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GAO

Report to the Honorable
Philip R. Sharp, Chairman,
Subcommittee on Energy and Power,
Committee on Energy and Commerce,
House of Representatives

March 1990

FOSSIL FUELS

Pace and Focus of the Clean Coal Technology Program Need to Be Assessed



Southern Company Services 

Southern Company Services, Inc.
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FIRST CLASS MAIL

PHOTOCOPY
PRESERVATION

K. McGinty
Sen. Gore's Office
Senate Russell Bldg.
1st & C Streets N.E.
Room 393



From: David P. Burford

23 Mar 90

To: K. McGinty

You and I can't seem to get together
on the phone so I thought I would
send this information on Clean Coal
Technologies to you. Please give me
a call if you would like to discuss
any of it further.
Have a nice weekend.



5-823

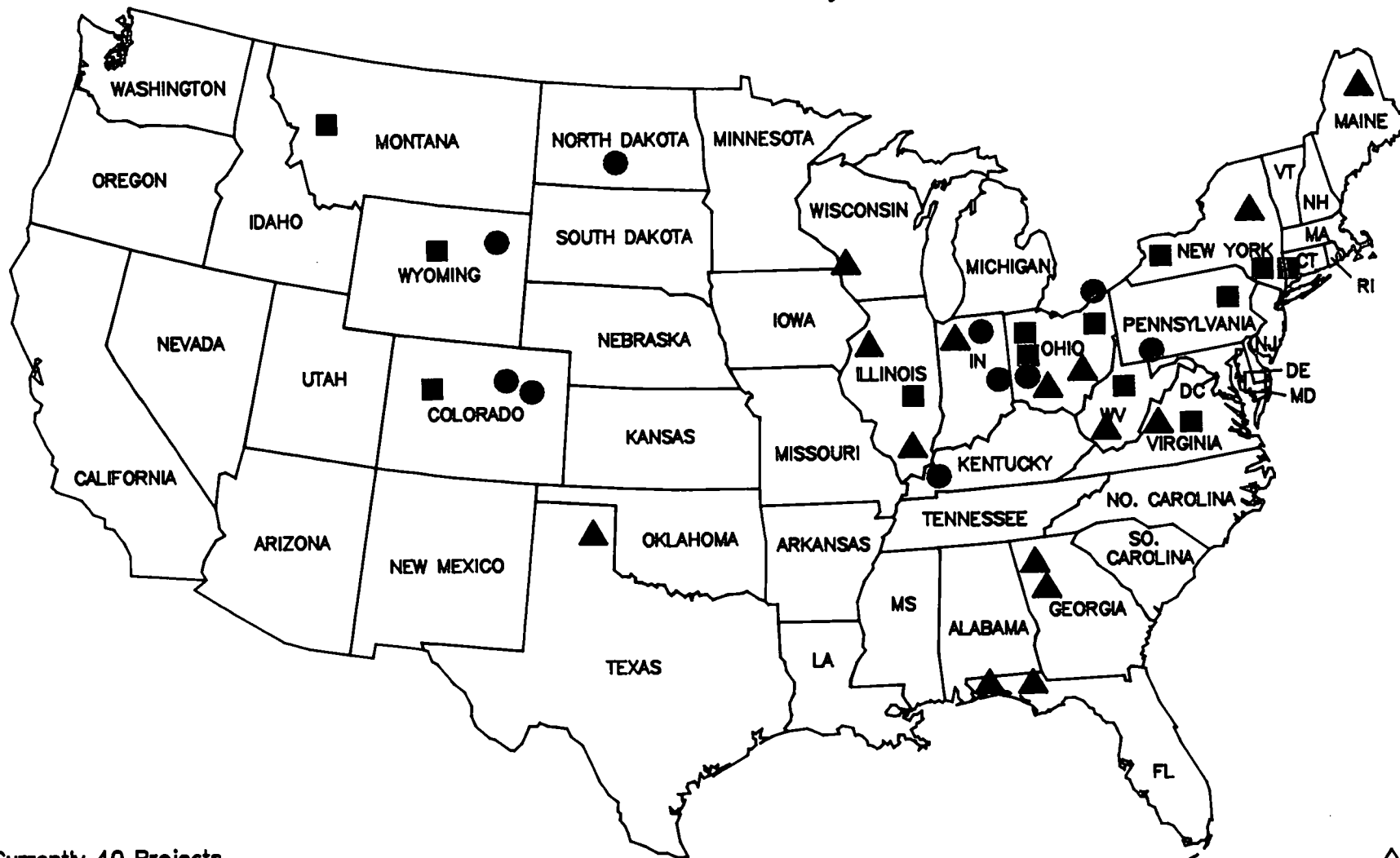
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David P. Burford
Legislative Affairs Coordinator



Clean Coal Technology Projects

DOE-Private Industry Effort



Currently 40 Projects

Total Value: \$3.22 Billion

Doe Funding: \$1.25 Billion

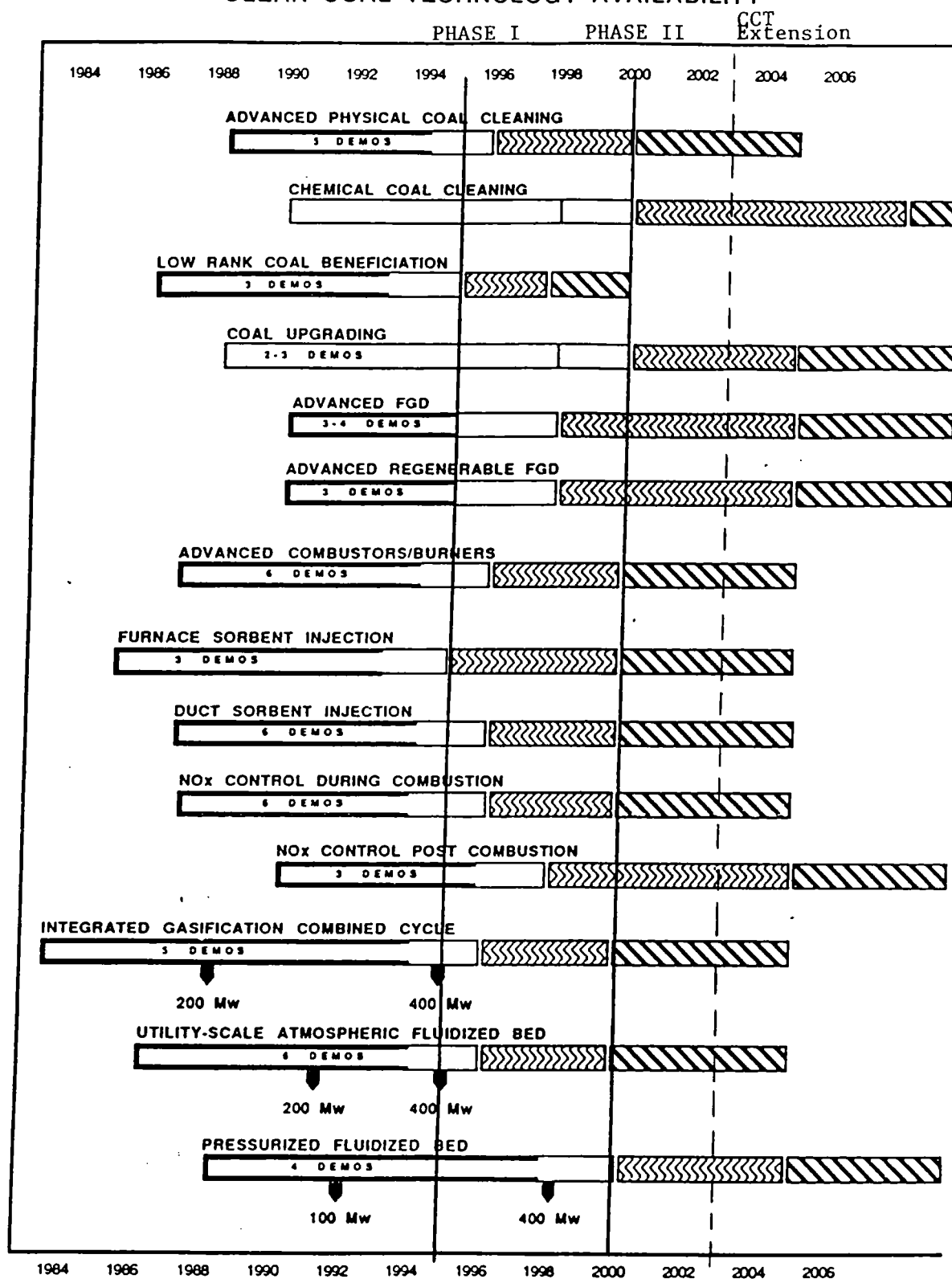
Private Industry Participation: 55.4%

- Round #1: 13 Projects (now 11)
- ▲ Round #2: 16 Projects
- Round #3: 13 Projects



USA4
22MAR90
D. Burford

CLEAN COAL TECHNOLOGY AVAILABILITY



- LEGEND:**
- Demonstration & Deployment Projects Undertaken and Completed
 - Estimated period after demo/deployment projects when Technologies likely to become available for Commercial Order
 - Period of time during which technologies could begin to enter the marketplace as commercial units
 - Period of time when technology could achieve potential widespread commercial use to achieve reductions of air pollutants

**COMPLETE SUMMARY OF CLEAN COAL TECHNOLOGY PROJECTS IN
ROUNDS I, II, AND III OF THE DOE CLEAN COAL PROGRAM**

February, 1990

Produced by:

The Clean Coal Technology Coalition
1050 Thomas Jefferson Street, N.W.
Sixth Floor
Washington, D.C. 20007

STATE (Total Number by location)	PROJECT SUBMITTERS	PROJECT TITLE	PROJECT LOCATION	PROJECT COST (in millions)	COST SHARE by private sector and % (in millions)	COST SHARE by DOE and percentage (in millions)	STATE (Total Cost by location) (in millions)	TOTAL STATE (DOE share and %) (in millions)	TOTAL STATE (Private sector share and (in millions)
ALASKA - 1	Alaska Industrial Development and Export Authority	Healy Cogeneration Project R; **, III	Healy, AK	\$191.7	\$98.53 51.4%	\$93.17 48.6%	\$191.7	\$93.17 48.6%	\$98.53 51.4%
COLORADO - 3	Energy and Environmental Research Corp.	Evaluation of Gas Reburning and Low NOx Burners on a Well Fired Boiler R; **, III	Denver, CO	\$14.4	\$7.2 50%	\$7.2 50%	\$91	\$18.91 45.1%	\$54.07 54.7%
	Public Service Co. of Colorado	Integrated Dry NOx/SO2 Emission Control System R; **, III	Denver, CO	\$24.5	\$12.25 50%	\$12.25 50%			
FLORIDA - 4	Colorado-Ute Electric Association Inc.	CFBC for Utility-Scale Retrofit Boiler P; *, I	Nuclea, CO	\$54.1	\$34.62 64%	\$19.48 36%			
	Southern Company Services	Demonstration of Selected Catalytic Reduction Technology for the Control of NOx Emissions R; **, II	Pensacola, FL	\$15.6	\$8.11 52%	\$7.49 48%	\$427.20	\$132.86 42%	\$294.34 58%
	Southern Company Services	180 MW Demonstration of Advanced Tangentially-Fired Combustion Techniques for the Reduction of NOx Emissions R; **, II	Panama City, FL	\$8.6	\$4.47 52%	\$4.13 48%			
	City of Tallahassee	Circulating Fluidized Bed Combustion P; **, I	Tallahassee, FL	N/A					
	CRSS Capital Inc.	West Virginia IGCC Demonstration P; **, III	Tallahassee, FL	\$403	\$282.10 70%	\$120.9 30%			
GEORGIA - 2	Southern Company Services	100 MW Demonstration of Innovative Application of Technology for Cost Reductions to the Chiyoda Thoroughbred 121 Flue Gas Desulfurization Process R; *, II	Atlanta, GA	\$35.8	\$18.26 51%	\$17.54 49%	\$46.5	\$22.78 49%	\$23.72 51%

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GEORGIA (continued)	Southern Company Services	500 MW Demonstration of Advanced Wall Fired Combustion Techniques for the Reduction of NOx Emissions from Coal-Fired Boilers R; *, II	Rome, GA	\$10.7	\$5.46 51%	\$5.24 49%			
ILLINOIS - 3							\$152.50	\$176.3 50%	\$176.3 50%
	Combustion Engineering	Innovative Clean Coal Gasification Repowering Project P; **, II	Springfield, IL	\$309	\$154.5 50%	\$154.5 50%			
	Transalta Resources Investment Corp.	Low NOx/SO2 Burner Retrofit for Utility Cyclone Boilers R; **, II	Marion, IL	\$13.6	\$6.8 50%	\$6.8 50%			
	Energy and Environmental Research Corp.	Gas Reburning and Induct Sorbent Injection Retrofit into Three Utility Boilers R; *, I	Springfield, IL	\$29.9	\$14.998 50%	\$14.998 50%			
INDIANA - 3							\$263.6	\$103.96 41.6%	\$159.64 58.40%
	Air Products, Chemicals Inc. and Mitsubishi Heavy Industries America Inc.	Advanced On-Site Flue Gas Desulfurization Process R; *, II	Gary, IN	\$140.9	\$77.49 55%	\$63.41 45%			
	Bethlehem Steel Corp.	Blast Furnace Granulated Coal Injection I; **, III	Harms Harbor, IN	\$104	\$72.80 70%	\$31.2 30%			
	IJFAC North America	Demonstration of IJFAC at Richmond Power & Light's Whitewater Valley 2 Powerplant R; **, III	Richmond, IN	\$18.7	\$9.35 50%	\$9.35 50%			
KENTUCKY - 1							\$4.9	\$2.4 49%	\$2.5 51%
	AirPol Inc.	10 MW Demonstration of Gas Suspension Absorption R; **, III	Paducah, KY	\$4.9	\$2.5 51%	\$2.4 49%			

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MAINE - 1							\$9.4	\$4.52 50%	\$4.52 50%
	Passamaquoddy Tribe	Innovative Clean Coal Technology Programs Application (Recovery Scrubber) R; *, II	Thomastown, ME	\$9.4	\$4.52 50%	\$4.52 50%			
MARYLAND - 1							\$45	\$13.5 29.8%	\$13.5 29.8%
	Bethlehem Steel Corp.	Innovative Coke Oven Gas Cleaning System for Retrofit Applications R; *, II	Sparrows Point, MD	\$45	\$31.5 70.2%	\$13.5 29.8%			
MONTANA - 1							N/A		
	Western Energy	Coal Preparation by Advanced Cleaning and Processing of Sub-bituminous and Lignite Coal F; **, I		N/A					
NEW YORK - 2							\$56.1	\$27.02 49%	\$28.98 51%
	Otiaca Industries	Production of Compliance OTBCA Fuel/Coal Water Slurry from High Ash and Sulfur Coal and Its Combustion in Retrofitted Industrial Boilers R; **, II	Syracuse, NY	\$7.1	\$3.5 50%	\$3.5 50%			
	TRW Inc.	Advanced Slagging Coal Combustor with NOx and SO2 Control R; *, I	Stoney Point, NY	\$49	\$25.48 52%	\$23.52 48%			
NORTH DAKOTA - 1							\$213.7	\$94.03 44%	\$119.67 56%
	Air Products and Chemicals	Commercial Scale Demonstration of the Liquid Phase Methanol Process F; **, II	Heulah, ND	\$213.7	\$119.67 56%	\$94.03 44%			

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OHIO - 7							\$529.1	\$170.44 41.34	\$158.66 58.66%
	The Babcock & Wilcox Co.	Full Scale Demonstration of Low-NOx Cell Burner Retrofits R; **; III	Aberdeen, OH	\$9.7	\$5.01 51.6%	\$4.69 48.4%			
	MK-Ferguson Company	Commercial Demonstration of the NOXSO SO2/NOX Removal Flue Gas Cleanup System R; **; III	Niles, OH	\$66.2	\$33.1 50%	\$33.1 50%			
	American Electric Power Service Corp.	70 MW Pressurized Fluidized Bed Combustion Combined Cycle Retrofit P; *; I	Brilliant, OH	\$167.5	\$107.30 64%	\$60.2 36%			
	Babcock & Wilcox Co.	Extended Test of 50-60% Simultaneous SO2/NOx Removal in Limestone Injection Multistage Burner Plus Sorbent Dust Injection R; *; I	Lorain, OH	\$19.4	\$11.83 61%	\$7.57 39%			
	Ohio Ontario Clean Fuels, Inc.	Prototype Commercial Coal/Oil Co processing Project P; *; I	Warren, OH	\$225.7	\$180.70 80%	\$45 20%			
	Combustion Engineering Inc.	Commercial Demonstration of Flue Gas Cleanup Technology to Catalytically Remove Both SO2 and NOx R; *; II	Niles, OH	\$30	\$15 50%	\$15 50%			
PENNSYLVANIA - 3	Babcock & Wilcox Co.	5 MW Demonstration of SO2/NOx RUX BOX Process R; *; II	Dalles Bottom, OH	\$10.6	\$5.72 54%	\$4.88 46%			
	Coal Tech Corp.	Slagging Cyclone Combustor with Sorbent Injection into the Combustor to Achieve SO2/NOx Control R; *; I	Williamsport, PA	\$0.8	\$.4 50%	\$.4 50%	\$9.34	\$4.65 50%	\$1.65 50%
	Combustion Engineering	Advanced Combustion of Medium and Deep cleaned Coal R; **; I	Homer City, PA	N/A					
	Bechtel Corp.	Confined Zone Dispersion (CZD)/Flue Gas Desulfurization Demo R; **, III	Indiana County, PA	\$8.5	\$4.25 50%	\$4.25 50%			

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TEXAS - 1	South Western Public Service Co.	Circulating Fluidized Bed Project P, **, II	Amarillo, TX	\$135	\$83.70 62%	\$51.30 38%	\$135	\$41.3 34%	\$83.70 62%
WEST VIRGINIA	American Electric Power Service Corp.	Pressurized Fluidized Bed Combustion Repowering Project P, *, II	New Haven, WV	\$579	\$393.70 68%	\$185.3 32%	\$579	\$185.3 32%	\$393.7 68%
WISCONSIN - 2	Dairyland Power Cooperative	Alma Pressurized Circulating Fluidized Bed (PFBC) Demonstration Project P, **, III	Alma, WI	\$183.8	\$95.58 52%	\$88.22 48%	\$183.8	\$93.22 49%	\$100.58 51%
	Babcock & Wilcox	Demonstration of Refueling for Cyclone Boiler NOx Control R, *, II	Caffville, WI	\$10	\$5 50%	\$5 50%			
WYOMING - 1	ENCOAL Corp.	ENCOAL Mild Gasification Demonstration Project P, **, III	Gillette, WY	\$72.5	\$36.25 50%	\$36.25 50%	\$72.5	\$36.25 50%	\$36.25 50%
TOTAL DOE FUNDING:		\$1.250 Billion							
AVERAGE DOE SHARE:		44.63%							
TOTAL PROJECT COST		\$3.22 Billion							

LEGEND:

*: Project Underway
**: Project Currently Under Negotiation

R: Retrofit Technology
P: Repowering Technology

F: New Fuel Form Technology
I: Round I Selection

II: Round II Selection
III: Round III Selection

1 The Program

Summary

The Clean Coal Technology Demonstration Program is a technology development program jointly funded by government and industry. It will take the most promising of the advanced coal-based technologies and, over the next decade, move them into the commercial marketplace through demonstration. These demonstrations will be at a scale large enough to generate data (from design, construction, and operation) necessary for the private sector to judge commercial potential and to make informed and confident decisions on commercial readiness.

