacity
	Economies of Scale (multiple products & multiple feedstocks)
	Integration with other processes.
4. Environmental-	Retrofit may grow if standards not too sever
	Foreign Opportunities
5. Government Dollars-	Expedited Permitting
	Tax Incentives Local
	Targeted Export Assistance
	State-Federal Coordination
6. CCT Energy Awareness-	SSEB (regional groups)
	1998 25th Anniversary of Oil Embargo

We can as Robert Bessette quoted from Jesse Jackson "like a honey bee have the sense to repollinate the flower". With a 7.5 Billion dollar investment I don't believe we will let this flower die!

ACTIONS

1. Develop comprehensive document listing State & Local incentives. (Taxes, Land, Permitting, etc.)

2. International conference on IGCC (explore integration with other processes, products, and feedstocks)

3. Fund groups like SSEB to promote CCT awareness

4. Start a program to tour key federal and state regulators through CCT sites

5. Lobby Congress for increased domestic resource use and dual-fuel standard for electric system reliability.

I will leave you with one final quote. It has to do with Capital. We have discussed capital expense , capital cost, capital outlays.

THOMAS EDISON SAYS :

> "TIME IS REALLY THE ONLY CAPITAL THAT ANY HUMAN BEING HAS AND THE ONLY THING HE CAN'T AFFORD TO LOSE."

I believe our time spent at this conference was not capital lost but capital well invested. We must go foreword now and change the stumbling blocks into stepping stones.

The Honorable Ralph Regula
Chairman
Subcommittee on Appropriations
U.S. House of Representatives
Washington, DC

Thank you.

I like to be out with the audience and I want to interact with you because we are teammates. You're not going to get another brilliant technology speech. But I think you've set the stage for what we need to do, and that is education. You're going to forget 99% of what I say, but I have a couple of things that I hope you remember.

First of all, I want to say you're my heros, because I think Clean Coal Technology is the future. We are sitting in this country, and many other countries, on tens of decades of supply. We fought a war over oil. You can talk about Desert Storm anyway you want to, but we were there because of oil and if there were no oil, we would not have been there, but neither would Saddam Hussein. So that's what it's about and I'm glad we have people here from other countries.

I'm on the North Atlantic Assembly as one of the delegates and now, in that body, we're talking about environmental issues. We used to talk about how we could kill each other; today we're talking about how we can create economic growth and jobs around the world. At our last meeting, I looked up at the dias where they have the flags of the countries. There normally would be 16 flags (16 NATO countries). This year there were 33 flags because 17 other countries were participating in these NATO discussions and talking about environmental issues and jobs. That's where it is in the future, and that's why clean coal technology is vital not only in the United States, but around the world. And I'm glad that we have people representing these other countries.

What I hope you remember is that each of you needs to be a lobbyist and each of you need to educate members' of congress or others. I met with a delegation from the Ukraine who was visiting probably the most modern steel mill in the world, the Timkin Company that's in my district. They were Ukraine steel plant managers who were in the United States because they were getting pressure from back home to clean up the steel industry. They were here in the United States visiting steel companies to find out how.

When I visited with them, I said that's fine but you also need to interact with your legislatures; after all they're part of the team. That's so important to all of you--to get on a one-to-one basis with members of congress, governors, and state legislators because we have critical issues coming up. It does make a difference and what you need to talk about is how it affects jobs.

Bill Clinton got reelected President because the economy is good, because of the pocketbook issue--that's what people understand. The best job of lobbying I've ever seen was done by the Chrysler Corporation. If you remember back when they were almost bankrupt, and we had to bail them out, we had to co-sign their note in effect, we the United States government. They came into my office and had documented, down to the last screw and bolt and nut, what was made in the 16th District of Ohio, because we have no auto industry. They had documented how many people were working in Chrysler agencies fixing cars and it turned out that the 16th District had 50 million dollars worth of activity, all affecting jobs. And believe it or not, they as you well know, got the bail out. I didn't vote for it because I didn't happen to think that it was an appropriate way for government to be involved. But never the less, it saved Chrysler. Today I read in *Forbes* magazine that they were nominated as the number one company of the year by the 400 CEOs that were polled by *Forbes*.

So, it illustrates that you need to talk about jobs, and the two big issues that will be of interest to all of you this year, next year, and probably a couple of years down the road, is the issue of the deregulation of electricity. It's coming. We deregulated trucking, shipping, telecommunications, and electricity is next in line. I tell my audiences back home, now at 5:30 when you sit down to dinner the telephone rings and somebody wants to sell you long distance service--MCI, Sprint, you name it. You get ready, in a couple of years they'll want to sell you electricity. It may be Pacific Gas, Tampa Electric, I hope I get a call from Bonneville because they've got a great rate because the government's taking care of that one. But I don't think I'll get a call from REA, rural electrification. I'll get a call from them, not to sell me electricity, but to tell me that deregulation is not a great idea.

So all I'm saying is, get in touch and don't just say I'm against it or for it. Tell people who represent you in the state legislature, in the Congress and the governors how this will affect jobs, how it will affect economic growth, how it will affect the competitiveness. Our governor in Ohio likes to say "the rust is off the belt" because Ohio was for many years called the "rust belt." It's not the "rust belt" anymore. People understand that this deregulation issue is very complex to say the least. You've got the problem of the stranded cost, you've got the problem of the REAs, you've got the problem of the Bonneville, how do they fit in TVA? I see enormous problems, but somehow we're going to work it out. And you, therefore, ought to be part of the process, and I hope if you forget everything I say that in the few minutes that I have, you'll remember that and take some responsibility for it.

And, of course, the second issue this time is going to be the clean air question. EPA has proposed changes to the clean air regulations. One of the things that we did in this session in the Small Business Recovery Act is put in a provision that a proposal and change of regulations require an economic impact statement. Meaning that when EPA proposes these, they've also got to say how it is going to impact on the economy; what it's going to cost in jobs; what it's going to add to the cost of electricity and of gasoline; and all kinds of other things, because regulations do have that kind of impact. What's it going to do to our competitive position in the world today, which of course relates backs to jobs. It relates back to taxes for school systems, United Way contributions and on and on and on. It affects the quality of life all across the board, and, therefore, it's important that you have input to us.

You know the 435 members of the House, 100 members of the Senate, legislatures and the governors, we've got it coming at us from all directions. I vote with a card, it's the world's greatest credit card because I can vote with this card and my grandchildren are going to get the bill. You put this voting card in a slot--I used it six or seven hundred times last year--and there are only two buttons. One that says present, if you want to cop out, otherwise it's yes or no. And when I vote, there are wide reaching ramifications.

The point is that I have to use that on a myriad of subjects. Therefore, it's important that I be educated, and the way that happens is that people that I know in my district, that are involved in the power industry or whatever, talk with me about what kind of impact deregulation will have; and what kinds of impacts Clean Air Act Amendments will have. And we're going to get the economic statement. That's a big improvement to the regulatory process. But also we're going to add 60 days in which we have to decide whether or not to try to modify these proposals or block them. It's a very important decision and we need as much information as possible, particularly because those who are on the other side for whatever reason are going to be very aggressive, very assertive in their position and, therefore, it's important that all of you be involved in that process. I think those will be the two big items that will affect your industry in 1997.

With respect to the deregulation issue, I think it will go on into 1998. There will be others that affect you. I thought one of the most significant pieces of testimony I heard last year was Alan Greenspan. Alan Greenspan, Chairman of the Federal Reserve, obviously sets monetary policy for the United States. By the way, he's going to get married. If you've read the papers, you can tell Alan is not one to act quickly. He's been going with Andrea Mitchell for 12 years, but he's finally taking the plunge. Maybe that will moderate interest rates, I don't know.

Alan Greenspan said, and I quote him almost verbatim, to the budget committee members "if you balance the budget in the next seven years," I think this was in 1995, "if you will do that, your children, your grandchildren will have a better standard of living than you do." Now that's an enormous promise and a very important one. Why did he say that? Because interest rates will come down and you and your industries can expand. My consultant companies, i.e., Republic Steel, Hoover, Rubbermaid and Smuckers can expand and produce more jobs, we're back to J-O-B-S, and be more competitive in the world marketplace. Because interest is a very significant part of the process of doing business. And so our mission on the legislative side is to help make that happen. Therefore, I think the number one issue in 1997 will be the budget.

I was in the President's office about a month ago--he signed a bill that I was involved in with a number of other members. After he signed the bill the press was out, the TV cameras and the first question from the presses was "Mr. Clinton, what is your number one issue for 1997?" And he immediately responded "balancing the budget." That's good news, now how we do it becomes a different matter, and how the priorities end up being allocated, but I think just agreeing to balance the budget is very important. It's important not only in the United States but around the world.