The goal of the program is to make available to the U.S. energy marketplace, particularly the industrial and utility sectors, a number of advanced, more efficient, and environmentally responsive coal technologies. These technologies will reduce and/or eliminate the economic and environmental impediments that limit the full consideration of coal as a future energy resource.

The strategy for achieving this goal is to implement a multi-phased effort consisting of at least five separate solicitations. When integrated, these solicitations will demonstrate technology options consistent with the demands of the energy

market and responsive to relevant environmental considerations. The projects will contribute essential data on technical, environmental, economic, and operational performance to the information base necessary to reduce the uncertainties of subsequent commercial-scale application of the technology. The program strategy involves working with other federal agencies, states, and international organizations as well as the private sector to foster an understanding of the program, its projects, and the benefits being derived from the demonstration and commercialization of clean coal technologies.

The federal government will capture and transfer to a broad spectrum of the private sector and international community sufficient technical, environmental, economic, and operational information to allow potential commercial users to screen the generic technologies for their applicability to operational requirements. The federal role further includes developing a technical, engineering, and environmental knowledge base so that sound policy decisions on future clean coal technology initiatives and environmental issues can be made. In addition, the federal government will provide the public

with the information needed to form a national consensus on controlling pollutants that may contribute to the formation of acid rain.

Industrial participants will be in a position to use the information and experience gained during the demonstration projects to promote, commercialize, and market the technology. The detailed data and experience gained during the demonstration will be vital to firms deciding to invest in and build, retrofit, or repower plants using clean coal technologies. This aspect of the industrial participants' role in the program is crucial to the ultimate goal of commercializing the successfully demonstrated technologies. In support, the program will provide a technology transfer mechanism to assure that the private sector has the necessary access to the data on clean coal technologies.

The program also supports the efforts to improve the regulatory and institutional climate to encourage commercialization of demonstrated clean coal technologies at a pace consistent with free market decisions. And as appropriate, the recommendations of the Task Force on Regulatory Relief and the Innovative Control Technology Advisory Panel (ICTAP), which emerge from analyses of issues related to

accelerating the commercialization of clean coal technologies, are implemented in the program.

1.1 Role of the Program

The objectives of the program respond directly to the strategic importance of coal both in the U.S. economy and in the international marketplace. Through the program, DOE is implementing activities that will resolve the conflict between increasing coal use and growing concerns about the environmental impacts of such use.

This conflict will be resolved by stimulating the development and fostering the commercialization of these technologies through the joint government/industry support of demonstration projects. The amount of data required on each project for the private sector to make rational and confident decisions regarding commercial deployment will vary among the technologies and will be related to their unique characteristics and the applications in which they are used. Concerns about the level of operational risk, degree of reliability, and operational maturity, for example, will be resolved by the data generated.

The overall schedule for achieving the program goal has been based on three factors:

- Almost 50 percent of the current inventory of electric generating capacity in the United States will be over 30 years old by 1997. The need to replace or refurbish this capacity plus add new capacity to keep

pace with the rising demand for electricity means that a major investment in electrical generation capacity will begin by the mid-1990s. Better technologies must be available and used commercially prior to the year 2000 to prevent the economic and environmental penalties associated with continued investments in current commercially available technologies.

- The concerns about acid rain and the debate over how best to solve this environmental problem are polarizing the U.S. public between those favoring regulatory solutions and those favoring the use of improved technology. Truly superior technologic options must be forthcoming in the foreseeable future if adverse economic consequences associated with the regulatory options are to be avoided. Validation of clean coal technologies as viable options will be key to achieving a healthier environment without higher energy costs.
- Other promising advanced technologies, which are not now sufficiently mature to justify demonstration, yet offer a wide range of future coal utilization options, will become available in the early 1990s. Subsequent demonstration of these technologies will make it possible for coal and coal-derived energy products to replace imported oil in a wide range of applications.

In resolving the conflict between the increased use of coal and the possible environmental impacts, a comprehensive strategy has been formulated for the Clean Coal Technology Demonstration Program that encompasses:

- The U.S. acid rain strategy
- The outlook for U.S. power production
- U.S. energy security issues
- U.S. competitiveness in international energy markets
- The synergism between R&D and demonstration.

1.1.1 The U.S. Acid Rain Strategy

Burning coal produces a number of gaseous compounds, including hydrocarbons, sulfur dioxide (SO₂), and nitrogen oxide (NO_x). These emissions are believed to contribute to the formation and deposition of "acid rain." In the United States, coal-fired boilers are the principal source of SO₂ emissions and a major source of NO_x emissions.

The principal consequences of acid deposition are damage to aquatic life in headwater lakes and streams and to forests, as well as accelerated weathering of some manmade materials. Historically, acid deposition has been associated with damaged aquatic resources in the Northeast. Yet, the types, causes, locations, and severity of damage are still highly uncertain: the pollutants

that cause harm and their exact relationship to specific emissions or to apparent effects are very difficult to pinpoint. A comprehensive federal program of research, monitoring, and analysis is under way. The objectives of this effort are (1) to increase the general knowledge base about the causes and effects of acid deposition and trends associated with damage and (2) to develop and demonstrate advanced coal-using technologies that emit lower levels of SO₂ and/or NO_x.

Efforts to address acid rain problems have been ongoing for some time. In the mid-1980s significant steps were taken by Canada and the United States to coordinate efforts to address transboundary air pollution.

In March 1985, President Reagan and Canadian Prime Minister Mulroney appointed Special Envoys Drew Lewis of the United States and William Davis of Canada to assess the international environmental problems associated with transboundary air pollution and to recommend actions that would help to solve them. Their conclusions are presented in the resulting *Joint Report of the Special Envoys on Acid Rain* and include the following:

1. Acid rain is a serious environmental problem in both the United States and Canada.
2. Emissions transported through the atmosphere undoubtedly are contributing to the acidification of sensitive habitats in both countries (a transboundary problem).

3. The potential for long-term socioeconomic costs is high.

The Special Envoys further concluded that presently the potential avenues are limited for achieving major reductions in air emissions contributing to acid rain, and all carry high socioeconomic costs. In particular, the Special Envoys' joint report noted that none of the conventional methods now available for controlling emissions provides a simple solution to the problem.

The joint report contained a number of recommendations to mitigate the problems, including the recommendation that the U.S. government implement a 5-year, \$5-billion, commercial demonstration of control technology in which the federal government and industrial sponsors would share the cost of the projects.

On March 18, 1987, President Reagan announced several steps to ensure a continued close working relationship between the United States and Canada in determining and addressing the effects of acid rain. The centerpiece of the President's initiative was a pledge to seek \$2.5 billion over a 5-year period to fund innovative clean coal technology demonstrations. These demonstrations would be directed as closely as possible to the Special Envoys' recommendations. Funding would be used to structure multiple rounds of competition. The competitive solicitations would be sequenced in such a way as to encourage the continued development of new,

potentially improved clean coal concepts and to consider them as candidate technologies for demonstration projects once they reached sufficient maturity.

1.1.2 The Outlook for U.S. Power Production

Two trends, aging power plants and increasing power demand, are converging at the same time environmental requirements for new power plants are becoming increasingly stringent. Since the passage of the Clean Air Act, Prevention of Significant Deterioration (PSD) regulations have significantly increased the time required to obtain permits for major new sources of emissions. In addition, the Clean Air Act amendments of 1977 introduced nonattainment area requirements for new sources setting, in many cases, emissions levels for individual plants that are more stringent than national emissions standards.

Today's technology will have difficulty responding to the rapidly changing environmental requirements being placed on power plants. New power options must be capable of meeting stringent siting and environmental demands without sacrificing productivity. The importance of new, more economical environmental control technologies is underscored by the fact that approximately 40 percent of the capital investment and 30 percent of the total cost of power for new, conventional, coal-fired power plants are related to environmental controls.

Power plants of the future must be not only clean and economical but also capable of being rapidly constructed, preferably in modular fashion, with a high degree of performance efficiency over a range of unit sizes. Future environmental control options must be less sensitive to fuel type and retain acceptable economics over a wide range of boiler sizes and models.

Present-day commercial technology cannot meet these requirements in many situations. In fact, conventional commercial technology--both for power production and pollution control--is nearing the end of its development potential. Therefore, the next decade will be critical to the development of new energy options that meet U.S. energy, economic, and environmental goals.

Coal has been the fuel of choice for most baseload electric utility capacity due to its lower fuel costs (relative to oil and natural gas) that can more than offset its higher capital costs. Today, coal produces more than 55 percent of the electricity generated in the United States. (In fact, electric utilities consume almost 80 percent of U.S. mined coal. The remaining 20 percent is split between industrial applications and metallurgical coal.) By the year 2010, coal is projected to comprise over 60 percent of the energy consumed by electric utilities. Moreover, most of the projected growth in U.S. coal demand will be consumed by electric utilities: utility consumption of coal is forecast to grow from 14.5 quads in 1986 to 31.4 quads in 2010.

For coal to share in this growth, however, potential users must be confident that (1) coal prices are predictable, (2) coal-burning and associated pollution control equipment are cost-effective and reliable, and (3) there are adequate financial incentives for risking higher capital investments.

The electric utility industry stands at the threshold of a fundamental change in the technological base of power generation, just as the Clean Coal Technology Demonstration Program is getting under way. By the mid-1990s, many utilities will be increasingly confronted by the dual problem of an aging boiler inventory and the potential long-term need for increasing their power generating capacity. More than half of all coal-fired boilers will be 30 years old or older by the mid-1990s. Utility decisionmakers will have to make some fundamental choices about many of these units--to retire, refurbish, repower, or replace them.

In this same time frame, reserve margins in generating capacity will be declining while demand for electricity will be growing. Utility decisionmakers have been reluctant in recent years to invest in large, conventional baseload plants--either coal- or nuclear-fueled. Uncertainty over anticipated growth in power demand coupled with uncertainty regarding future environmental regulations have stalled many construction projects.

Thus, the uncertainty in the timing associated with the anticipated future demand for new facilities, either to meet new demand or as a replacement for older units, plus today's slowdown in construction, has created an opportunity for new clean coal technologies in the 1990s and the early 21st century. Specifically:

- Approximately 320 gigawatts (GW) of additional coal-fired capacity will be required between 1995 and 2010 to satisfy increased demand.
- Approximately 59 GW of generating capacity will need to be replaced by 2010.
- Up to 200 GW of generating capacity, which will become 30-35 years old between 1995 and 2010, comprise a potential target for repowering.

It is anticipated that the utility sector will be the largest U.S. market for clean coal technologies. This market includes new coal-fired generating capacity and replacement or repowering of existing capacity with coal-based technology.

The past decade has brought substantial changes in traditional electric power generation. These changes, including independent power production, qualifying facilities, and cogeneration, are all supported by regulatory provisions and can have a pronounced effect on the market for clean coal technologies. Proposed regulations have the potential to increase the availability, diversity, and competitiveness of

alternative sources of power purchased by utilities. They also have the potential to increase the client base for clean coal technologies beyond the traditional utility industry, thus opening new opportunities and markets.

1.1.3 A Passport to Energy Security

Coal's abundance makes it one of the nation's most important strategic resources in building a more secure energy future. Comprising 80 percent of the known domestic fossil fuel resources, coal can be one of the most useful energy sources well into the 21st century and beyond. With current prices and technology, U.S. recoverable reserves of coal could supply the nation's coal consumption at current rates for nearly 300 years.

Although the United States is endowed with vast quantities of coal, it must be recognized that coal is a demand-constrained commodity. The characteristics of coal tend to inhibit its greater use as a fuel: it is bulky, relatively expensive to move, requires substantial storage space at the site of its use, and produces significant amounts of waste products that require proper disposal; coal-burning equipment is generally more expensive than oil-burning systems so higher capital costs tend to limit coal to applications where large capacities and high utilization rates can compensate for greater initial capital costs; and emissions-control devices for coal-burning plants are expensive to install and maintain.

Any effort to increase coal's use beyond forecasted levels must be directed primarily toward expansion into new markets while increasing its competitiveness in traditional markets. Although lower coal prices would promote some increase in consumption, more substantial demand increases are currently hindered by various technical, regulatory, environmental, and other obstacles.

For coal to reach its full potential, advanced coal-using systems must be developed that are economically competitive, capable of meeting stringent environmental requirements, and sensitive to diverse energy markets and site-specific factors. An expanded slate of innovative clean coal technologies would resolve many of these obstacles through substantially improved options that are preferable to today's choices.

1.1.4 The Competitive Edge In International Markets

International markets offer commercial opportunities for the clean coal technologies being developed and demonstrated in the United States. Through the year 2000, energy consumption in the European countries of the Organization for Economic Cooperation and Development (OECD), Japan, and developing economies combined is projected to grow significantly faster than in the United States.

Japan, however, has made enormous strides in reducing energy intensity per capita, and it is likely that energy consumption will remain relatively low despite economic expansion. To some degree, growth in the projected energy demand may depend upon the extent to which foreign consumer products penetrate the Japanese domestic markets.

The developing economies are expected to increase energy consumption at a greater rate than other global economies. The International Energy Agency (IEA) projects that developing economies will increase their energy consumption to the extent that by 2000 they will consume more energy as a group than will Western Europe. In developing economies, the commercial sector is expected to account for the increases. Capital constraints affecting power plant construction and other industrial enterprises may temper those numbers, but the trend is appropriately cast.

The nations of Western Europe and Japan are establishing stringent environmental regulations. Pollution control technologies are of interest as alternatives to using lower sulfur coal as a pollution control strategy. This suggests some opportunity for U.S. clean coal technologies. IEA projects that OECD Western Europe as a region will require 265 GW of new electric capacity by the year 2000; of this, approximately 44 GW will be coal-fired capacity.

This large projected growth in energy consumption worldwide offers a potentially

sizable market for U.S. exports of coal, coal-based fuels, and coal technologies. New technology will be a major factor in making the coal export package attractive. The technologies emerging from the Clean Coal Technology Demonstration Program may provide the single most important advantage that the United States could have in the global race for new technologies and new energy supplies.

The ability to show a prospective overseas customer an actual operating facility running on U.S. coal, rather than just a drawing-board concept or an engineering prototype, is expected to be a very persuasive inducement. It easily could be the advantage that will sway overseas consumers to buy U.S. coal together with the proven technology to burn it cleanly and effectively. The development of advanced clean coal technologies also will satisfy the demand for less costly and more efficient energy concepts that will not reverse the recent gains in economic growth by imposing new costs on consumers.

The marketing advantage of advanced clean coal technologies in supplying the demand for better equipment is clear when it is recognized that most of the technology on the market is vintage 1940. Such technology cannot compete with the efficiency or lower emissions of modern fluidized-bed boilers or other advanced combustion or conversion concepts.

Hardware and power generating concepts--from combustors to gas clean-up; to advanced sensors,

instrumentation, and diagnostics; to repowering technologies such as pressurized fluidized-beds and gasification combined cycles--can be an effective marketing tool when included with the coal itself. The linkage can be a most effective marketing edge and can provide essential options to foreign utilities to address problems similar to those expected by the U.S. power industry. Unless resolved, these problems will adversely affect the industry's ability to meet increased power demands in an environmentally acceptable manner. The future of coal as a desirable energy option lies in the development and subsequent use of these advanced clean coal technologies.

1.1.5 The Research and Development Interface

There is significant synergism between the Clean Coal Technology Demonstration Program and DOE's Coal Technology R&D Program. The demonstration program builds upon the R&D by demonstrating the commercial feasibility of the most promising coal concepts emerging from the nation's research and engineering laboratories. For example, pressurized fluidized-bed technology has emerged from the results of government and industry R&D programs. Its demonstration is being financed through cooperative, cost-shared arrangements under the first competition; and the technology has been selected for further scale-up demonstration under the second solicitation.

DOE's Coal Technology R&D Program is broadly based and contains long-term, high-risk research that supports the development of innovative concepts for a wide variety of coal technologies through the proof-of-concept stage. This research is aimed at improving the economics of using coal, improving the environmental performance associated with its use, and increasing its convenience of use by conversion to lower cost substitute fuels. DOE's R&D program includes research in control technologies, combustion systems, coal liquefaction, coal gasification, coal preparation, gas stream clean-up, heat engines, alternative fuels, magnetohydrodynamics, and fuel cells.

This R&D provides a basis for some of the concepts, design, and testing that support the demonstrations. As problems are identified during the demonstration of technologies, R&D programs can develop information for their solution. Further, the demonstration projects may serve as a test bed for verifying solutions to technical problems at a scale unattainable in the laboratory.

1.2 Program Flexibility and New Issues

The flexibility of the program and its responsiveness to newly identified issues and changing demands are clearly evident in the two solicitations completed to date and in the wide range of demonstration projects now in the program. During 1988, however, two concerns

were aired that have had an impact on the planning process implemented to guide the program through the third solicitation and to achieve its overall goals. These issues were global warming and the program's responsibilities to make available the total coal resource base (Western as well as Eastern coal).

1.2.1 Global Warming

A critical environmental issue gaining national attention is the possibility of significant changes in global climate as a consequence of changes in atmospheric concentrations of "greenhouse" gases--most notably carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and chlorofluorocarbons (CFC).

The atmospheric concentration of CO₂ increased 9.5 percent between 1960 and 1986. It is generally agreed that combustion of fossil fuels is the primary contributor, although global deforestation also has been a factor. In 1986, the United States was responsible for 22 percent of the global CO₂ emissions from burning fossil fuels. Of this, electric power generation contributed 35 percent, transportation 30 percent, industrial sources 24 percent, and residential and commercial sectors the remaining 11 percent. It is estimated that approximately 37 percent of the CO₂ emitted in the United States is attributable to the combustion of coal which thus accounts for 8 percent of global CO₂ emissions.

The question of whether the earth is really warming because of the generation of these greenhouse gases is still a matter of debate and scientific analyses. Moreover, there are significant questions about the relative contributions of various human activities. Nevertheless, if scientific evidence ultimately shows that remedial actions are necessary to mitigate climatic change, technologic modernization is an alternative strategy to regulatory constraints.

Clean coal technologies can cut the emission of "greenhouse" gases in two fundamental ways. First, many of the clean coal technologies improve the efficiency of the conversion of coal to useful energy. Technologies such as pressurized fluidized-bed combustors, integrated gasification combined-cycle systems, and fuel cells will consume less coal per unit of useful energy produced and thus reduce relative CO₂ emissions. Second, low-NO_x burners, selective catalytic reduction, and other technologies will reduce NO_x emissions, which should reduce N₂O formation.

If global warming becomes an increasingly important issue, the reduction of emission of greenhouse gases may increase in priority, and the worldwide commercial deployment of clean coal technologies would take on even greater significance.

1.2.2 Western Coal Initiatives

More than half of U.S. coal reserves are located west of the Mississippi River. The largest single source of energy supply in the world is also located in the West in the form of a very low-sulfur coal. The coal producing state of Wyoming has, in addition to many other coal reserves, 60 percent of the enormous Powder River Basin coal reserve.

Western coal producers have targeted expansion of coal markets to include California and other West Coast states as well as the Pacific Rim which comprises the largest growing market for steam coal. Yet numerous barriers--economic and technical--have severely constrained the marketing radius for Western coals.

The first two solicitations for clean coal demonstration projects attracted relatively few proposals from the West, and overall participation in the program by Western entities has been low. On December 2, 1988, DOE held a public meeting in Cheyenne, Wyoming, to learn what obstacles Western interests might be encountering in the clean coal competition and what can be done to increase dramatically the role of Western projects in the program. Over 100 people representing primarily Western interests met with senior executives of DOE's Clean Coal Technology Demonstration and R&D Programs. Recommendations made at the Cheyenne public meeting include: soliciting projects aimed at all

coals, all technologies, and all markets; extending the program to pilot-size plants; placing greater emphasis on NO_x control; allowing technologies that will open new Western markets, including the Pacific Rim; clarifying PON language to make it more understandable; employing a two-phase selection process and allowing discussions between evaluators and proposers; clarifying the repayment provision; assessing cost effectiveness by means of a measure of SO_x and NO_x emissions per unit of energy; and increasing the time allowed for submitting proposals.

In conclusion, the participants pointed out that the language of the second solicitation package was not compatible with Western coal projects. Many technologies aimed at using Western coals are not mature enough for demonstration; more emphasis on R&D of these technologies is needed to bring them to the demonstration stage. Participants also pointed out that state funding is limited in the West and that there is a lack of Western host sites. Also they thought that the cost of preparing proposals is very high and that debriefings are of limited value.

These comments and recommendations are being considered in planning the third solicitation.

1.3 The Technologies

The term "clean coal technology," as used by DOE's Office of Fossil Energy, refers to advanced coal-based systems that offer significant

potential for improved environmental and economic performance in power generation and industrial applications, as well as for other uses.

For power generation, clean coal technologies can improve performance and thermal efficiency and thus dramatically improve the economics of operation. These technologies can be used to minimize the system's environmental impact, and many can be added to the utility in modular fashion to permit the utility to better match supply and demand requirements. The technologies can be designed to use a variety of coals, and they can be used to repower existing coal-fired boilers, extend plant life, increase the plant's power output, and, at the same time, greatly reduce emissions. The clean coal technologies used to address some of the current as well as projected problems in power generating systems include fluidized-bed combustion, integrated gasification combined-cycle systems, and direct coal-fired turbines and diesels.

For pollution control, clean coal technologies can be used to reduce the amounts of sulfur oxides (SO_x), nitrogen oxides (NO_x), and other pollutants discharged from coal burning systems. These technologies can be used for meeting New Source Performance Standards (NSPS) for new boilers more economically than conventional control equipment. Clean coal technologies also are potentially low-cost retrofit devices for meeting state or local environmental requirements for existing units.

Clean coal technologies can include coal conversion processes that have the capability to produce liquid and gaseous fuels for the industrial, commercial, residential, and transportation sectors. These technologies include coal gasification, coal liquefaction, *in-situ* gasification, and coal/oil coprocessing. These technologies have the potential to increase energy efficiencies over currently available technologies as well as increase the use of domestic coal.

Clean coal technologies offer the opportunity to produce usable energy at costs much lower than current state-of-the-art systems. From an environmental standpoint, clean coal technologies open the door to a future of sustained reductions in the acid rain precursors, SO_x and NO_x. Further, the high efficiency offered by some of the technologies will reduce the amount of coal burned and thereby reduce emissions of CO₂ and other greenhouse gases that may be contributing to global warming.

The majority of the clean coal technologies in this program are generally grouped into one of three categories: (1) retrofit technologies which can be used on existing plants to reduce emissions; (2) repowering technologies which replace a significant portion of the original plant and increase the power output of the facility; and (3) conversion technologies which are used to produce liquid and gaseous fuels for industrial, commercial, transportation, and residential markets. Repowering technologies have the

potential to reduce the absolute cost and increase the productivity of power generation, while retrofit options limit the cost increase that would otherwise be imposed by installing more expensive pollution controls. Yet despite this distinction, these options have in common several advantages relative to existing technologies:

- Better integration of emissions control with the coal-based power generation process, thus reducing the complexity and quantity of required equipment while better addressing the range of environmental issues affecting coal
- Simplified process design leading to improved reliability and construction modularity
- Improved flexibility to target the wide range of site-specific requirements associated with variability in coal type, plant design, and operating characteristics
- Production of by-products that are more easily managed and potentially marketable.

1.3.1 Retrofit Technologies

Retrofit technologies, listed in Exhibit 1-1, include concepts such as advanced coal cleaning, limestone injection multistage burners (LIMB), slagging combustors, gas reburning, in-duct sorbent injection, coal-water mixtures, and advanced flue gas clean-up. These technologies, used separately or in combination, can control

Exhibit 1-1 Retrofit Technologies

Pre-Combustion Cleaning	Combustion Modification	Post-Combustion
Physical Fine grinding (micronization) Advanced froth flotation Heavy media cyclones Micronization w/limestone Microbubble flotation Advanced drying	Combustor/Burner Types Slagging combustors Rotary cascading-bed combustors Entrained combustors Limestone injection multistage burners Gas reburning	In-Duct Injection Sorbent injection Catalytic reduction
Physiochemical Molten caustic leaching Organic solvent	Fuel Types Coal-water slurries Coal-gas co-firing Coal-water-gas co-firing	Post-Combustion Devices Vanadium pentoxide afterburners Ternary boiler w/pollutant capture Furnace injection w/water activation reactor Post-combustion oxidation w/fluid-bed lime reactor Fluid-bed absorption
Microbial Bioleaching		Advanced Scrubbers/FGD Devices Spray dryers Regenerable scrubbers Dual alkali scrubbers Electron beam scrubbers Ion exchange membrane FGD Magnesium enhancements NO _x specific scrubbers Electrode precharger enhancements to precipitators High-temperature baghouses

Exhibit 1-2 Repowering Technologies

Fluidized-Bed Combustion	Gasification-Based	Advanced Options
Atmospheric Circulating bed Bubbling bed Pressurized Circulating bed Bubbling bed Hybrid Designs Bubbling-circulating bed Coal pyrolyzer/fluid bed	Gasifier Types Fixed bed Fluid bed Entrained flow Rotary kiln-type Gas Clean-up Systems Conventional "cool" gas clean-up Zinc ferrite hot gas clean-up Ceramic filter clean-up In-situ desulfurization	Gasification w/Fuel Cell Magnetohydrodynamics Direct Coal-Fired Turbines

both SO_x and NO_x. Although some may be less able to reduce sulfur emissions than conventional flue gas scrubbing, these retrofit technologies can reduce levels sufficiently to meet possible future environmental requirements for existing plants.

Commercial acceptance for specific applications will depend on a number of variables including control requirements, cost, and functional criteria, such as plant design and space limitations. These can be particularly important constraints when retrofitting existing plants. Unlike new plants,

where the boiler and emissions controls can be designed as an integrated unit, retrofitting requires adaptation to a plant not designed for such modifications. Nevertheless, retrofitting can become particularly valuable in the event emissions controls are required on existing high-sulfur coal plants. The potential for 40-70 percent reductions in SO₂ and NO_x is attractive under these circumstances. The value of retrofitting is due to lower capital costs, compared to existing controls, as well as reduced

process complexity which simplifies integration with existing plants.

Of increasing interest is the ability of many retrofit technologies to be operated as combined systems. Benefits of such operation can include greater reductions in SO_x and NO_x emissions as well as costs. For example, coal cleaning combined with duct injection and combustion modification can significantly reduce both pollutants. By combining coal cleaning and duct injection, the overall cost of reducing SO_x emissions can be cut for many coals.

The relative benefits of combined systems mainly depend on the sulfur content of the coal and the efficiency of sorbent utilization in the control system. For example, because furnace sorbent injection has a comparatively low sorbent utilization rate, the economics of pollutant reduction are significantly improved when the coal is cleaned first to reduce its sulfur content. Further, using physically cleaned coal in LIMB technology to remove 85-90 percent of the SO_x is more cost effective than burning run-of-mine coal in a plant equipped with a wet limestone flue gas desulfurization system.

Thus, either by themselves or in combination, the advanced technologies have the potential to meet a wide variety of site-specific needs of individual utilities. This includes meeting NSPS and other requirements such as those of State Implementation Plans.

Most of the retrofit technologies are designed to control emissions only. When NSPS were enacted in 1977, Congress anticipated a routine replacement of old and less stringently regulated equipment with new boilers having pollution controls. However, because of regulatory uncertainties, a demand for electricity lower than expected, and the high capital costs of new power generating equipment, electric utility companies are opting to extend boiler life. As a result, the anticipated routine replacement of old, uncontrolled facilities with new, less polluting plants is being delayed.

If new pollution control regulations now being considered are established and the further control of emissions from these older boilers is mandated, the utility industry will be forced to make immediate decisions on control equipment. Utilities would have to choose from today's control options--flue gas scrubbers, coal cleaning, and coal switching. Development of advanced control systems would be delayed. The long-range impact of this delay would be increased power costs and less-than-optimal efficiency in the removal of pollutants. Moreover, the maximum reduction in pollutants would be considerably less than could be achieved with the advanced control systems.

1.3.2 Repowering Technologies

Repowering consists of modifying aging coal-fired electric power plants with a new

Exhibit 1-3 Conversion Technologies

Mild gasification
Gasification with once-through methanol production
Underground coal gasification
Coal liquefaction
Direct
Indirect
Coal/oil coprocessing

generation of environmentally improved, highly efficient coal utilization technologies. This group of clean coal technologies, listed in Exhibit 1-2, includes concepts such as fluidized-bed combustion, gasification combined cycles as well as advanced options such as gasification with fuel cells, and direct coal-fired turbines and diesels.

A repowered coal-fired plant would retain much of its existing solids handling equipment and virtually all of its steam cycle, electrical generating, and power conditioning hardware. Thus, repowering also can be considered part of a life extension program.

From an environmental standpoint, repowering opens the door to a future of sustained deep

reductions in nationwide emissions of SO₂. Repowering concepts are among the cleanest of coal-burning options. Fluidized-bed combustors can eliminate 90-95 percent of the potential sulfur pollutants during the combustion process itself, eliminating the need for post-combustion sulfur controls. Combined-cycle coal gasification systems can remove more than 99 percent of sulfur emissions from coal-derived gases.

Repowering a plant improves its emissions control capability, boosts energy production efficiency, and enhances the cost-effectiveness of operation. Further, these repowering technologies can be used in new plants that will be constructed to satisfy future growth in electric power demand.

However, two key questions must be resolved before commercial acceptance is feasible: (1) proof of their long-term reliability under utility operating conditions and (2) determination of the range of conditions within which they are the most economically attractive.

1.3.3 Conversion Technologies

Coal conversion technologies (Exhibit 1-3) have the capability to produce liquid and gaseous fuels from coal for use in industrial, commercial, residential, and transportation sectors. Surface and underground coal gasification can produce clean fuels and chemical products for use in industrial or utility applications, or as substitute natural gas. Coal liquefaction technologies rely on pyrolysis, direct and indirect liquefaction, and coal/oil coprocessing to convert coal into liquid products. Coal-based alternative fuels also include coal-liquid mixtures, coal-sorbent mixtures, and preprocessed coal.

project selections for the third solicitation would be made in late December 1989.)

- Funds borrowed by REA Electric Cooperatives from the Federal Financing Bank are eligible as cost-sharing in the clean coal technology program.

2.3.2 Public Meetings

Following past practices, public meetings will again be held in preparation for the CCT-III PON. These meetings will take place as follows:

Denver, Colorado	January 18, 1989
Irving, Texas	February 2, 1989
Atlanta, Georgia	February 16, 1989

Procedures similar to those used in the ICCT solicitation will be followed. Each meeting will be started with a brief plenary session during which DOE officials will present program overviews. The audience subsequently will break into small workshops which will run concurrently to facilitate discussions and to make efficient use of the time available. Each group will discuss the same issues. During the closing plenary session, each workshop facilitator will present highlights of the group's discussion and summarize recommendations. As in the earlier meetings, the opening and closing plenary sessions will be transcribed and proceedings published.

Prior to concluding each public meeting, a presentation will be made on DOE procurement

Exhibit 2-3 Overview of Funding for the Clean Coal Technology Demonstration Program (Million Dollars)								
Program Phase	FY86	FY87	FY88	FY89	FY90	FY91	FY92	Cumulative Totals
CCT-I (Budget Authority)	99.4	149.1	149.1					397.6
ICCT (CCT-II) (Budget Authority)			50.0	190.0	135.0	200.0		575.0
CCT-III (Appropriations)					575.0			575.0
CCT-IV (Budget Request)						600.0		600.0
CCT-V (Budget Request)							600.0	600.0
Annual Total	99.4	149.1	199.1	190.0	710.0	800.0	600.0	2,747.6

practices by a member of the Office of Procurement. Following that presentation, a panel composed of members of DOE's Offices of the General Counsel, Business Clearance,

Procurement, and Clean Coal Technology Program will answer all questions received from the attendees.

Exhibit 4-3 Geographic Locations of CCT-I Projects

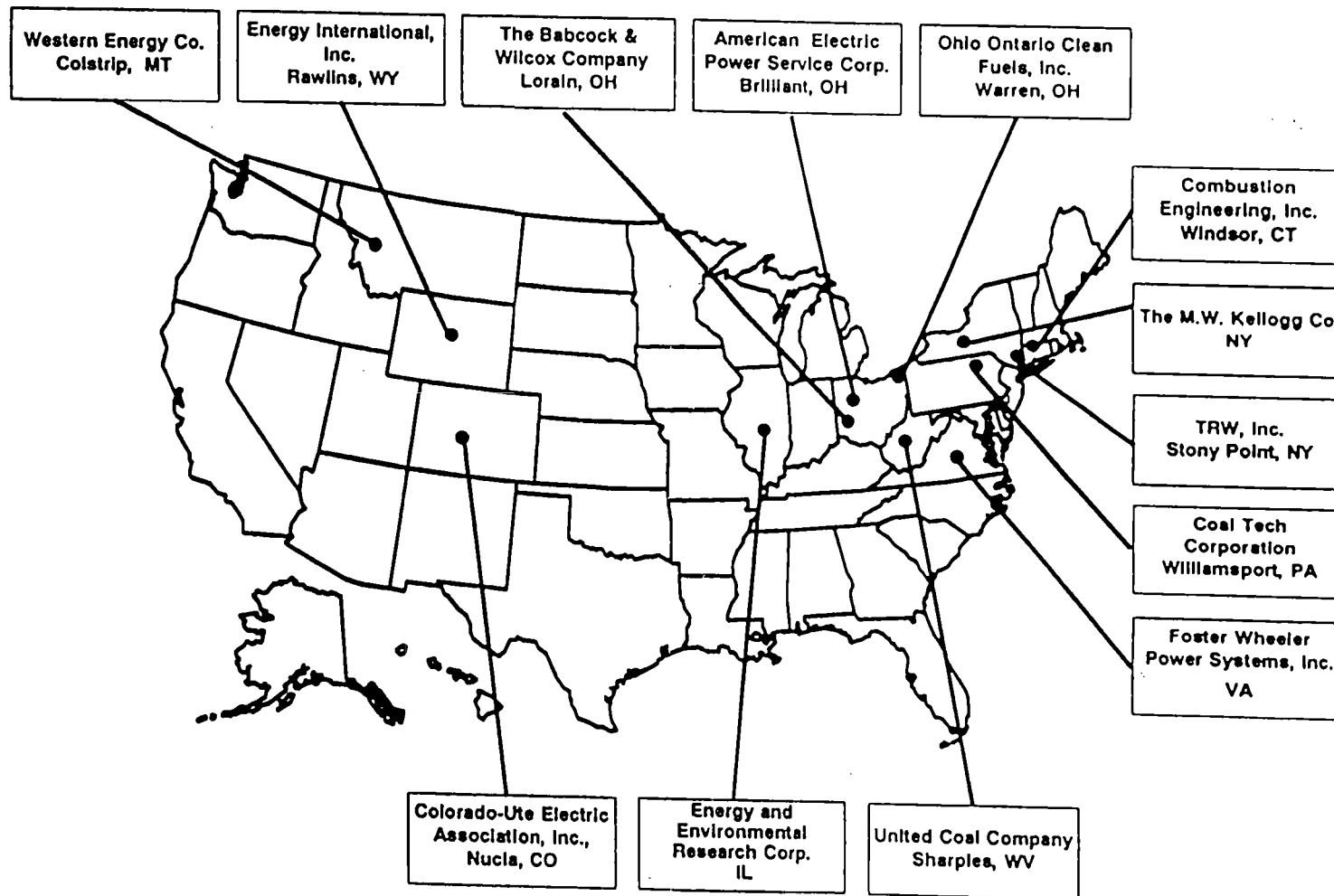


Exhibit 4-2 CCT-I Projects

Project and Industrial Participant	Project Location	Technology
Advanced Cyclone Combustor Demonstration Project (Coal Tech Corporation)	Williamsport, PA	Slagging combustor and sorbent injection into combustor, 1,000 tons of coal per day
Advanced Slagging Coal Combustor Utility Demonstration Project (TRW, Inc.)	Stony Point, NY Cleveland, OH	Advanced slagging coal combustor with NO _x and SO _x control
The Appalachian IGCC Demonstration Project (The M.W. Kellogg Company/Bechtel Development Company)	NY	Fluidized-bed gasification with hot gas clean-up integrated with combined-cycle demonstration plant, 60 MWe
Clean Energy IGCC Demonstration Project (Foster Wheeler Power Systems, Inc.)	VA	Integrated combined-cycle power system for coproduction of power and steam
Gas Reburning/Sorbent Injection Demonstration Project (Energy and Environmental Research Corporation)	Bartonville, Hennepin, and Springfield, IL	Gas reburning and sorbent injection retrofit of three utility boilers, 117 MWe, 80 MWe, 40 MWe
LIMB Demonstration Project Extension (The Babcock & Wilcox Company)	Lorain, OH	Extended test of limestone injection multistage burner plus sorbent duct injection, 105 MWe
Nucla CFB Demonstration Project (Colorado-Ute Electric Association, Inc.)	Nucla, CO	Circulating fluidized-bed combustion, utility retrofit, 100 MWe
Prototype Coal/Oil Coprocessing Project (Ohio Ontario Clean Fuels, Inc.)	Warren, OH	Coal-oil processing 800 tons of coal per day plus residual oil to yield 11,750 barrels of clean distillate liquid per day
Tidd PFBC Demonstration Project (Ohio Power Company)	Brilliant, OH	Pressurized fluidized-bed combustion combined-cycle utility retrofit, 70 MWe
Underground Coal Gasification Demonstration Project (Energy International, Inc.)	Rawlins, WY	Steeply dipping bed underground coal gasification integrated with ammonia plant, 500-1,000 tons for coal per day
Advanced Coal Cleaning Demonstration Project (Western Energy Company)	Colstrip, MT	Advanced coal cleaning process coupled with physical coal cleaning techniques, 1,200 tons of coal per day
Clean Coal Combustion Testing Project (Combustion Engineering, Inc.)	Windsor, CT	Performance testing of cleaned coals including field tests in tangentially and wall-fired combustion systems, 480 tons of coal per day, 200 MWe
Coal Waste Recovery Demonstration Project (United Coal Company)	Sharples, WV	Microbubble flotation and centrifugal drying of coal recovered from refuse disposal impoundment, 385 tons of coal per day