I noticed that some of the countries like Sweden and Norway, which traditionally have socialistic governments are beginning to discover that the cost of all these programs is becoming an excessive burden and makes them less competitive in the marketplace. So, the number one issue next year is going to be the budget issue. Another issue for 1997 will be taxes. Bill Archer is Chairman of the Ways and Means Committee. He went down and had a one-on-one with the President--no staff present, just the two of them talking about tax reform--and he came back somewhat optimistic. The President, in the campaign, promised some changes like making your home sale tax free and allowing you to deduct the cost of sending your children to college. But in order to get those, which he obviously will propose, we the Republicans will probably say how about some capital gains relief. How much, I don't know? How about some individual relief. So all I'm saying is this whole tax issue, I think, will be discussed at great length in the 1997 session.

We, of course, have the "flat tax" proposal that Steve Forbes put out there. It has its fans, including Dick Army, the number two Republicans in the House and then Bill Archer, Chairman of the Tax Writing Committee who would like to go to a national sales tax or something like a "value added tax." So there's going to be a lot discussion, but again it will affect your businesses considerably. Therefore, it's important again that you get involved. I'm not going to ask a show of hands, but if any of you do not personally have a contact with your congressman, senator and your state legislature, you're missing the boat. I don't mean sending a check for their campaign, I mean getting to know them. Call them up, go to a meeting if necessary and buttonhole them. They buttonhole me all over the place.

Best lobbying job I ever had was when I was in the State Senate--we were going to change the driving age. The AAA was for it, the state patrol was for it, the insurance industry was for it. Ohio's age was 16, and we were going to raise it to 18. Well my two boys who were about 15 and 13 said Dad we want to have a little meeting with you. They said Dad how are you going to vote on the driving change, the age? Well I said, everybody is for it. They said if you vote for it, you can mow the lawn yourself. That got my attention.

All I'm saying is that you have got to get to know and contact people. You bring to us this process called education because again we've got so many different things to deal with everyday and, therefore, it becomes important that we have this base of knowledge when we go in and put this voting card in the slot. And, of course, in the committee hearings it's not just the card in the slot. It's the committee hearings I vote in, but there's not normally public awareness on committee votes, yet those are the ones that have a great impact on how you put a bill together. The Commerce Committee has to deal with the deregulation issues, and, once a bill gets to the floor, its tough to change. You can offer amendments, but the real work is done in the committees, that's where the house is built. You might put a little extra around the house but you do most of the building in the committees.

So beyond talking to members, you should talk to members that are on the Commerce Committee in the case of deregulation. You should talk to members on the Ways and Means Committee in the case of taxes.

Now another area I think would be important in 1997 is "education." We've passed the Welfare Reform Bill. We're saying that in two years people are off of welfare. Well we're a compassionate society and we're not going to shove people out on the street with their three or four kids--that single mother--it's just not going to happen. That means, of course, that we've got a two-year window to ensure that individuals get some education, some skills, and we need to work on that. I think that's a big issue and it's a big social problem that we all need to be involved with. Your companies ought to be looking at ways in which you may be able to offer some employment opportunities to these people, because welfare is changing and that means that these people have to have jobs. I think that in terms of entitlements, that'll be another tough issue. I don't have time to get into that, but I would say overall what we're trying to do, believe it or not, in the Congress is manage government better.

I'm a fan of Edward Demning. Japan had to teach us that Edward Demning had the right idea, he was not a prophet in his own country. He went to Japan and they learned well from him and then he finally came back here. We've got to do that in government. We can't balance the budget in the way that Alan Greenspan is talking about unless we manage better; and we have taken some steps. I'm on the Appropriations Committee and we cut $53 billion dollars out of the budget over the last two years. That's $53 billion dollars that we're not going to send to my grandchildren in the way of a bill; not only the $53 billion dollars but that compounded interest that goes on and on and on.

The interest on just the National debt now is one of the biggest items in the budget and it's growing, so we need to address it, and it can be done. There are some very popular things like parks, forests, recreation, and the Smithsonian--yet we've cut employment levels--just in our Subcommittee 15%, and we've cut the budget 9½%. It can be done, just as you are. Because of competition, we're going to have to continue to look at that. That will be one of the phases of deregulation; you'll no longer have a Public Utility Commission standing guard and telling you here's what your guaranteed profit will be for the next period of time. You're going to be looking at ways on how to be more competitive, and I hope that the use of coal will be one of them. I think it will be and that's why these clean coal technologies becomes extremely important.