Exhibit 4-5

Geographic Locations of ICCT Projects

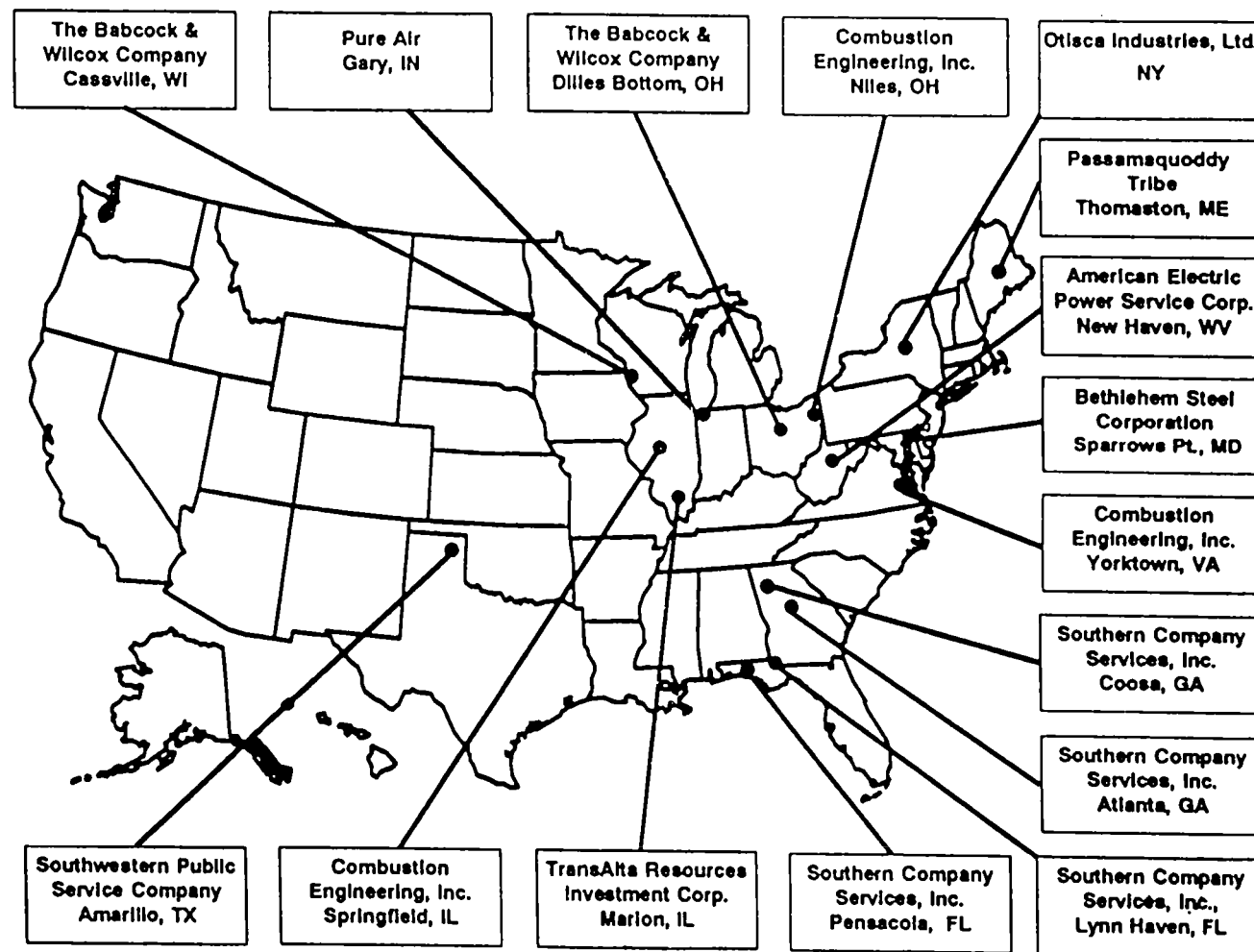


Exhibit 4-4 ICCT Projects

Project and Industrial Participant	Project Location	Technology
Advanced Limestone Scrubber FGDA Demonstration Project (Pure Air)	Gary, IN	Advanced wet limestone FGD, utility retrofit, 500 MWe
Advanced Tangentially Fired Combustion Demonstration Project (Southern Company Services, Inc.)	Lynn Haven, FL	Three in-furnace NO _x control techniques, utility retrofit, 180 MWe
Advanced Wall-Fired Combustion Demonstration Project (Southern Company Services, Inc.)	Coosa, GA	Three in-furnace NO _x control techniques, utility retrofit, 500 MWe
Cement Kiln Gas Cleaning Demonstration Project (Passamaquoddy Tribe)	Thomaston, ME	Recovery scrubber for cement kiln, plant retrofit, 274 tons of coal/day
Coal Reburning in Cyclone-Fired Boilers Demonstration Project (The Babcock & Wilcox Company)	Cassville, WI	Coal reburning for NO _x control, utility retrofit, 100 MWe
Coke Oven Gas Cleaning Demonstration Project (Bethlehem Steel Corporation)	Sparrows Point, MD	Gas stream clean-up of coke oven gas in a steel plant, plant retrofit, 5,687 tons of coal/day
CT-121 FGD Demonstration Project (Southern Company Services, Inc.)	Newnan, GA	Advanced wet limestone FGD, utility retrofit, 100 MWe
IGCC Repowering Project (Combustion Engineering, Inc.)	Springfield, IL	Air blown, dry feed, entrained flow gasifier with limestone injection, integrated combined-cycle, 6.5 MWe.
LNS Burner for Cyclone-Fired Boilers Demonstration Project (TransAlta Resources Investment Corporation)	Marion, IL	Advanced slagging combustor with low NO _x /So _x burner, utility retrofit, 33 MWe
Nichols CFB Repowering Project (Southwestern Public Service Company)	Amarillo, TX	Circulating fluidized-bed combustion, utility retrofit, 250 MWe
OTISCA Fuel Demonstration Project (OTISCA Industries, Ltd.)	Syracuse, Jamesville, Oneida, NY	Ultra-clean coal-water slurry fuel using selective agglomeration process, 360 tons of coal/day
Philip Sporn PFBC Repowering Project (American Electric Power Service Corporation)	New Haven, WV	Bubbling pressurized fluidized-bed combustion with combined cycle, utility repowering, 330 MWe

Exhibit 4-4 (continued) ICCT Projects

Project and Industrial Participant	Project Location	Technology
Post-Combustion Sorbent Injection Demonstration Project (Combustion Engineering, Inc.)	Yorktown, VA	Three dry sorbent injection technologies for SO _x control, utility retrofit, 180 MWe
Selective Catalytic Reduction Demonstration Project (Southern Company Services, Inc.)	Pensacola, FL	Selective catalytic reduction for NO _x control, 7.5 MWe
SOX-NOX-ROX Box Flue Gas Clean-up Demonstration Project (The Babcock & Wilcox Company)	Dilles Bottom, OH	Sorbent injection, selective catalytic reduction, high temperature baghouse, 158 MWe
WSA-SNOX Flue Gas Cleaning Demonstration Project (Combustion Engineering, Inc.)	Niles, OH	Catalytic reduction of SO ₂ and NO _x utility retrofit, 35 MWe

Advanced Tangentially Fired Combustion Demonstration Project (Southern Company Services, Inc.)

Southern Company Services, Inc., will demonstrate three advanced NO_x control technologies for retrofitting tangential-fired, pulverized-coal boilers: (1) advanced over-fire air which consists of deep stage, high-rate air injection, (2) low-NO_x concentric-fired systems, and (3) advanced tangential-fired systems. The advanced NO_x control technologies will be sequentially applied to a single tangential-fired boiler at Unit 2 of Gulf Power Company's Plant

Smith in Lynn Haven, Florida. The 180-MWe demonstration boiler is representative of a large class of tangentially fired boilers.

Advanced Wall-Fired Combustion Demonstration Project (Southern Company Services, Inc.)

Southern Company Services, Inc., will demonstrate three advanced NO_x control technologies for retrofitting wall-fired, pulverized-coal boilers. The three NO_x control technologies are (1) advanced over-fire air (AOFA) which consists of deep stage, high rate air injection, (2) second generation low-NO_x burner (LNB), and (3) LNB with AOFA. The advanced NO_x control technologies will be

sequentially applied to a single furnace, sub-critical, wall-fired boiler at the Georgia Power Company's Plant Hammond, Unit 4, at Rome, Georgia. The 500-MWe demonstration boiler is representative of a large class of wall-fired boilers.

Cement Kiln Gas Cleaning Demonstration Project (Passamaquoddy Tribe)

The Passamaquoddy Tribe will demonstrate a scrubbing system for removing SO₂ emissions from existing coal-burning cement kilns. The project features a recovery scrubber which can reduce SO₂ emissions by over 90 percent. The process uses kiln waste dust as the scrubbing

\$1.3 billion, in Clean Coal Round 3

The Department of Energy on December 21 selected 13 "clean coal technology" projects, adding more than \$1.3 billion in advanced "showcase" ventures to the nation's efforts to combat acid rain and improve the quality of its air.

Admiral James D. Watkins, the Secretary of Energy, announced the selections at a Washington DC press briefing.

Watkins said the projects "will further solidify the U.S.'s technological leadership in a new environmental movement now taking place around the globe. They represent concrete examples that environmental quality can be achieved concurrently with energy security—not instead of it."

The selections were made by the Energy Department in the third round of competition in its *Clean Coal Technology Program*.

The program, an outgrowth of a 1985 U.S.-Canadian agreement to reduce pollutants causing acid rain, will provide more than \$5 billion in public and private financing to build advanced coal-burning facilities during the 1990s. It is the

largest federal energy initiative currently underway.

The 13 projects picked by the department will join 27 other active clean coal ventures selected in two earlier competitions, conducted in 1986 and 1988. Ten states, six east of the Mississippi River and four in the West (including Alaska), will host the new projects. In all, the Clean

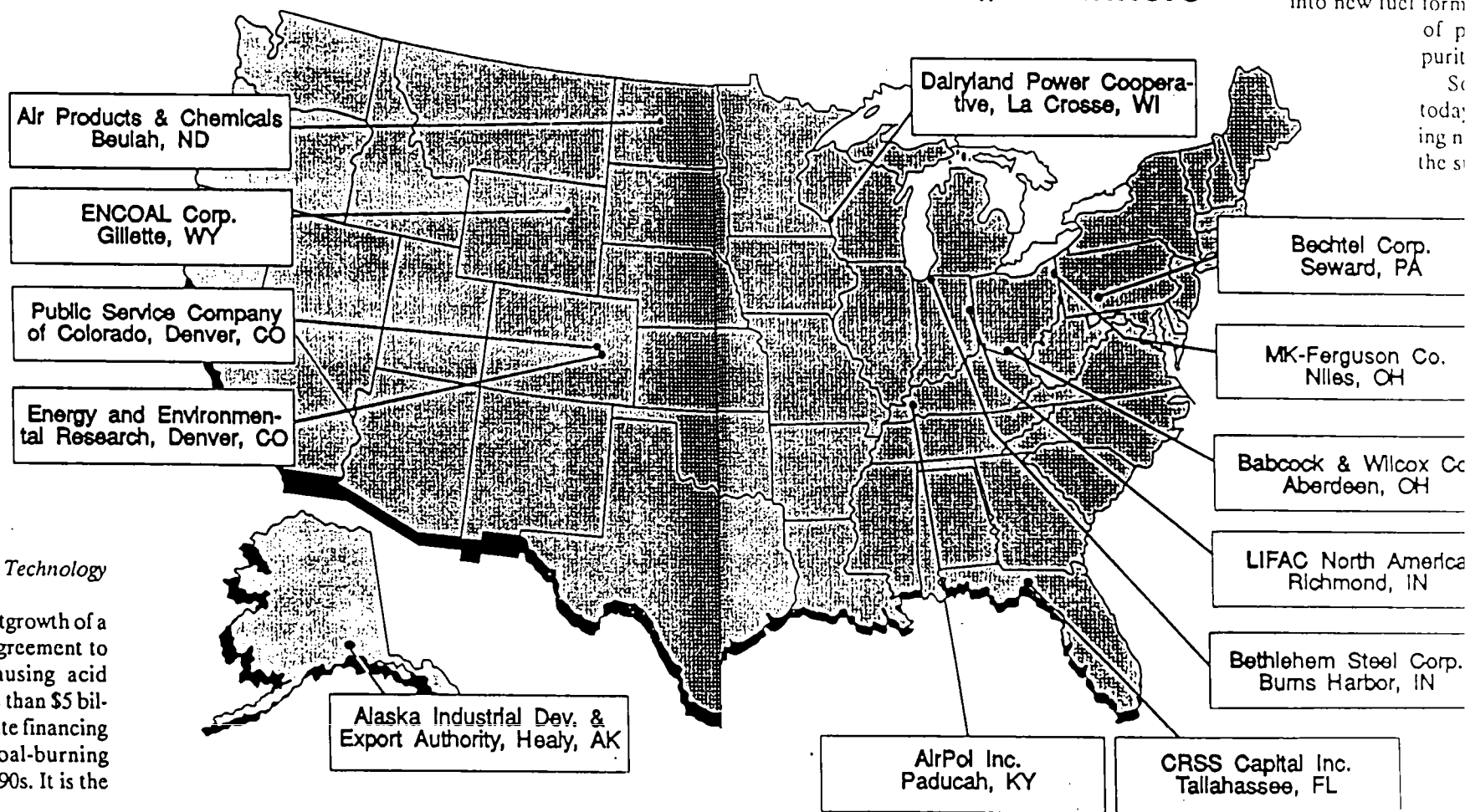
hope for using its most abundant energy resource, coal, while preserving, and improving, the quality of our environment."

President Bush called for an expedited Clean Coal Technology Program last February in his first address to Congress. More recently, the President included provisions in his clean air proposals to encourage commercial use of these innova-

\$777 million will cost and, in some cases, more.

The projects will demonstrate new ways to improve the cleanliness of coal-burning power plants more than today's plants, designed to remove pollutants from the combustion process and demonstrate methods for converting coal into new fuel forms.

Round #3 Winners



Clean Coal Technology Round #3 Selections

AirPol Inc., Teterboro, NJ — AirPol will join with its parent company, FLS miljo of Copenhagen, Denmark, the Tennessee Valley Authority and other future sponsors to demonstrate "gas suspension absorption, an advanced technique for removing sulfur pollutants from the flue gas of coal combustion. The project would take place at the Shawnee Fossil Plant, in Paducah, KY. *Information contact: Richard Rubio, Sales Manager, AirPol Inc., 32 Henry Street, Teterboro, JH 07608, (201) 288-7070.*

Air Products and Chemicals, Inc., Allentown, PA, and Dakota Gasification Company, Beulah, ND — The two firms will install an advanced process for making methanol at the nation's largest commercial coal-to-gas complex, the Great Plains Coal Gasification Plant in Beulah, ND. The process, termed "liquid phase methanol synthesis," will use a portion of the gas produced by the Great Plains facility to produce 500 tons per day of methanol. *Information contact: W.R. Brown, Manager, Syngas Conversion Systems, Air Products & Chemicals, Inc., Allentown, PA 18195, (215) 481-7584.*

Alaska Industrial Development & Export Authority, Anchorage, AK — The proposed demonstration project, the Healy Cogeneration Project, would involve a new coal-fired facility, to be built near Healy, AK, that would produce both electric power and process heat. The facility will incorporate a "slagging coal combustor" developed by TRW Inc. and a heat recovery system that captures excess heat for possible use in an adjacent coal drying pilot facility. *Information contact: W.R. Snell, Project Director, Alaska Industrial Development & Export Authority, Anchorage, AK 99503, (907) 561-8050.*

The Babcock & Wilcox Co., Alliance, OH — Babcock & Wilcox will team with Dayton Power & Light Co, the Electric Power Research Institute, the Ohio Coal Development Office and five other utilities to demonstrate at full scale a newly developed "low NOx cell burner." The burner is designed to cut the release of nitrogen oxide pollutants by 50% to 60% from a boiler type commonly built in the 1960s. The project will take place at Dayton Power and Light's Stuart Station in Aberdeen, OH. *Information contact: Todd I. Johnson, Marketing Specialist, The Babcock & Wilcox Co., Alliance, OH, (216) 829-7355.*

Bechtel Corporation, San Francisco, CA — Bechtel will join with Pennsylvania Electric Co. of Johnstown, PA, to demonstrate the "confined zone dispersion" process for removing both sulfur and nitrogen pollutants from the flue gases exiting a coal-fired boiler. The technique injects a sulfur-absorbing lime slurry into a duct carrying the flue gases from the boiler to an electrostatic precipitator. The project will take place at the Seward Station near the borough of Seward, PA. *Information contact: Jimmie R. Bowden, Manager and Energy and Process Programs, Bechtel Group, San Francisco, CA (415) 768-5986.*

Bethlehem Steel Corporation, Bethlehem, PA — Bethlehem Steel will demonstrate an advanced process for using coal directly in a steel mill blast furnace, rather than the current method of first converting the coal to coke. By eliminating the coke oven, the new process could significantly reduce sulfur dioxide, nitrogen oxide and other noxious emissions. The project is planned for the Burns Harbor Steel Plant, Burns Harbor, IN. *Information contact: Marshall R. Mazer, Government Programs, Bethlehem Steel Corp., Bethlehem, PA 18016 (215) 694-2389.*

CRSS Capital, Inc., Houston, TX — CRSS Capital, in a joint venture with TECO Power Services Corp., Tampa, FL, will design, build and operate an integrated gasification combined cycle power plant at the site of an existing utility plant in Tallahassee, FL. The project will integrate a Lurgi Mark IV gasifier with a GE developmental hot gas clean up system and a GE gas turbine. *Information contact: James T. Stewart, President and CEO, CRSS Capital, Inc., Houston, TX 77027, (713) 552-2000.*

Dairyland Power Cooperative, La Crosse, WI — Dairyland Power will construct a pressurized circulating fluidized bed coal combustor combined cycle system to repower two older generators at the Alma Steam Power Generating Station in Alma, WI. The project will use a fluidized bed combustor supplied by the Pyropower Corp. of San Diego, CA, to generate 40 megawatts of electricity. *Information contact: Richard E. Shimshak, Director-Project Engineering, Dairyland Power Cooperative, La Crosse, WI 54602 (608) 787-1422.*

ENCOAL Corporation, Houston, TX — ENCOAL will be joined by The M.W. Kellogg Co. of Houston, SGI Int. and TEK-KOL, both of La Jolla, CA, and Shell Mining Co. of Houston, in demonstrating a "mild gasification" process at the Triton Coal Company's Buckskin Mine in Campbell County, WY. *Information contact: J.P. Frederick, Staff Mining Engineer, Shell Mining Co., Houston, TX 77252, (713) 870-3148.*

Continued on page 8

Clean Coal Round #4 preparations to begin with San Francisco, Boston meetings

DOE will give industry and the general public an opportunity to offer suggestions for its next round of project competition in the Clean Coal Technology Program at public meetings to be held in San Francisco and Boston.

The San Francisco meeting will take place on Tuesday, February 13, 1990, at the Hilton Square Hotel. The Boston meeting will be held on Thursday, March 1 at the Copley Plaza Hotel.

"We have purposefully scheduled the next Clean Coal public meetings for regions that are not often associated with coal," said Michael R. McElwrath, DOE's acting assistant secretary for fossil energy. "Not only will these meetings allow us to hear from potential proposers, but they give us an opportunity to convey information about new coal innovations to people who may not deal with coal directly."

Scheduling of the Boston meeting follows the recent resolution by New England governors to encourage the development of new technologies "which will allow coal-fired and other generating plants to fur-

ther reduce emissions." The governors, meeting in Portland, Maine, on December 13, called attention to the vulnerability of New England to "the existing and potential effects of air pollution including acid deposition and global climate change."

The fourth round of competition will begin on June 1, 1990, when DOE issues a call for proposals for nearly \$600 million in federal funds.

To prepare the forthcoming solicitation, DOE is especially interested in hearing comments on possible provisions dealing with foreign technology and international participation in clean coal demonstration projects. The department also wants to hear public opinion on the possibility of giving greater attention to projects that reduce the release of gases suspected of contributing to global warming. Other specific issues to be discussed will deal with the repayment of government financial support.

Both day-long meetings will begin at 8:30 a.m. Prospective attendees should contact Ms. Jean Lerch (301) 353-5357.

"Not only will these meetings allow us to hear from potential proposers, but they give us an opportunity to convey information about new coal innovations to people who may not deal with coal directly."

Michael McElwrath

Clean Coal Round #3 Selections (continued)

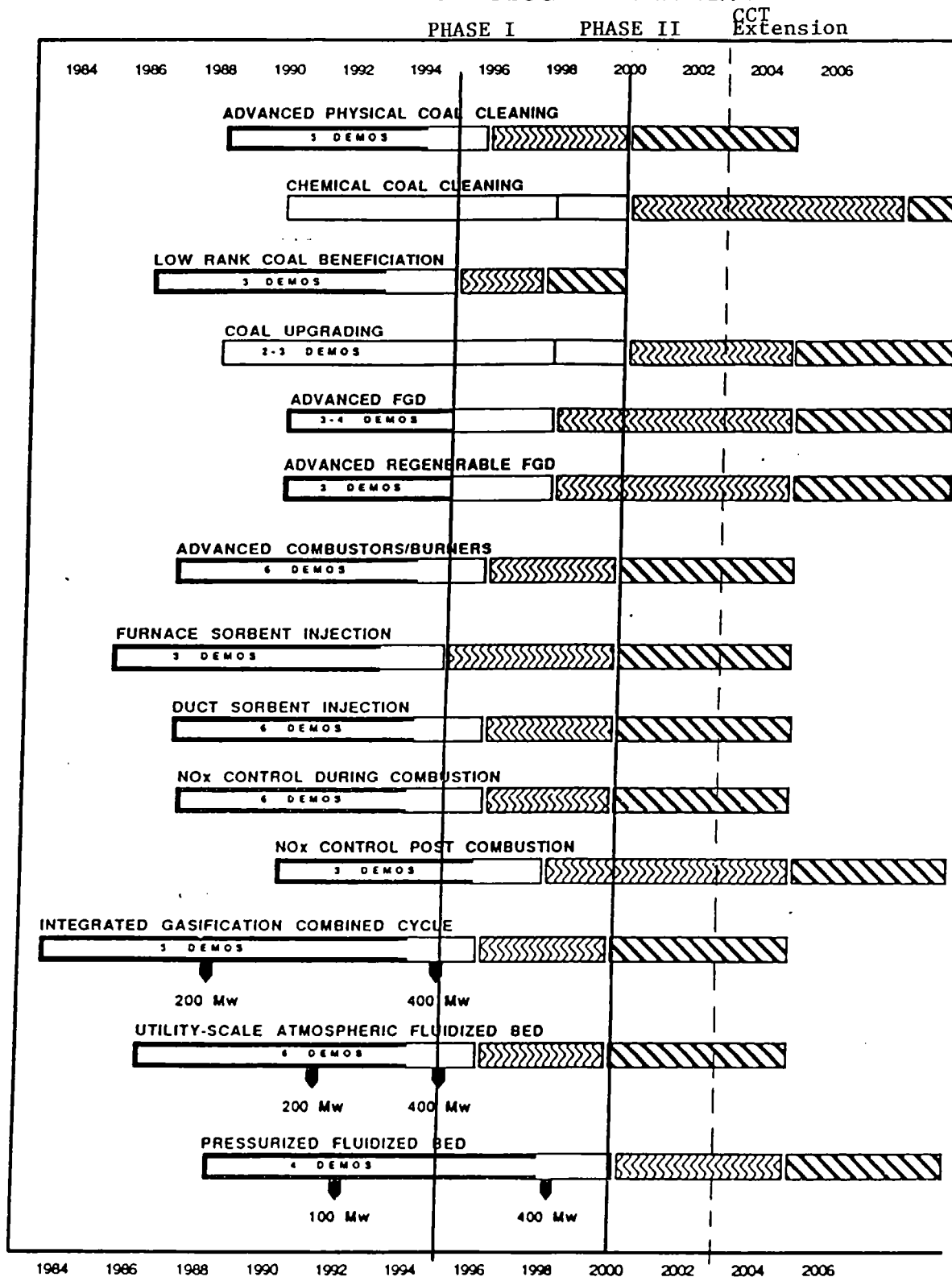
Energy and Environmental Research Corp., Irvine, CA — EER will combine "gas reburning" and low-NOx burners in a demonstration project to reduce nitrogen oxides at a wall-fired utility boiler at Public Service Company of Colorado's Cherokee Power Station near Denver. Combining the gas reburning technique with commercially-available low-NOx burners could reduce NOx emissions by as much as 75%. *Information contact: Dr. Blair A. Folsom, Vice President, Energy and Environmental Research Corp., Irvine, CA 92718, (714) 859-8851.*

LIFAC North America, Oakland, CA — LIFAC-North America is a joint venture of ICF Kaiser Engineers and Tampella Ltd. of Finland. Its demonstration project will test a technique for removing sulfur pollutants in coal flue gases by injecting limestone into the upper regions of a boiler's furnace. A humidification chamber installed between the air preheater and the electrostatic precipitator will adjust the flue gas moisture to obtain optimum levels of sulfur capture. The technique will be tested at Richmond Power and Light's Whitewater Valley Plant, in Richmond, IN. *Information contact: William C. Stitt, President, ICF Kaiser Engineers, Inc., Oakland, CA 94612, (415) 268-6000.*

MK-Ferguson Company, Cleveland, OH — MK-Ferguson, teaming with the NOXSO Corp. and W.R. Grace & Co., will scale up the NOXSO process that employs a porous, regenerable sorbent that captures both SO₂ and NO_x from coal combustion flue gases. The project will take place at Ohio Edison Co.'s Niles Station in Niles, OH. *Information contact: C.W. Hyvonen, Vice President, MK-Ferguson Co., Cleveland, OH 44114, (216) 523-5691.*

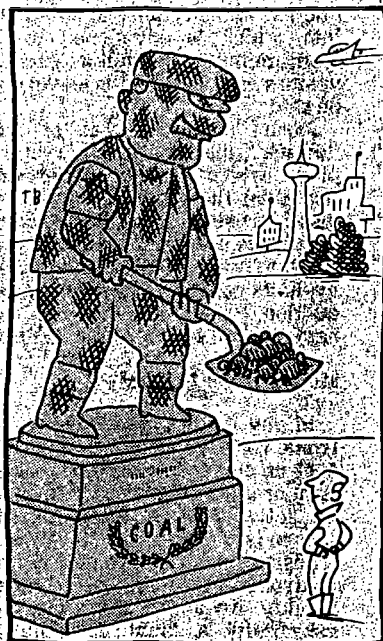
Public Service Co. of Colorado, Denver, CO — The utility will team with several private engineering and research firms to demonstrate a combination of low-NOx burners (applied for the first time in the U.S. to a down-fired pulverized coal burner), urea injection and sulfur-absorbing duct injection at the Arapahoe Steam Electric Generating Station in Denver. *Information contact: George P. Green, Manager, Electric Operation Services, Public Service Company of Colorado, Denver, CO, 80207, (303) 329-1948.*

CLEAN COAL TECHNOLOGY AVAILABILITY



- LEGEND:**
- Demonstration & Deployment Projects Undertaken and Completed
 - Estimated period after demo/deployment projects when Technologies likely to become available for Commercial Order
 - Period of time during which technologies could begin to enter the marketplace as commercial units
 - Period of time when technology could achieve potential widespread commercial use to achieve reductions of air pollutants

A Coal Furnace Delivers Cleaner Heat



Tom Bloom

A clean, efficient and low-maintenance home heating system of the future may run on coal.

Working under a grant from the Department of Energy, a team of engineers at Avco Research Laboratory Inc. of Everett, Mass., has built a coal furnace that produces 100,000 British thermal units an hour, the size commonly found in a single-family home. The combustor bears little resemblance to the coal furnaces of years past, nearly all of which were supplanted by oil and natural gas decades ago.

The classic coal furnace burns continuously, like a fireplace. The Avco design burns closer to the way an engine cylinder burns gasoline — in pulses. A prototype burns for a tenth of a second each second. Combustion takes place at two to four times atmospheric pressure, at very high temperature making for clean and thorough burning with less pollution. Because the burn is so short, there is nearly no time for formation of nitrogen oxide, a major pollutant.

In place of a stoker shoveling coal, a blower delivers pulverized coal automatically. From a cold start, the burner uses natural gas, propane or oil to

reach the right temperature, then runs on coal alone. And coal costs a fraction of the equivalent amount of oil or gas.

The coal burner could run a forced hot air or a radiator system, said Ashok U. Chatwani, a research scientist at Avco. The dimensions of the coal furnace are comparable to those of a gas or oil burner, he said, and the fuel tank need not be much bigger than an oil tank.

The coal would have to be pulverized before delivery and could be brought to the home by a truck, Mr. Chatwani said. It has to be an airtight system, with a pipe connecting it to the tank, so there are no particles of coal flying around in the basement, he said.

The ash is collected in a filter that resembles a vacuum cleaner bag, and must be emptied twice each heating season.

The Avco team thinks the technical problems have been solved, but sees some other difficulties. For example, with only 500,000 home heating customers using coal nationwide, few companies still deliver it in household quantities.

667-5018

Gore

Class of '85 $\rightarrow$ 65% none in TN.

EPA option plans to be most prominent.

- More techs put on the list, more units will get to 2003 to comply
- addresses a very specific need $\rightarrow$ enhance eff / multiple pollutants / $\downarrow$ waste & sludge.

Most retrofit don't meet all these characteristics

Will have to make more concessions $\rightarrow$ Byrd adamant.

extra time
reg. incentives

Criteria must be met to consider

- needs lead time
- to eff.
- more than 1 pollutant
- $\downarrow$ pollutant waste (+ sludge)

* v. good re: Cl_2

Sanit Wheeler tel. conf. 2/15

scrubbers $\rightarrow$ they don't meet these criteria
dry level ash = byproduct
{ 3-7% of units output put to
from the scrubber.

not on 2nd page
"over" delete.

DOE's demonstration techs.

only 16 ^{projects} plants in DOE's Clean coal tech.
program

* want @ least to be able to
continue to use these.

< 40 plants to be affected

make these technologies avail. for
the extension.

stage now → put @ the conceptual

J. Wheeler to find out

① DOE criteria

② has this already been
suggested to Congress

EHV claim

- include "retrofit" in bills
Clean Coal Tech. generation - not just repowering
- why Pres. Gorb. rejected?
- cap busted?

added by House
of 2/4/89

Amendment

to

"Clean Air Act Amendments of 1989"

(S. 1630; December 20, 1989)

Subject:

Restore the incentives provided to qualifying repowered sources under section 508 of the President's bill and expand the scope of that section to include clean coal retrofit and replacement units.

Explanation:

1. What the Bill Requires.

94-
Director
of State
Dept.
Section 409 of the Senate bill provides certain regulatory incentives to existing utility generating units repowering with a qualifying clean coal technology. These incentives include: (i) an extension of the Phase II compliance deadline for sulfur dioxide from January 1, 2000 until December 31, 2003, and (ii) special rules for allocating allowances before and after the repowering technology has been installed. Affected units eligible to receive these incentives include only those units with coal-fired boilers that are being repowered with one of a finite number of specified clean coal technologies that can be applied only at the combustion stage.

2. What the Amendment Does.

The amendment would achieve two purposes. First, it would restore several other clean coal technology incentives contained in section 508 of the Bush Administration's bill (H.R. 3030). These incentives include: (i) a similar extension for achieving the emission reductions of nitrogen oxides; (ii) an exemption from the various new source permitting requirements under section 111 and Parts C and D of the Clean Air Act; and (iii) bonus allowances for repowered units increasing their generating capacity.

Second, the amendment would expand the scope of section 409 to include any unit (not limited to those with coal-fired boilers) that is retrofitted or replaced with a qualifying clean coal technology. "Retrofit" is defined under the amendment to include replacement of all or part of an existing unit with equipment or facilities utilizing a clean coal technology at the same site. "Replace" is defined to include the replacement of an

existing unit with a new clean coal unit that is located at a different site, provided that (i) the existing unit will be retired from service on or before the date on which the designated unit enters commercial service, and (ii) the replacement unit is either owned or operated by the same utility that owns or operates the existing unit or located in the same air quality control region as the existing unit.

In addition, the amendment would adopt the definition of clean coal technology set forth in section 515 of the President's bill (H.R. 3030). Under this definition, the types of qualifying clean coal technologies would be expanded to include any type of precombustion, combustion, postcombustion technology that achieves significant emission reductions of sulfur dioxide or nitrogen oxides and is not in widespread use.

Under this amendment, clean coal retrofit units would qualify for the extension of Phase II deadlines, and would be subject to the same emission control and allowance provisions as section 508 of the President's bill now provides for repowered units. Units replaced by a new clean coal unit also would receive the extension of the Phase II deadlines and similar treatment for allowances as retrofitted units. However, they would not be exempt from any of the new source permitting requirements under section 111 or Parts C and D of the Act.

Amendment:

Page 451, strike out lines 4 through 11 and insert in lieu thereof the following:

"(1)(A) The term 'clean coal technology' means any technology including technologies applied at the precombustion, combustion, or postcombustion stage, at a new or existing facility which will achieve significant reductions in air emissions of sulfur dioxide or oxides of nitrogen associated with the utilization of coal in the generation of electricity, process steam, or industrial products, which is not in widespread use as of the date of enactment of this title.

"(B) The term 'clean coal unit' means a unit that utilizes a clean coal technology.

"(C) The term 'retrofit' means to install a clean coal technology at an existing unit. Such term includes replacement of all or part of an existing unit with equipment or facilities utilizing a clean coal technology at the same site.

"(D) The terms 'replace' and 'replacement' mean to replace an existing unit with a new clean coal unit which is located at a different site, but only if (i) the new unit is designated under

section 409(a) to replace such existing unit, (ii) the existing unit will be retired from service on or before the date on which the designated unit enters commercial service, and (iii) the designated unit is (I) owned or operated by the same person that owns or operates the existing unit (or by an affiliate of such person) or (II) located in the same air quality control region as the existing unit.

Page 478, strike out line 17 and insert in lieu thereof the following:

"SEC. 409. CLEAN COAL RETROFIT AND REPLACEMENT UNITS.

Page 478, strike out line 22, and insert in lieu thereof the following: "retrofitted as a clean coal unit or replaced with a clean coal unit designated by the owner or operator of the existing unit, for purposes of complying".