Housekeeping issues: At least for the time being, the focus will move to the Senate in the Congress. In the last two years, the House has tended to be the place where the initiatives came from, but I see that changing, partly because the Speaker has some difficulties. The Senate picked up a seat and Trent Lott is a new person. Trent is going to be a very effective leader. He will be able to communicate extremely well with the President. I know Trent, he and I came to Congress together, and he's a very able-bodied individual. The President is going to be interested in his place in history, he certainly is not going to run for any more offices, I don't think. The Republicans want to demonstrate that we know how to govern; we discovered that when we shut government down, it didn't do any good for us politically, so we're not going to do that again. But, we are going to try to work with the President to manage this government better to accomplish his goal, which is a balanced budget, and there will be some give and take. We demonstrated in the last six months of 1996 that it can happen. We worked out a number of very significant issues, a budget got signed, we had Welfare Reform, emigration reforms, some regulatory reform and a number of other things--because we had a little give and take. What the American people want is for the politicians to work in ways that will be beneficial to the public and not worry so much about partisanship. I think that could well be the hallmark of the 1997 session as we deal with some of these tough issues. But you're part of the team too and you have to have your input not only in terms of your professional association but as individuals. Therefore, I come full circle and say get involved, get to know the people that represent you give them your input so that we can make good judgements, so that we can make policy that will be of significance and worthwhile value for a long time.

Deregulation, that's going to have an impact for decades, and, therefore, we need to do it right. On the Telecommunications Bill, we sent it down and the President vetoed it (it came back). I didn't vote for it the first time. I didn't like all the characteristics of it. We finally got something, it may not be perfect, but it's better than when it went into the shoot to start with, and that's all a part of the legislative process.

Lastly, we're going to make an effort to get growth. We're at about 2.3%, 2.5% annual. We need to do things to get it up to 4% because that will help to solve the entitlement problem, that will help to solve the deficit problem, that will help to solve the problem of being competitive in the world marketplace. So many things could flow out of getting this country in a 4% growth pattern, which it used to be. It will, of course, come back to jobs, when you have 4% growth you have jobs available, you have a high level of employment. We can make jobs for those people who are going to be pushed off of welfare, but, they in turn have to do their share by learning a skill. We need to give them the opportunity.

Right now we've got 165 post-high school programs. I'm not talking about college, I'm talking about skill programs--some big ones and some little ones. We want to consolidate those into three or four really good programs that will help these people get skills. But again, you need to be involved in the mix in the local communities so that there's a market for the skills given them, because there'll be nothing worse than to have somebody spend six months acquiring a skill and there's no job that fits that skill. Too often we have not tried to coordinate it.

Well again, you're my heros because you're working on a program, the Clean Coal Program, which we had a real struggle to get. What I like about it is, its going to reduce our dependency on oil long-term. We required a 50/50 match in terms of the private sector and that's become a pattern on a lot of things in government. I think clean coal is one of the first major policy areas where we did that requirement of having 50% from the private sector. As it's worked out, its really 60/40, because it's a bidding process: 60% private, 40% government. It's been very successfully--we're going to do our children and grandchildren a great favor if we can expand the use of coal. We're now at 56% of the power produced in this country from coal generation. I think it would be a shame to give them a legacy of dependency on imported petroleum because we've used it to produce electricity when coal can do it so well, while at the same time taking care of the emission requirements to meet the standards.

Luncheon Address

Completing the CCT Mission: The Challenge of Change

Remarks by

Hazel R. O'Leary
Secretary of Energy
to the
Fifth Annual
Clean Coal Technology Conference

January 10, 1997

I wanted to join you today for two reasons.

First, I believe it is altogether fitting to enter the final 10 days of my post in much the same way as I started my very first association with energy -- watching coal head out over the horizon, in pursuit of new opportunities.

As a youngster growing up in Virginia, I sat on the docks at Hampton Roads with my father and watched coal colliers being loaded and bound for European markets.

There was a touch of mystery in what lay over the horizon for those ships. It was from that early lesson that I learned energy was global and it meant jobs at home. In those huge coal piles at the docks, I gained a sense of familiarity. At a young age I sensed the power and strength represented by those storehouses of coal. I saw firsthand the linkage between coal and jobs and economic prosperity.