Page 478, line 23, insert "or 407" after "section 405".

Page 478, line 26 to line 1 on Page 479, strike out "repowering" and insert "retrofit or replacement".

Page 479, line 2, strike out "to repower" and insert "for".

Page 479, line 7, strike out "that unit" and insert "the unit to be retrofitted or replaced".

Page 479, insert after line 13 the following section and reorder all subsequent sections as appropriate:

Q = must cap? (c) CONTROL REQUIREMENTS.--(1) Any source that is retrofitted as a clean coal unit qualifying for an extension under this section ("qualifying source") shall not be required to meet any standard of performance under section 111. Any qualifying source that will not increase emissions of any pollutant relative to its pre-repowering level, as measured by its potential to emit, expressed as mass per unit of time, shall not be subject to the requirements of parts C and D of this Act for that pollutant. *? over and under? shift activities?*

(2) Any qualifying source that will increase emissions of a pollutant relative to its potential pre-repowering level shall not be subject to the requirements of parts C and D of title I of this Act for that pollutant: Provided that the owner or operator of such source submits information sufficient to demonstrate to the Administrator (in consultation with the Federal land manager with respect to subparagraph (C) below) that the increased emission level will not:

"(A) cause or contribute to an exceedance in any area of any national ambient air quality standard or any of maximum allowable increase in concentrations established under part C of the Act; or

"(B) interfere with reasonable further progress within the meaning of part D of title I; or

"(C) result in an adverse impact on visibility or air quality related values in any class I area under part C of title I.

Upon receipt of a complete submission, the Administrator shall determine within 90 days whether the requirements of subparagraphs (A) through (C) have been met.

Page 479, line 21, strike out "The" and insert "In the case of any existing unit that is to be retrofitted as a clean coal unit, the".

Page 479, line 25, strike out "repowering" and insert "clean coal".

Page 480, line 4, strike out "repowering" and insert "clean coal".

Page 480, strike out lines 7 through 10 and insert in lieu thereof the following:

"(3) Except as provided in paragraph (4), allowances for calendar year after the year the retrofit or replacement is complete shall be based on 1.20 lb./MMBtu of sulfur dioxide multiplied by the baseline.

"(4) In lieu of meeting the requirements of paragraph (3), the owner or operator of such unit may elect to receive allowances calculated as the sum of the following:

"(A) 1.2 lb./MMBtu emission rate multiplied by the baseline, divided by 2,000, and

"(B) the annual equivalent emission rate required by the standard under section 111 that would apply in the absence of subsection (c)(1) of this section, multiplied by the difference between the nameplate electric generating capacity of the unit after retrofit or replacement and the nameplate capacity prior to retrofit or replacement, multiplied by the heat rate of the retrofit or replacement unit, multiplied by 3.1.

"At such time as a replacement clean coal unit enters commercial service, any allowances otherwise available to the existing unit it is designated as replacing shall expire (notwithstanding section 403(a))."

Amendment

to

"Clean Air Act Amendments of 1989"

(S. 1630; December 20, 1989)

Subject: Establish a "safe harbor" list of clean coal technologies eligible for the Phase II extension.

Explanation:

1. What the Bill Requires.

The bill does not identify with particularity the types of clean coal technologies that would be eligible for the Phase II extension under section 409(b). Rather, the bill contemplates that the permitting authority will determine the eligibility of a particular clean coal technology on a case-by-case basis during the permitting process. This regulatory approach creates considerable uncertainty as to whether a particular innovative control technology selected by an owner or operator of an affected unit will in fact qualify for the section 409(b) extension.

2. What the Amendment Does.

The amendment would require the Secretary of Energy, in consultation with the Environmental Protection Agency, to publish a list of clean coal technologies that would be eligible for the Phase II extension. Although this list would establish a "safe harbor" list of eligible technologies, owners and operators intending to apply for a Phase II extension would be free under section 409(a) to demonstrate to the permitting authority that another technology not listed by the Secretary of Energy also qualifies as a clean coal technology. Under the amendment, approval for the clean coal technology is obtained once (i) the owner or operator of an affected unit submits a Phase II permit application and compliance plan under section 408(b) identifying a listed clean coal technology as the control technology to be used to achieve Phase II emission reductions for the facility, and (ii) the permitting authority approves that application and compliance plan under section 408(d).

Amendment:

Page 479, line 3, insert after the period the following:

If the owner or operator of an existing unit proposes to retrofit or replace such unit with a clean coal unit that uses a clean coal technology listed under subsection (f), and such proposed retrofit or replacement is incorporated in a compliance plan under section 408(b) and an approved permit under section 408(d), approval of such permit shall be deemed to satisfy the requirements of the first sentence of this subsection.

Page 257, insert after line 19 the following:

"(f) Clean Coal List. -- Not later than December 31, 1992, the Secretary of Energy, after consultation with the Administrator shall publish (and may from time to time thereafter revise) a list of technologies that meet the requirements of section 402(1)(A). Inclusions on such list is not a prerequisite to qualification as a clean coal technology.

Amendment

to

"Clean Air Act Amendments of 1989"

(S. 1630; December 20, 1989)

Subject: Extend the Phase II compliance deadline until December 31, 2005.

Explanation:

1. What the Bill Requires.

Owners and operators of affected utility generating units using eligible clean coal technologies have until December 31, 2003 to achieve the Phase II emission reductions for sulfur dioxide and nitrogen oxides.

2. What the Amendment Does.

The amendment would extend the compliance deadline for achieving the Phase II emission deadlines for affected units using clean coal technologies for an additional two years, until December 31, 2005. Without this additional two-year extension, the use of clean coal technologies would most likely not be a viable Phase II compliance option for many utilities. The extension will provide utilities with additional time to demonstrate, deploy, and make available for widespread commercial use the suite of innovative technologies now being developed under the Department of Energy's five-year and \$5 billion clean coal program.

Amendment:

Page 479, line 7, strike out "2003" and insert "2005".

Amendment

to

"Clean Air Act Amendments of 1989"

(S. 1630; December 20, 1989)

Subject: Allow Phase II extension to continue in the event that a clean coal technology proves to be economically or technologically infeasible.

Explanation:

1. What the Bill Requires.

An extension of the Phase II compliance deadline is provided under section 409(b) for owners and operators of affected units that elect to use a clean coal technology to achieve the mandated emission reductions. The bill, however, is unclear as to the availability of that extension if a particular clean coal technology being deployed at an affected unit proves to be either economically or technologically infeasible.

2. What the Amendment Does.

The amendment would clarify this issue. Specifically, an extension granted under section 409(b) would continue if the owner or operator demonstrates to the Environmental Protection Agency that (i) the clean coal technology initially selected is economically or technologically infeasible, and (ii) the mandated emission reductions for the affected unit will be achieved through the installation of another clean coal technology or other available control technology. The extension, however, would continue under these circumstances only for so long as the Environmental Protection Agency determines is necessary to install the alternate emission control equipment or facilities. In addition, the amendment makes clear that the emission control requirements under section 409(c) and the allowance provisions under section 409(d) would not apply if the owner or operator of the affected unit decides to use a conventional (rather than clean coal) technology to achieve the mandated emission reductions.

Amendment:

Page 479, line 4, insert "(1)" after "Extension.--".

Page 479, insert after line 13 the following:

"(2) If (A) the owner or operator of an existing unit has been granted an extension under paragraph (1) in order to retrofit or replace such unit with a clean coal unit, and (B) such owner or operator thereafter satisfies the Administrator (i) that the clean coal technology to be utilized by such unit is economically or technologically infeasible, and (ii) that such existing unit will be retrofitted or replaced with equipment or facilities utilizing another clean coal technology or other available control technology, then such extension shall continue to be available for the period the Administrator determines is necessary to install such equipment or facilities. Subsections (c) and (d) of this section shall be inapplicable after the expiration of such extension unless the existing unit is retrofitted as or replaced with a clean coal unit.

Amendment

to

"Clean Air Act Amendments of 1989"

(S. 1630; December 20, 1989)

Subject: Restore the clean coal technology incentives proposed under Section 515 of the President's bill and expand the types of clean coal demonstration projects eligible to receive Federal regulatory rate incentives proposed under that section.

Explanation:

1. What the Bill Requires.

The Senate Committee on Environment and Public Works eliminated entirely the suite of clean coal technology incentives proposed under section 515 of the Bush Administration's bill (H.R. 3030). Briefly these incentives include: (i) a five-year demonstration program that would provide Federal regulatory rate incentives, such as an incentive rate of return for qualifying clean coal technologies, and a 10-to-20 year rate of amortization period to recover capital costs of such technologies; (ii) preapproval of prudence for clean coal technology projects that incur project-related costs within prenegotiated cost limitations; (iii) an exemption from some or all of new source permitting requirements under section 111 and Parts C and D of the Clean Air Act; and (iv) declaration as Federal policy that States are encouraged to adopt certain enumerated regulatory incentives.

2. What the Amendment Does.

The Amendment would restore the clean coal technology incentives set forth in section 515 of the President's bill (H.R. 3030). These incentives would encourage utilities to develop, deploy and make available for widespread commercial use innovative clean coal technologies in order to achieve the emission reductions mandated under Title IV of the Senate bill.

In addition, the amendment would expand the types of demonstration projects eligible to receive the Federal regulatory rate incentives to include: (i) any clean coal demonstration project funded by the Department of Energy or the Environmental Protection Agency, and (ii) any project using a clean coal technology that has been listed by the Department of Energy as a

technology eligible for the Phase II extension under section 508 of the bill. Such a change would further promote the Federal government's commitment to promote the development of innovative control technologies that limit power plant emissions.

Amendment:

"SEC. 415. CLEAN COAL TECHNOLOGY REGULATORY INCENTIVES.

"(a) FEDERAL RATE INCENTIVES.--(1) Within 24 months after enactment of this section, the Federal Energy Regulatory Commission shall complete a rulemaking to establish a demonstration program for regulatory incentives to promote the development of clean coal technologies and other innovative control technologies that limit powerplant emissions. The regulatory incentives shall include--

"(A) establishment of an incentive rate of return for clean coal or other innovative emission control technologies that recognizes their inherent risk; and

"(B) allowance of a 10-to-20-year amortization period to recover the capital costs of a clean coal or other innovative emission control technology.

"(2) The Federal Energy Regulatory Commission demonstration program is subject to the following--

"(A) the program initially will have a 5-year life;

"(B) the program will cover each clean coal technology demonstration project (as defined in subsection (c)(1)) and any clean coal unit using a clean coal technology listed pursuant to Section 402(1)(A)(ii); and

"(C) the technology classes eligible for the program should be reasonably likely to realize significant cost reductions when employed.

"(3) At the end of the 5-year demonstration program, the Federal Energy Regulatory Commission shall review the merits of the program and determine whether it should be extended or made permanent.

"(b) FERC PREAPPROVAL OF PRUDENCE FOR CLEAN COAL TECHNOLOGY COSTS.--The Federal Energy Regulatory Commission shall establish a process for negotiating with potential developers of clean coal technology or other innovative control technology projects to agree upon cost caps for future projects and preapproval of the

prudence of expenses for those projects if the expenses fall within the agreed-upon cap.

"(c) REVISED REGULATIONS FOR CLEAN COAL TECHNOLOGY DEMONSTRATIONS.--(1) The Administrator shall promulgate regulations under this subsection to revise requirements under section 111 and parts C and D of the title I, as appropriate, to facilitate temporary and permanent clean coal demonstration projects, consistent with the attainment and maintenance of national ambient air quality standards and prevention of significant deterioration as provided in paragraphs (2) and (3). Such regulations shall address physical or operational changes to existing facilities for the sole purpose of installation, operation, cessation, or removal of a clean coal technology demonstration project. For the purposes of this section, a clean coal technology demonstration shall mean a project conducted under title II, section 101(d) of the Further Continuing Appropriations Act of 1985 (section 5903(d) of title 42 of the United States Code), or subsequent appropriations, up to a total amount of \$2,500,000,000 for commercial demonstration of clean coal technology, or similar projects funded through appropriations for the Environmental Protection Agency. The Federal contribution for a qualifying project shall be at least 20 percent of the total cost of the demonstration project.

"(2) TEMPORARY PROJECTS.--Installation, operation, cessation, or removal of a temporary clean coal technology demonstration project that is operated for a period of five years or less, and which complies with all State implementation plans and other requirements necessary to attain and maintain the national ambient air quality standards during and after the project is terminated, shall not subject such facility to the requirements of section 111 or part C or D of title I.

"(3) PERMANENT PROJECTS.--(A) For permanent clean coal technology demonstration projects, any qualifying project shall not be subject to standards of performance under section 111.

"(B) Any permanent demonstration project that complies with all State implementation plans and other requirements necessary to attain and maintain the national air quality standards shall not be subject to the requirements of part C or D of title I: Provided that the project will not result in an increase, relative to its predemonstration levels, as measured by its potential to emit, expressed as mass per unit of time, of any pollutant regulated under this Act. For any project that will result in an increase in potential emissions of any such pollutant, the owner or operator and the Administrator shall follow the procedure specified in section 409(c)(2) for that pollutant.

"(4) PREEXISTING REQUIREMENTS.--Any clean coal demonstration technology project shall be subject to its preexisting obligations under this Act until such time as it qualifies under regulations implementing this section for alternate requirements.

"(d) ENCOURAGEMENT OF STATE INCENTIVE PROGRAMS.--Because the use of clean coal technologies is in the national interest, States, including their agencies and political subdivisions which regulate public utility rates and charges, are encouraged to provide additional incentives for their implementation. Those incentives may include, but are not limited to--

"(1) preapproval of recovery of capital costs and other expenses, within reasonable bounds agreed upon before project construction;

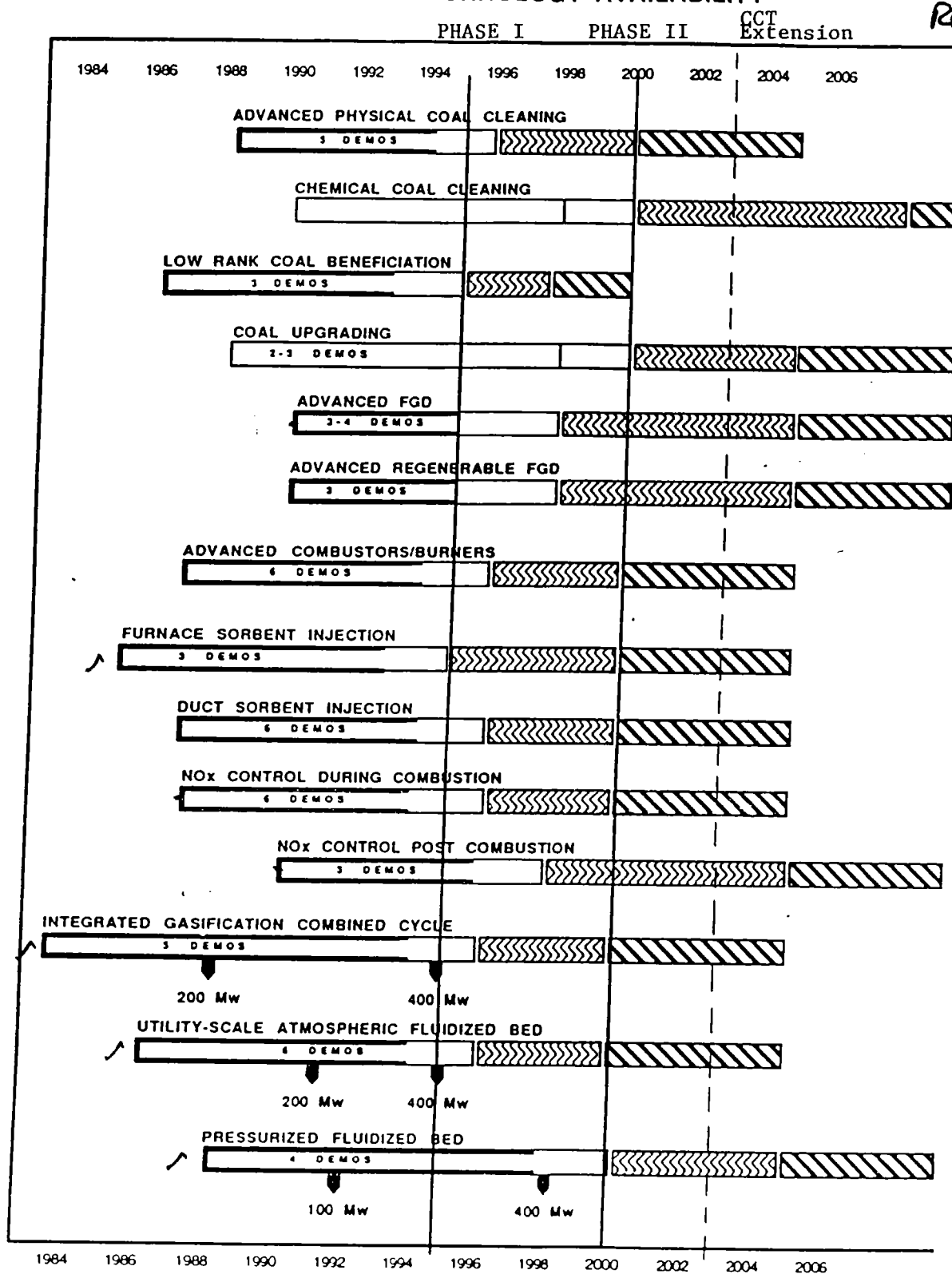
"(2) elimination of retroactive 'used and useful' reviews for clean coal technologies;

"(3) rapid amortization of clean coal technology expenditures; and

"(4) immediate recovery of a portion of clean coal technology expenses through a fuel adjustment clause or by some other method."

CLEAN COAL TECHNOLOGY AVAILABILITY

*Repairing
Retrofit*



- LEGEND:**
- Demonstration & Deployment Projects Undertaken and Completed
 - Estimated period after demo/deployment projects when Technologies likely to become available for Commercial Order
 - Period of time during which technologies could begin to enter the marketplace as commercial units
 - Period of time when technology could achieve potential widespread commercial use to achieve reductions of air pollutants

**SOUTHERN ELECTRIC SYSTEM
CLEAN COAL TECHNOLOGIES**

In the recent Innovative Clean Coal Technology solicitation by the Department of Energy (the second such solicitation), the Southern electric system submitted four of the sixteen projects selected by DOE for funding. These four projects amount to almost \$71 million of which The Southern Company will contribute almost \$26 million. The common purpose of each of the four Southern electric system projects is to produce more reliable performance and more accurate cost information on these retrofit technologies.