The interconnection between coal and energy and the advancement of people in every corner of the globe was real to me watching those ships being loaded and disappear over the horizon to faraway, exotic places.

I gained an appreciation for the people whose hardwork and sweat was responsible for those huge coal piles.

My father was a physician in the Tidewater area. He took care of longshoremen who helped load that coal. They were his patients and our friends.

So, for this Secretary of Energy, very early on, coal was both life and livelihood.

Today those distant horizons are much closer....the world in many ways much smaller...the health and prosperity of <u>each</u> of us now much more dependent upon the actions of <u>all</u> of us. Our economies are global. Economic security and environmental protection are no longer the priorities of individual nations....today, they are universal imperatives.

We live today much more like a single, worldwide community...our futures interdependent.

We share common horizons for tomorrow. And increasingly, those horizons are being set -- and achieved -- by technology....in this case, clean coal technology.

I wanted to join you in Tampa today because, like the youngster on the docks at Hampton Roads, the horizons I see today for coal offer the same remarkable opportunities.

There is still a touch of mystery in what the 21st century holds, but today we undertake the voyage toward that new world equipped with new technology.

It is with this new technology that coal can continue, as your conference theme so aptly states, to "power the next millennium."

A Tribute to Clean Coal Pioneers and Partnerships

The second reason I wanted to be here today is to pay tribute to the people whose genius and hardwork made this new technology possible.

"Clean coal technology" is the product of partnerships. Nothing like the TECO project, or the Wabash River project in Terre Haute, Indiana, that I visited in November 1995, or the Pure Air project on the banks of Lake Michigan -- or any of the projects displayed on the posters around this room and in the exhibit hall -- would have been possible had it not been for the determination of farsighted individuals.....in the private sector....in state agencies....and in the legislative and executive branches of government....individuals in this room today.

You had the determination to shoulder the risks of this new experiment in public-private cooperation.

For those who may not be familiar with the origins of the clean coal technology program in this country, let me tell you it was a risk.

It was 1984 when the clean coal experiment began, and it is important to reflect back on the mood of the times. I had completed my first tenure in government during the tumultuous '70s, and was happily at work in the private sector.

I can tell you -- from the perspective of both a public and private official -- government's track record as a partner in new energy programs was not good.

The synthetic fuels program, begun with great fanfare when energy expectations were different, had collapsed. Major international demonstration projects in coal technology -- the Solvent Refined Coal projects with Japan and Germany -- had been abruptly terminated. Congress had killed the Clinch River Breeder Reactor. The Great Plains Gasification Project in North Dakota was on the verge of being abandoned even before the first cubic foot of coal gas made it into the pipeline.

One can certainly argue whether any of these "grand initiatives" should have continued...or whether all might have wound up as white elephants. But regardless of whether each was right or wrong, one common thread ran through them all. As a predecessor of mine (Don Hodel) put it at the time, these projects begged the question "Did the federal government have the moral conviction to complete anything it starts?"

It was in that era of broken commitments -- ill will from our friends in Japan over the SRC project, distrust from many in our own private sector -- that the Clean Coal Technology Program was launched. And it is a tribute to many of you in this room that in an era of deep skepticism, the U.S. Clean Coal Technology Program not only succeeded but became a model of government-industry partnerships.

The Clean Coal Program *"is an example of a federal program that works." "Congress should support similar government-industry* *ventures to speed technology transfer...."* Those aren't my words. Those are the words of the General Accounting Office, the investigative arm of congress, when it reported on the benefits of government-industry cooperative R&D in 1994.

Why did it work? What made it different from the other "big ticket" initiatives that never got off the drawing boards? Most importantly, what lessons do we take from the clean coal program into the next millennium?

The Environmental Ethic Comes Home

First, Clean Coal was a program that met a clear public need. It responded to an environmental ethic that people in the 1980s began to take personally.

Our environmental consciousness was born in the earth day movements of the late 60s and early '70s, but it changed in the 1980s. It deepened. It began to hit home.

Twenty years ago, the environmental movement spoke about the esthetic effects of human activities -- whether our air was clear or dirty, whether our waters ran pure or polluted, whether the landscape around us remained scenic or obstructed.

Today there is a new environmental consciousness. We are concerned with the effects of human activities on human health and wellbeing.