1. **Demonstration of the Chiyoda Thoroughbred-121 Flue Gas Desulfurization System**

This \$36.3 million project will test the retrofit of an SO₂ scrubber to Georgia Power's 100MW Plant Yates Unit #1, south of Atlanta. The scrubber will incorporate fiberglass as a corrosion resistant material in its single absorbing vessel and will produce a gypsum byproduct rather than the traditional calcium sulfite waste material. It will achieve over 90% SO₂ reduction.

2. **Demonstration of Advanced Wall-Fired Combustion Techniques for Reducing NO_x**

This \$10.7 million project will test the performance of NO_x reduction techniques and hardware for wall-fired units through low cost combustion air changes and higher cost burner retrofitting at Georgia Power's 500MW Plant Hammond Unit #4 near Rome, Georgia. Approximately two-thirds of the Southern electric system boilers are wall-fired.

3. **Demonstration of Advanced Corner-Fired Combustion Techniques for Reducing NO_x**

This \$8.6 million project will test the performance of NO_x reduction techniques and hardware for corner-fired units through low cost combustion air changes and higher cost burner retrofitting at Gulf Power's 180MW Plant Lansing Smith Unit #2 near Panama City, Florida. Approximately one-third of the Southern electric system units are corner-fired.

4. **Demonstration of Selective Catalytic Reduction Technology for the Postcombustion Reduction of NO_x**

This \$15.6 million project will test the performance of several types of NO_x conversion catalysts on 10MW of flue gas from either Unit #5 or Unit #6 of Gulf Power's Plant Crist near Pensacola, Florida. Selective catalytic reduction technology is of interest because of its higher NO_x removal potential (up to 90%).

03-07-89

SOUTHERN COMPANY

	<u>COOPER</u> <u>(H.R. 144)</u>	<u>BONKER</u> <u>(H.R. 5562)</u>
Peak Year	2005	2003
Increase	\$1.06 billion	\$1.055 billion
% Increase	6.6%	7.5%
Cumulative (through 2013)	\$12.7 billion	\$15.7 billion
Present Value	\$2.68 billion	\$3.92 billion
Scrubbing	6,271 MW	11,228 MW
Fuel Switching	7,069 MW	2,570 MW

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Innovative Clean Coal Technology Deployment

November 1988

THE NATIONAL COAL COUNCIL

H.R. 3030 and S. 1630 Amendment

Greenfields Offsets

The greenfields provision requiring SO₂ offsets for new utility units, in concert with the allowance system, will have disparate regional impacts, potentially stifling economic growth in some States. This results because the proposed legislation would allocate the bulk of allowances to utilities which have large, coal-fired units. Utilities in States and regions which are experiencing rapid economic growth tend to be those utilities which have added or are adding generating capacity subject to more restrictive emission limitations for new sources (new source performance standards) or which use less-polluting oil- or gas-fired units. Consequently, the ability of these latter utilities and the States they serve to produce allowances for additional capacity additions is diminished.

However, even larger utilities, such as TVA, that may be able to free up allowances used by their older units to offset emissions for their own capacity additions can only do so at a significant cost. If TVA fulfills all of its presently projected capacity (6500 MW) needs with new coal-fired units, its total annual compliance costs under the legislation will increase by CY 2010 from \$600 million to \$750 million under H.R. 3030 and from \$750 million to \$900 million under S. 1630 (1990 \$).

To avoid these problems and additional costs, the greenfields provision could be eliminated. However, this provision is viewed as essential to prevent backsliding from the 10-million-ton SO₂ reduction goal and as an important inducement to making the allowance system work. Alternatives to elimination of the provision should be considered. One such alternative would be to partially or fully exclude from the provision SO₂ emissions from new units employing a clean coal technology. Those technologies capable of achieving a sulfur dioxide removal efficiency of 97 percent or a sulfur dioxide emission rate of 0.2 lbs/106 Btu (on an annual basis) should be fully excluded from the offset requirement. Those clean coal technologies which are not capable of achieving either of those levels should be required to only offset the difference between what they can achieve and the specified level. For example, if a new fluidized bed combustion unit can only achieve a removal efficiency of 95 percent, it would be required to offset (obtain allowances) for 2 percent of its uncontrolled emissions (97-95).

Unless compensated for by other changes, this sliding exclusion would result in some degree of backsliding from the 10-million-ton reduction goal. However, the specified removal efficiency and emission rates are

*Q = want
CIP
yes*

*std should just be whether meet emission lbs.
* but Q: meeting Q2 → thought old were only
to meet 1.2 → shouldn't this be well - below?? →
yes → but is x so that will have to be offset.*

→ difference of Southern is that I want all plants
using clean coal techs. to ~~achieve~~ get extension.

so stringent that the increase in emissions will be small and may be compensated for if reductions are required from other acid rain sources such as industrial boilers. More significant, such a change will provide a safety valve for new growth while fostering development and deployment of clean coal technologies. This safety valve will also provide an automatic check on any anticompetitive hoarding of allowances. A small power producer unable to obtain sufficient allowances from a larger utility at a reasonable price could employ a clean coal technology rather than a conventional technology with the approach proposed here. Finally, this limited modification of the greenfields provision will alleviate the pressure to scrap or substantially change the allowance system before it has had an opportunity to work.

H.R. 3030

Amend Section 503(e) (page 263, lines 4-12):

"(e) NEW ELECTRIC STEAM UNITS.—The owner or operator of each new steam electric unit, except for those new units employing a clean coal technology (as defined in section 515(a)), must hold allowances equal to the annual tonnage of sulfur dioxide emitted by the unit, after December 31, 2000. Such new units shall not be eligible for an allocation of sulfur dioxide allowances under subsection (a). An owner or operator of a new unit employing a clean coal technology must hold allowances equal to the annual tonnage of sulfur dioxide emitted by the unit at rates greater than 0.2 lbs/10⁶Btu or with a removal efficiency of less than 97 percent. Notwithstanding the geographic limitations on transfers of allowances in subsection (b), such new units may obtain allowances from any unit allocated allowances under this title.

S. 1630

Amend Section 403(e) (page 456, lines 7-20):

"(e) NEW UTILITY UNITS.—The owner or operator of each new utility unit, except for those new units employing a clean coal technology (any technology, including technologies applied at the precombustion, combustion, or postcombustion stage, which will achieve significant reductions in air emissions of sulfur dioxide or oxides of nitrogen associated with the utilization of coal in the generation of electricity, process steam, or industrial products, which is not in widespread use as of the date of enactment of this title), must hold allowances equal to the annual tonnage of sulfur dioxide emitted by such unit after January 1, 2000. Such new utility units shall not be eligible for an allocation of sulfur dioxide allowances under subsection (a). An owner or operator of a new unit employing a clean coal technology must hold allowances equal to the annual tonnage of sulfur dioxide emitted by the unit at rates greater than 0.2 lbs/10⁶Btu or with a removal efficiency of less than 97 percent. Notwithstanding the geographic limitations on transfers of allowances in subsection (b), new utility units may obtain allowances from any unit allocated allowances under this title. After January 1, 2000, it shall be unlawful for any new utility unit to emit sulfur dioxide in an amount exceeding the allowances the owner or operator of such unit holds for such unit. The owner or operator of any new utility unit in violation of this subsection shall be liable for fulfilling the obligations specified in section 411 of this title.

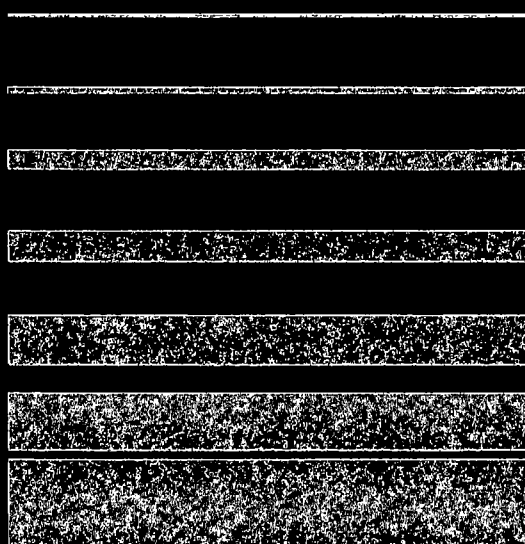
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CLEAN COAL TECHNOLOGY



The New Coal Era

U.S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY FOR FOSSIL ENERGY



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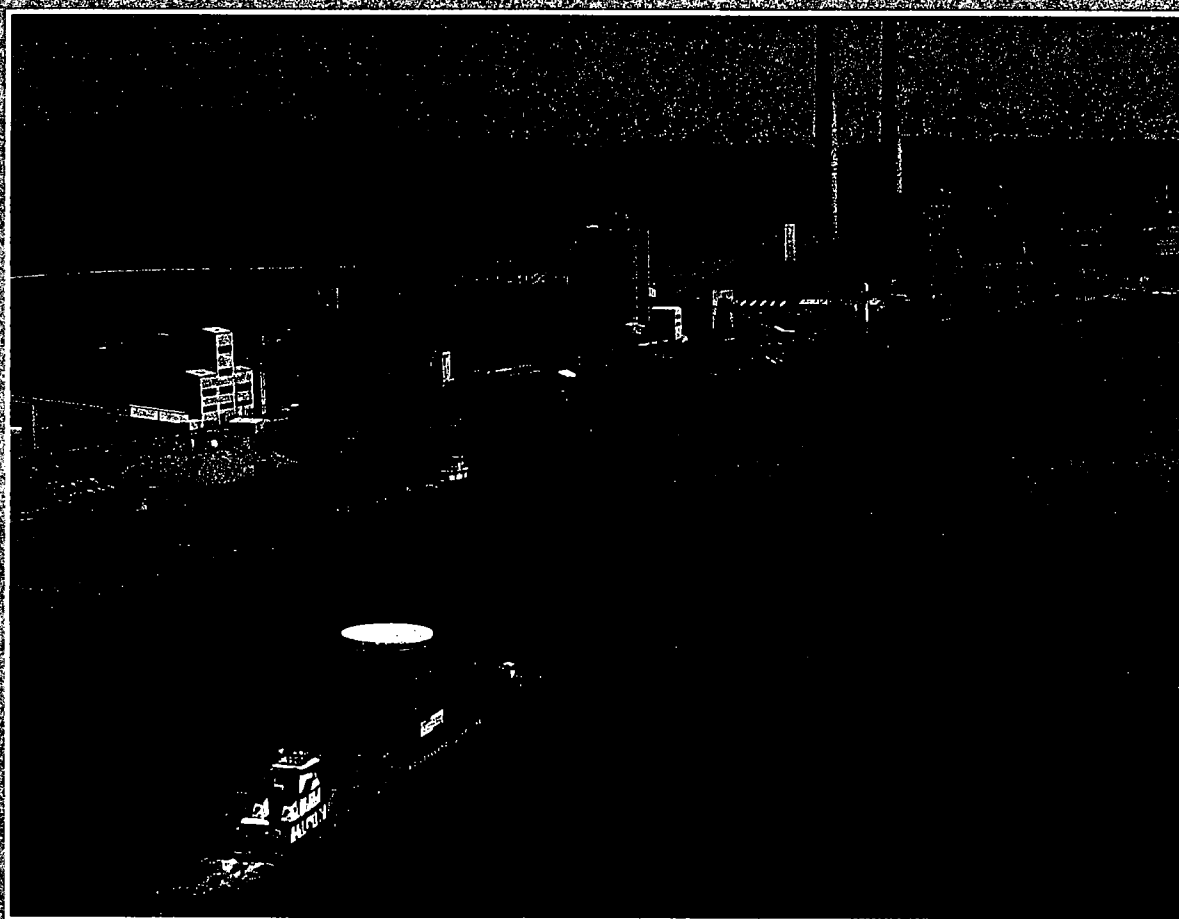
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CLEAN COAL TECHNOLOGY



Tidd

The Nation's First PFBC Combined-Cycle Demonstration

● ENVIRONMENTAL AND ENERGY STUDY CONFERENCE

SPECIAL REPORT

Oct. 31, 1989

Clean coal technologies: A key clean air issue

by Mike McQueen

The fruits of the \$5 billion government-industry clean coal technology program have a big stake in the congressional fight over the shape of acid rain control legislation.

President Bush's comprehensive clean air proposal announced June 12 set a key benchmark for the future of the clean coal program. To help reduce acid rain, Bush wants to reduce annual sulfur dioxide emissions from utility power plants in two phases: 5 million tons by the end of 1995 and another 5 million tons by the end of 2000. A three-year extension of the 2000 deadline would be available to plants using new technologies to repower old plants and reduce emissions. The proposal also includes regulatory incentives for using clean coal technologies, exemptions for demonstration projects from some Clean Air Act requirements and financial incentives such as better rates of return and relaxed payback requirements.

Utilities, which have long argued that acid rain legislation would divert funds from clean coal research by forcing immediate expenditures on current, proven, but expensive control technology, fear the Bush plan won't change that.

The Edison Electric Institute said it "shares the president's continuing

AL GORE, BOB WISE, *Co-Chairmen*; JOHN McCain, JAN MEYERS, *Co-Vice Chairs*

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LINDA CARTWRIGHT, *Director*

commitment to the clean coal technology program.”

“We are concerned, however, that the limited, three-year extension period proposed will not be sufficient for utilities to incorporate these technologies into their compliance plans,” EEI said.

An American Electric Power Service Corp. official echoed those sentiments, saying that utilities will have to decide by 1995 whether to add expensive scrubbers or go with clean coal technologies in order to meet the 2000 deadline. “The utility industry — each utility — will proceed very carefully when applying a new technology,” said R. E. Disbrow, the company’s president, in testimony before a Senate Energy and Natural Resources subcommittee in July. “A longer period of time, to the year 2005, would be more realistic if clean coal technologies are to play a significant role in any mandatory reduction program.”

Disbrow also suggested that the projects eligible for the deadline extension be expanded to include all clean coal technologies being developed for new utility plants, the replacement of old plants, as well as retrofitting and repowering old plants.

A March 1989 General Accounting Office report also warned Congress that adopting too strict emission reduction deadlines could adversely affect the development of clean coal technologies.

Rep. Philip R. Sharp (D-Ind.), chairman of House Energy’s Energy and Power Subcommittee, expressed disappointment with the lack of cost-sharing in the president’s bill. Indiana and eight other states, Sharp said, would have to bear a disproportionate share of the cleanup costs under the president’s proposal, he said.

Sharp said the inequity could be partially offset by earmarking the \$1.2 billion left in the clean coal fund for projects in those states.

Although Bush’s clean air proposal is the bill under consideration in the House, it will face numerous efforts to change it in committee and perhaps on the floor. It has cleared one hurdle — House Energy’s Health and Environment Subcommittee — with its acid rain section intact. Still ahead is a possible markup in the Energy and Power Subcommittee before consideration by the full Energy and Commerce Committee.

In the Senate, Majority Leader George Mitchell (D-Maine) and Senate Environment’s Environmental Protection Subcommittee Chairman Max Baucus (D-Mont.) will introduce an acid rain bill soon.

Like Bush’s bill, the Mitchell-Baucus bill is expected to call for a two-phase, 10-million-ton reduction in sulfur dioxide emissions by the end of 2000 with a three-year extension for clean coal repowerings.

The clean coal debate

For years, the utility and coal industries — with backing from the Reagan administration — have opposed acid rain control legislation, instead supporting clean coal technology development as the proper response to the acid rain problem. Proponents say clean coal technologies, led by the smaller and less expensive retrofit technologies that will start to become commercially available in the mid- to late 1990s, could reduce

emissions of sulfur dioxides and nitrogen oxides more cheaply than existing technologies, especially flue-gas desulfurization scrubbers. The more expensive, larger repowering technologies that promise greater reductions also will be available for commercial use in the same time frame but wide acceptance and use will probably take place up to a decade later, industry spokesmen argue.

Environmentalists say demonstration of clean coal technologies is no substitute for acid rain controls, and have in the past opposed appropriations for the program in the absence of controls. With his fiscal 1990 budget proposal and acid rain legislation, President Bush has outlined his support for substantial clean coal funding while endorsing the kind of controls favored by environmentalists.

The electric utility and coal industries have contended that leading acid rain control bills would slow or halt development of new clean coal technologies. They said controls would divert billions of dollars away from new technology development and force utilities to quickly install costly existing technologies.

Environmentalists have said that stringent controls on sulfur and nitrogen oxide pollutant levels are needed as soon as possible, and that cost-effective control technologies are available now. They argue that there will not be broad use of clean coal technologies without mandated reductions in acid rain-causing emissions.

The clean coal issue has been central to the U.S.-Canada negotiations over the acid rain problem. In the 1986 report of the U.S. and Canadian special envoys, the United States — though refusing to commit to reducing emissions that contribute to acid rain in Canada — committed itself to a five-year, \$5 billion clean coal technology program. The federal government was to contribute half the money, industry the other half.

The Reagan administration and Canada in January 1987 had a public flap over whether the United States was living up to its clean coal funding commitment and selecting projects that met the terms of the envoys’ agreement. The funding disagreement was resolved in March 1987 when Reagan announced he would seek the full \$2.5 billion in federal money over five years. Bush also has said he supports the \$2.5 billion commitment.

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Current and planned technologies

The term "clean coal technology" as used by the Department of Energy refers to advanced coal-based systems that offer significant potential for improved environmental and economic performance in power generation and industrial applications.

The technologies are classified into three categories: retrofitting, repowering and conversion technologies. Retrofitting refers to technologies that can be used on existing coal-fired plants to reduce emissions. Repowering refers to replacing a significant portion of an existing plant while increasing its power output. Conversion technologies refer to processes that change coal into a liquid or gas to be used for industrial, commercial, transportation or residential purposes.

Retrofitting: Retrofit technologies would be of most benefit at old coal-fired plants that need to meet stricter new sulfur dioxide and nitrogen oxide pollutant control levels. Retrofit categories include pre-combustion cleaning of coal through physical, chemical or microbial means; combustion modification such as sorbent injection and gas reburning; and post-combustion gas cleanup processes such as advanced scrubbers. Use of these technologies, either alone or in combination, have the potential to reduce emissions significantly, more simply and cheaply than current methods, extending plant life.

Repowering: These technologies, while still aimed at older coal-fired electric utility plants, promise deeper reductions in pollutants while boosting energy production. Included in this category are fluidized-bed combustion systems, which would be as effective or more effective than flue-gas scrubbers by eliminating more than 90 percent of SO₂ emissions. Gasification-based systems and advanced options such as magnetohydrodynamics and gasification with fuel cells also are being investigated.