It's not just whether the air looks dirty or smells bad but whether it is harmful to us and to our children....whether it carries unseen impurities that can damage our health.

In the 1980s, we became concerned about the personal cost of environmental damage, the price we must pay... in monetary and, most importantly, in <u>human</u> terms.

Clean coal technologies succeeded because they responded to that environmental ethic and, at the same time, they made economic sense.

They offered a way for us to improve the quality of our air and to reduce the eyesores of solid wastes without imposing exorbitant new costs on consumers and dragging down our economy.

Clean <u>and</u> affordable energy -- clean coal gave us a way to achieve <u>both</u>.

It gave us a vision of the future in which the public would no longer associate the word "dirty" with the word "coal." It gave us a future in which our most abundant energy resource -- <u>the world's</u> most abundant energy resource -- could continue to fuel economic growth... without sacrificing our environment.

Just look at one of the many success stories coming out of the clean coal experiment:

Today, more than one-fourth of all coal-fired capacity in this country -- nearly 250 boilers -- have been outfitted with Low-NOx burners demonstrated in the Clean Coal Technology Program. By the year 2000, more than 75% of coal-fired boilers will have this new, lower-cost technology. Emissions are coming down. The air is becoming cleaner. The new technology of coal responded to the new environmental ethic. And the economy is better off.

Ratepayers have saved nearly $20 billion in emission compliance costs from low-nox burners alone. Commercial sales have amounted to almost $1 billion.

Not a bad payback for a $40 million Federal investment....a good lesson for the 21st century as we tackle the problems of CO2, air toxics and particulates.

Industry Picks the Technologies

The Clean Coal program also succeeded because industry was the driver. Government did <u>not</u> pick "winning technologies," it looked to the private sector and picked willing and able partners.

Government programs in the past failed largely because government tried to dictate the portfolio -- so many gasification projects, so many oil shale projects, perhaps even a breeder reactor if anyone would build it.

This time, industry came to the table with technological solutions...and with the conviction and resources to invest in their demonstration. And come to the table they did.

Let me tell you a story about the origins of the Clean Coal Program.

The current program, as many of you remember, began in response to the U.S./Canadian transboundary problem of acid rain.

Then-Prime Minister of Canada Brian Mulroney had hammered President Reagan to adopt the recommendations of the U.S./Canadian Envoys on Acid Rain -- the centerpiece being the Clean Coal Program.

But on that day in March 1987 when Ronald Reagan stunned many inside and outside of his administration by agreeing to a new $5 billion public-private initiative, several of his budget-cutters -- who certainly didn't want to see another big government initiative, no matter the need -- were quick to tell the Department of Energy "Don't count on seeing any of that money."

Yes, the Federal share would be offered, they said, but it would be window-dressing. Industry would never put up the required matching funds. The program would die on the vine.

But they were wrong.

Those career officials at the Department of Energy -- many in this room today -- fashioned a program that put industry in the drivers' seat. That took courage.

Sure there were safeguards in place. The whole process was set up to run competitively. Performance standards had to be met. But government set <u>only</u> the criteria. Industry determined how best to meet it.

And the skeptics were wrong. Industry not only put their dollars on the table side-by-side those of government, they did much better. For every $1 dollar the government invested, industry laid down $2.

The $5 billion program envisioned by the Special Envoys is today nearly a $6 billion program because industry and states upped their contribution. The 50/50 funding split originally envisioned -- and required by Congress -- is today 65/35 with the 65 being the contribution of industry and states.

And let's not forget the States. This program succeeded because the Clean Coal partnerships involved states like Ohio and Illinois, Indiana, Pennsylvania, Alaska -- and the tireless, grassroots efforts of state officials like Jackie Bird.

One out of every 3 projects in the clean coal demonstration program (14 out of 40) involves state co-funding.

The Clean Coal formula worked because states were part of it from day one.

It took courage for you in industry and in state agencies to take another chance on the government. And it took courage by many government employees to break from the past and design an effort based on industry's -- not government's -- knowledge of what would work best in the market.

Just as I learned from my father back in Hampton Roads about the personal side of the industry, I fully recognize today that the true strength of the Clean Coal Program lies with the dedication and devotion of the individuals behind the dollars and the technology.

It is appropriate that we pay tribute to those individuals....those in this room today, both in government and industry ....and those who are not.

I especially want to remember those who played such a key role in forging this program....but who were tragically taken from us before they could see the full results of their labors.

We pledged we would never forget, and so it is appropriate that we remember --

George Weth -- who was to head the selection panel for Round 4 of the Clean Coal Program but who died in a plane crash in Los Angeles in 1991.

The nine employees of our Pittsburgh and Morgantown centers: Bill Peters, Bob Evans, Steve Heintz, Tom Arrigoni, Tim Mcilvried,Manville Mayfield, Randy Dellefield, Bill Langan, and Sandy Webb, who were aboard the USAir flight that crashed outside of Pittsburgh in 1994.

Their colleagues from industry who were aboard the same flight: Ed Wiles and Shelly Ziska, who were with the Center for Energy and Economic Development, our co-sponsor for this conference; Todd Johnson from Babcock and Wilcox, Bernie Koch of CONSOL, John Cooper with Allegheny Power, and Daniel Kwasnoski with Bethlehem Steel.

Let us also not forget the loss of my good friend and colleague Ron Brown and the U.S. delegation he was leading to Croatia in April of last year. Bob Whittaker of Foster Wheeler International, Robert Donovan of ABB, and Claudio Elia of Air and Water Technologies Corporation were part of that delegation because they understood that rebuilding the energy infrastructure of a nation was crucial to restoring a shattered economy.

I believe it is altogether appropriate that we remember someone who spent his entire career as an advocate for coal and coal technology -- Jack O'Leary.

When the Department of Energy was first formed -- coalescing from 30 different departments and programs in the Federal government -- Jack was the first deputy secretary. One of the battles he took on early in the game was to preserve federal coal technology research.... specifically the research underway at the government laboratories in Morgantown, West Virginia, and Pittsburgh, Pennsylvania.

There were those at high levels in the department who didn't believe those centers should continue...they didn't have the critical mass. But Jack knew they had the critical expertise.

He knew that to sharpen that expertise, the centers had to be kept open and challenged. He worked with others to turn them from inward-looking researchers to outward-focused technology partners.

Jack went to the mat for the centers. And today many of the technologies in the Clean Coal Program cut their teeth in those laboratories. Equally important, those centers were responsible for the federal stewardship of the program.

Another reason the Clean Coal partnership succeeded was that we preserved and nutured the talents and expertise in the centers. As a result, we have people in government who speak the same language as those in industry.

So it the courage and conviction of individuals -- and their faith in the future -- that we honor today.

Congress' Commitment to Results

There were others acts of courage in those early days of the Clean Coal Program that I also want to acknowledge.

It was the courage of the few in Congress who understood the imperative that government follow through on its commitments.

Congressman Ralph Regula -- here with us today -- was one of the leaders who understood that need. Robert Byrd on the Senate side understood that need. And together, with colleagues from both sides of the aisle, they pushed through full advance funding for the Clean Coal Program.

Mr. Chairman, that was a remarkable act of leadership and vision. But that confidence was well founded.

Perhaps more than any single factor, your action broke with the past and removed the doubts.

Knowing that the government had the dollars up front to back up its words gave industry the confidence to step forward. It sent the signal that government was ready to follow through. This industry and this country owes you and your clean coal colleagues in Congress a great tribute, and I am proud to extend it here today.

Powerful Possibilities

There is a third -- and final -- reason why I am so pleased to join you today. As Thomas Jefferson said, *"I like the dreams of the future better than the history of the past."*

And that is what I want to leave with you today... *"dreams of the future"*.... visions of the challenges that await us... the grand opportunities and powerful possibilities that lie over the horizon.

I am convinced -- as I prepare to leave what will likely be my final post in government -- that governments and industries throughout the world must find ways to maintain the passion -- and courage -- to invest in the future.

How do we keep alive the same spirit of innovation that led to your bold investment in clean coal technology?

First, we must continue to think globally.

The problems we will confront in the 21st century will not be limited by geographical or political boundaries. The quality of our environment, the strength of our economies, the peace and security of our societies...none of these will be confined to lines on a map.

One of the accomplishments I am most proud of in the last 4 years are the efforts we made with industry to open doors to new energy technology throughout the world.

We were driven by a vision....our view that secure, affordable energy could be an instrument for global peace and prosperity, not a reason for competition and conflict.

And I am proud that we acted on that vision... that we had the passion to be bold...that we worked hard in the office buildings of the world's major capitals and the grass huts and shanties of remote villages to bring about greater economic growth...to create jobs, to build the middle class, to attack poverty, to protect the environment and to build democracy.

No future initiative, in my view, will be more worthwhile for any Cabinet secretary...and that includes any future Secretary of Energy....than strengthening trade relations, improving environmental quality, and promoting peace and prosperity among nations.

We can't ignore the globalization of this technology.

The leaders of this government -- in concert with industry -- have a moral responsibility to deal with global problems, particularly when we have solutions at hand. We cannot let the partisan political climate of Washington destroy our will to take on international initiatives. There is too much at stake.

I am very proud that we made coal a major part of our international efforts.

We worked to advance clean coal in China -- following the way paved for us by Jack Siegel, who guided our fossil energy team through much of the Clean Coal partnership. We worked to deploy clean coal technologies in Pakistan, South Africa, India, Japan, Australia and Eastern Europe.

We supported clean coal in virtually every region of the world because coal will continue to be the most widely-used energy resource.

That is not a fact to be feared, but an opportunity to be seized.

More than one-half of the $1.4 trillion that the nations of the world are expected to invest in electric power technology in the next dozen years will go to coal-fired plants. Today we have the tools to take full advantage of that enormous opportunity.

The challenge I leave with you for the near-term is to build on what you have accomplished. In the projects you discussed this week, you have offered us a preview of the future.

Now, all of us must work together to bring down the barriers that stand between demonstration of these technologies and our ultimate goal...deployment.

You are true pioneeers. You deserve the title. You have reshaped the future of your industry. And pioneers, by their nature, always seek new challenges. They always look to the mysteries over the horizon.

So, my final challenge to you today is to urge you to look beyond the near-term...to look to the "powerful possibilities" that await us in the 21st century....and to recognize that they can only be realized by ***global*** partnerships in research and technology:

Climate change. Thanks to clean coal technology, the energy plants of the early 21st century will be more efficient, and that means less CO_2 -- perhaps 20 to 30% less from the plants of the early 21st century.

But we believe it is possible to push the envelope further.

In the R&D pipeline today, we have advances in turbine technology... advances in coal gasification and combustion....advances in fuel cells....that could push efficiencies for our visionary power plant of the year 2025 to 60% or more...and cut CO_2 emissions in half.

If we sustain our commitment to research and technology, we can do even better.

We believe it might be possible, one day, to eliminate CO_2 from a coal-fired power plant altogether....capture it and convert it into useful products -- perhaps through artificial photosynthesis.

That's a "powerful possibility." It may be far into the future, but that's the nature of research....to prepare for tomorrow.

Biotechnology. We have achieved remarkable advances in biotechnology. We believe that, one day, we might use these advances to make liquid fuels from coal affordable.

High performance computing. A few weeks ago, we joined with intel to announce a breakthrough in high-speed computing -- the first ever capability to carry out 1 trillion calculations per second.

The computers of the 21st century will be capable of calculating the enormous complexities of nuclear explosions -- allowing us to simulate underground testing of nuclear weapons.

If we can develop this remarkable capacity to simulate a virtual nuclear explosion, might we look to high-performance computers to mimic new coal combustion and conversion processes as well?

Tomorrow's supercomputers will provide new insights that could lead to even more efficient and cleaner technologies. It will mean that expensive pilot plants will be reliably simulated on an engineer's computer terminal, allowing technology to be scaled up at much less cost than required today by the need to build expensive test facilities.

The Power of Partnerships

These are remarkable possibilities. They can be realized....but only if we expand on the one lesson that stands out above all others during the last decade of the clean coal experiment -- the power of partnerships.

To meet the challenges of the 21st century, tomorrow's partnerships in new technology must be global.

But to attain it, we must all look across our boundaries and join together, tackle global problems cooperatively, leverage our resources, carry out research projects jointly.

This conference is meant as a way to forge those partnerships. Use it. Build on it. Dare to be bold in your thinking about tomorrow...about the next millennium.

The future of the 21st century is, quite frankly, our's to get, to have, to keep. To attain it, we must all look across our boundaries and join together, tackle global problems cooperatively, leverage our resources, and carry out research projects jointly.

In short, we must create among our nations partnerships for progress.

You have in front of you a future in which coal use, environmental protection, economic security and global peace are synonymous...and sustainable.

I believed that as a youngster being taught by my father on the docks at Hampton Roads looking out at the horizon and building a personal vision of the possible.

I believe that just as strongly today.

List of Attendees

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