Conversion: Surface and underground coal gasification, and coal liquefaction technologies such as coal/oil coprocessing are among the conversion processes under investigation. These technologies are not expected to play a major role for utilities in trying to meet stricter emissions reductions for acid rain control.

Current technologies

Emission reductions are currently achieved mainly by four methods: cleaning the coal to reduce sulfur content; switching to coal with a lower sulfur content; wet flue-gas desulfurization; and combustion controls for NO_x emissions.

Cleaning: According to the September 1987 National Acid Precipitation Assessment Program interim report, more than half of all domestic coal is cleaned before being burned. While it is uneconomical to clean low-sulfur, low-ash Western coals, nearly all Appalachian and Illinois basin coals are cleaned before being burned.

Current physical coal cleaning technology can reduce SO₂ emissions by up to 50 percent, although 10 percent to 30 percent reductions are more common, because costs escalate for greater percentage reductions. NAPAP lists costs of \$210-\$290 per

metric ton of SO₂ removed, in 1986 dollars. All following cost estimates also are from the NAPAP study.

Switching: Switching to low-sulfur "compliance coal" is an attractive option for coal-burning plants that were operating or under construction prior to September 1978 since they are not subject to the 1979 New Source Performance Standards. The 1970s-era plants must meet the less stringent 1971 NSPS requirements: SO₂ emissions rates of 1.2 lbs. per million Btu. The 1979 standards, which generally call for 70 percent SO₂ emissions reductions for low-sulfur coal and 90+ percent reductions for high-sulfur coal, mostly eliminated this alternative. The 1979 NSPS also require a maximum NO_x emission level of 0.6 pounds per million Btu.

Scrubbing: Flue-gas wet scrubbing for new plants currently removes up to 90 percent of SO₂ emissions and 50 percent of NO_x emissions for \$340 to \$590 per ton of pollutant removed, depending on sulfur content of the coal and size of the plant. NO_x reductions are typically achieved through the use of low nitrogen oxides burners.

The SO₂ is removed by injecting lime, limestone or other materials into the post-combustion gases, which can produce usable sulfuric acid and gypsum or unusable sludge or dry solids, depending on the process and sulfur content of the coal used.

Leading new technologies

There is a wide and ever-expanding array of technologies under various stages of development for use in reducing sulfur dioxide and nitrogen oxide emissions from coal. Many combinations of each technology are being investigated. What may be the "best" technology for one utility plant may not be the best for another because of the many factors that affect costs and benefits, including:

- utility plant or boiler size, location, and type;
- the sulfur content and type of coal used;
- emission type and reduction desired; and
- whether the project under consideration is a repowering, retrofit or new plant.

Additional uncertainties exist because not much information on performance levels is available for many of the newest technologies and different studies show disagreement over potential emissions reductions and costs.

Retrofitting

Retrofit technologies aim at reducing either sulfur dioxide, nitrogen oxides or both. These technologies are usually grouped into combustion or post-combustion categories.

Among the more promising innovative technologies for reducing SO₂ emissions are advanced coal cleaning, sorbent injection and advanced flue-gas desulfurization. For NO_x reductions, staged combustion with low NO_x burners, gas reburning and selective catalytic reduction are among the technologies showing promise. For both NO_x and SO₂ emissions during combustion, the limestone injection multistage burner and the advanced slagging combustor have high emission reduction

potential. For post-combustion cleanup, E-beam, copper-oxide, NOXCO and SULF-X may produce up to 90 percent reductions for both NO_x and SO₂.

SO₂ reduction

Advanced coal cleaning: Innovative physical coal cleaning methods such as multistage flotation, electrostatic separation and oil agglomeration can remove up to 65 percent of the sulfur in coal at a cost of \$240 to \$270 per ton removed. These processes are expected to be available for commercial order between 1994-96 with potential widespread use by 2000-05, according to testimony by the Clean Coal Technology Coalition July 11 before the Senate Energy subcommittee on energy and natural resources. All following availability predictions come from the same testimony.

More exotic chemical cleaning could remove up to 95 percent of the sulfur at significantly higher costs but at a competitive level with other processes that remove comparable percentages of sulfur. Expected commercial availability is 1998-2000

with widespread use between 2010-2015.

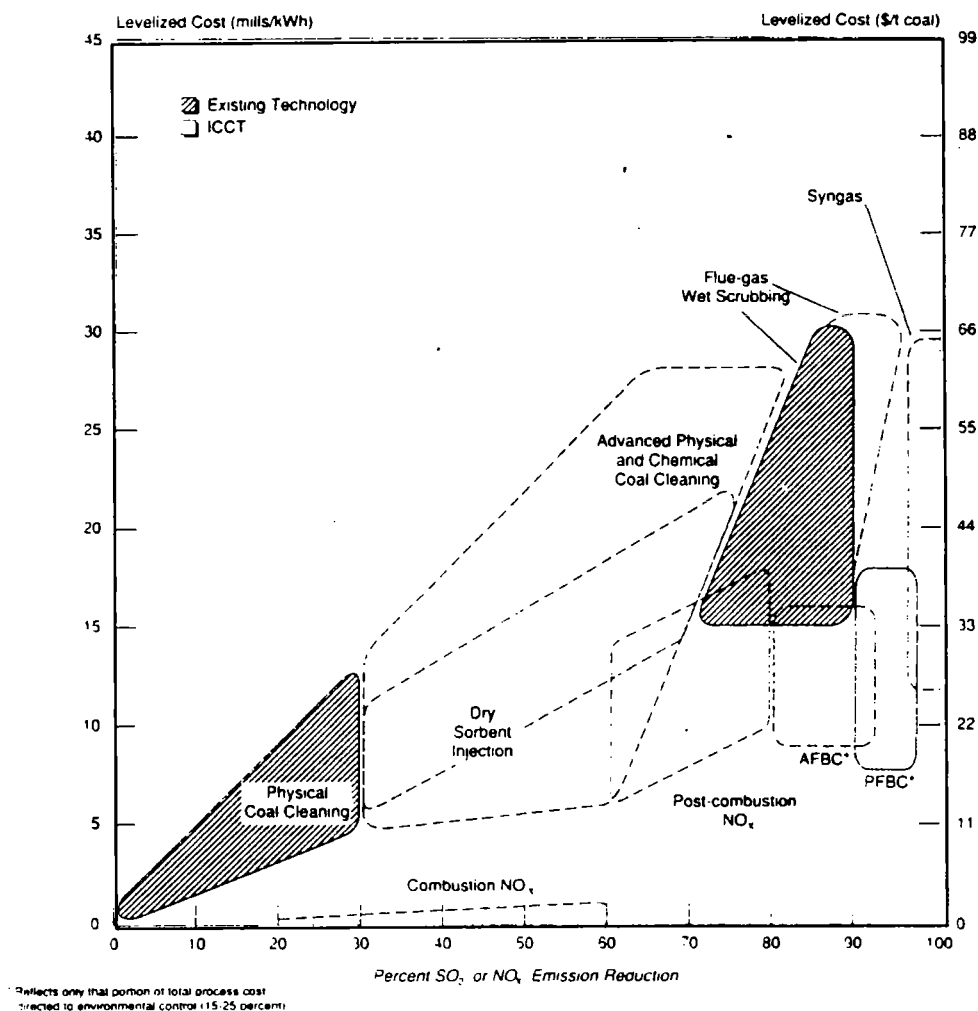
Sorbent injection: This technology has the potential to reduce sulfur dioxide emissions by up to 70 percent for \$180 to \$650 per metric ton removed. The combustion zone sorbent injection process is known as furnace sorbent injection, while the post-combustion process is called low temperature sorbent injection. These processes are expected to be available between 1993-96 with potential widespread use by 2000-05.

Furnace sorbent injection introduces a calcium based sorbent material, such as limestone or calcium hydroxide, into the furnace. The heat decomposes the sorbent into lime, which in turn captures the SO₂ and forms calcium sulfate. This is screened out of the flue gas along with fly ash.

While this SO₂ removal process can be cheaper than current wet flue-gas scrubbing, problems such as equipment fouling and waste disposal are still unresolved.

Post-combustion sorbent injection also sprays a calcium-based sorbent into the flue gas, but farther downstream from the combustion zone. It is potentially cheaper than both furnace

Clean coal cost effectiveness: new vs. existing technologies



Source: Electric Power Research Institute

sorbent injection and wet flue-gas scrubbing but also has a host of technical problems that need further study.

Advanced scrubbing: Further progress on wet scrubbing of flue gas to reduce SO₂ emissions could cut emissions by 97 percent. Various alternative technologies are being tested to produce both throwaway and recyclable by-products, which could be available between 1995-98 with widespread use by 2005-2010.

NO_x reduction

Staged combustion with low NO_x burners: Early indications show that up to 80 percent reductions in NO_x emissions are possible using this technology at costs of \$200 to \$400 per ton removed. This process restricts airflow into the combustion chamber, which lowers combustion temperatures and NO_x formation in certain retrofit conditions. Advanced NO_x combustion processes such as staged combustion and gas reburning that reduce NO_x emissions are expected to be commercially available domestically between 1994-96 and potentially in widespread use between 2000-05.

Gas reburning: Fuel staging, or gas reburning, has been retrofitted primarily to oil- and gas-fired installations in Japan. In this process, natural gas or a portion of the primary fuel is burned in a secondary combustion zone, which destroys the NO_x produced in the primary combustion zone. It has the potential to cut NO_x emissions by 60 percent, but the cost of \$500 to \$1,500 per ton removed reflects the uncertainty of cost of the secondary fuel and complexity of the retrofit.

Selective catalytic reduction: This process, which is used in Japan and West Germany, can achieve up to 90 percent reductions in nitrogen oxide emissions but is extremely expensive, at \$2,200 to \$3,900 per ton of NO_x removed. Advantages include simple equipment and no by-product, but uncertainties include cost, catalyst life and performance. This post-combustion control technology is expected to be available in 1996-98 and with potential wide use in 2005-10.

SO₂ and NO_x reduction

LIMB: The limestone injection multistage burner process involves two processes — the injection of a dry sorbent (limestone) into a boiler to capture sulfur dioxide from combustion gases, combined with the use of low nitrogen oxide burners, in which staged combustion is used for nitrogen oxide control. LIMB has the potential to reduce SO₂ emissions by 70 percent and NO_x by 50 percent for \$400-\$500 a metric ton.

DOE reported in 1987 that capital costs for LIMB were 50 percent less than scrubbers. Annual costs for LIMB and an accompanying humidification system were estimated to be about 30 percent lower than the current scrubber technology for a 105-megawatt plant.

Both the Environmental Protection Agency and DOE have funded a project investigating variations on the LIMB design at a Babcock and Wilcox Co. site in Lorain, Ohio. The DOE project, which is part of the clean coal round one group, is projected to cost \$19.4 million. The demonstration phase of the DOE project started in March 1989 and is expected to be completed by April

1991. Sulfur dioxide reductions of up to 80 percent and nitrogen oxide reductions of up to 60 percent are expected, according to DOE.

Advanced slagging combustor: Slagging combustors, originally aimed at ash control, date back to the 1940s but were phased out in the early 1970s because of their poor sulfur dioxide and nitrogen oxide controls. In the process, the ash is melted prior to combustion and runs off as a molten slag. The advanced versions add processes for pre-combustion removal of sulfur and nitrogen oxides as well. The economic advantage of these combustors is the avoided cost of flue-gas clean up.

There are three slag combustor projects in the DOE clean coal program. The Coal Tech Corp. project, now projected to cost nearly \$1 million, would burn high-sulfur Pennsylvania coal. The technology aims to reduce SO₂ by 90 percent, coal ash by 90 percent and NO_x to 100 parts per million, about a 70 percent to 80 percent reduction. Limestone is used to capture the sulfur; nitrogen oxide reduction is achieved by reducing oxygen in the first stage of combustion; and the ash is captured by a spinning cyclonic action in the combustor.

TRW Inc. is designing a much bigger, \$49 million project, which would convert a utility boiler from oil to burning low-to-medium-sulfur coal without losing power. Testing will occur at a Cleveland, Ohio, site and at the four-boiler retrofit taking place at Stony Point, N.Y.

A second round project by TransAlta Resources Investment Corp. aims to demonstrate a boiler retrofit that would cut sulfur emissions by more than 70 percent while limiting nitrogen oxide to 150 parts per million using high-sulfur Illinois coal. The 33-megawatt boiler would burn 240 tons of coal a day.

E-beam, copper oxide, NOXSO and SULF-X: These emerging post-combustion technologies aim to reduce up to 90 percent of both sulfur and nitrogen oxide pollutants at a cost of \$300-\$425 per metric ton of pollutant removed. They are in the development stage so that costs and performance are considered more uncertain than the technologies already discussed.

The electron beam process irradiates SO₂ and NO_x, which changes them into sulfuric and nitric acids, respectively. The Tennessee Valley Authority Shawnee Steam Plant in Paducah, Ky., operated pilot-scale versions of the process in 1984.

The copper oxide method chemically changes sulfur dioxide into copper sulfate, which in turn changes nitrogen oxides into nitrogen when combined with ammonia. Up to 90-percent removal has been achieved at the Pittsburgh Energy Technology Center, with other work being done at the Commonwealth Edison Kincaid Power Plant in Illinois. Costs for both the electron beam and copper oxide processes are estimated at \$300 to \$400 per ton of pollutant removed.

Early reports showed the NOXSO process to be slightly more expensive in capital costs than the other two processes. The process chemically changes sulfur dioxide and nitrogen oxide into sulfur and nitrogen, respectively. A NOXSO consortium has applied for \$33 million in round three clean coal funding to demonstrate this technology at the 115-megawatt level. The SULF-X uses iron sulfide to achieve the same end products with slightly lower nitrogen oxide reductions. Preliminary costs are

Estimated commercial availability of clean coal technologies

<i>Class</i>	<i>Available</i>	<i>Wide use</i>
Physical coal cleaning	1994-1996	2000-2005
Chemical coal cleaning	1998-2000	2010-2015
Low rank coal drying	1993-1995	1998-2000
Coal upgrading	1998-2000	2005-2010
Advanced flue gas desulfurization	1995-1998	2005-2010
Furnace sorbent injection	1993-1995	2000-2005
Duct sorbent injection	1994-1996	2000-2005
Combustion NOx control	1994-1996	2000-2005
Post combustion NOx control	1996-1998	2005-2010
Int. gasification combined cycle	1994-1996	2000-2005
Atmos. fluidized bed combustion	1994-1996	2000-2005

significantly higher, up to \$550 per ton removed.

Repowering and new plants

Many of these emerging technologies may be usable for boosting power and lowering emissions at existing plants as well as for use in new plants. Repowering comes into play when existing coal-fired plants are about 25 years old and a utility must decide whether to retire or rebuild the facility. Repowering also becomes attractive when power generation needs have increased, since repowering on an existing site avoids finding, developing and winning approval for a new site. Among the most promising processes for both repowering and new-plant use are the integrated gasification combined cycle process, atmospheric fluidized bed combustion, and pressurized fluidized bed combustion.

Integrated gasification combined cycle: This integrated process of gasifying coal and generating electric power was conceived by the Electric Power Research Institute in collaboration with Texaco and member utility companies during the 1970s. The technology will not be cost-competitive until natural gas prices reach at least \$4 per thousand cubic feet (mcf). The 1988 average price of gas for electric utilities was \$2.34 mcf. However the environmental control cost of IGCC plants is competitive with current scrubbing technology.

The NAPAP report estimates that the cost of IGCC repowering of a large, 600-megawatt unit is approximately \$1,100-\$1,200 per kilowatt, with cost effectiveness of pollutant removal at \$60-\$200 per metric ton removed. For new plants using IGCC technology, the report shows that capital and electricity costs are comparable to anticipated conventional coal-fired steam plants as well as fluidized-bed systems. Commercial availability should start between 1994-96 with widespread use possible in the 2000-2005 period.

Three versions of IGCC technology were chosen for co-

funding in the federal clean coal program, although one project has been dropped. DOE is continuing to negotiate with Foster Wheeler Power Systems Inc. regarding their 44-megawatt, 600-ton-per-day IGCC repowering project proposed for Richmond, Va. The company earlier had said it would decide by August whether to proceed with the project, which has been delayed by a site change from West Virginia.

A second repowering project, selected in the second round of DOE clean coal projects, would convert 480 tons of 2.5 percent Illinois bituminous coal into gas to produce 65 megawatts. The Combustion Engineering Inc. repowering project in Springfield, Ill., is estimated to cost \$309 million and is still under negotiation.

The third project, which was withdrawn in June, was sponsored by M.W. Kellogg and Bechtel Development companies, which were designing a \$244 million project that would convert 551 tons of high-sulfur coal a day into gasified fuel to produce 63.5 megawatts. DOE and the sponsors agreed to drop the project after a location for it couldn't be found. A circulating fluidized bed combustion project in Tallahassee, Fla., replaced the Kellogg project.

Two of the bigger existing IGCC projects are the 100-megawatt Cool Water project, which operated from June 1984 until early this year in Daggett, Calif.; and the 115-megawatt Dow Chemical Gasification project in Plaquemine, La., which has been operating commercially since May 1987. Although the plant processes are different, emissions are similar, with 99 percent sulfur dioxide and 95 percent nitrogen oxide removal.

In the Cool Water process, a coal-water mixture is injected into a pressurized, oxygen-fed gasifier. A medium-grade fuel results. The sulfur in the coal is converted mostly into hydrogen sulfide gas, and the nitrogen oxide in the coal is converted into molecular nitrogen. The resulting hot gases and molten slag pass by tubes of water, which are heated to create steam. The steam drives turbines, which creates part of the electricity for the plant. The gas and the slag are then separated.

A sorbent is used to strip 97 percent to 99 percent of the sulfur from the gas that is produced from the coal (syngas). To create more electricity, the cleaned gas is burned in a turbine at a low temperature, which also lowers nitrogen oxide production.

Of the 120 megawatts produced, 20 are consumed in the process. The plant's efficiency, the ratio of input energy to usable electricity, is 32 percent — at the low end of the range for conventional coal-fired plants with flue-gas scrubbers.

Industry estimates in the National Coal Council report show that three IGCC facilities are currently operating, with four more at the pre-operational stage.

Atmospheric fluidized-bed combustion: This technology is showing the greatest near-term potential for repowering, according to the National Coal Council. More than 1,000 megawatts of existing coal-fired capacity already are being converted to this technology. About 109 smaller non-utility applications are generating power or are on order. At least 11 more in the utility sector are operating or on order, according to NCC.

Larger utility scale AFBC systems are expected for commercial use during the 1994-96 time period with widespread usage possible in 2000-05. Pollutant removal cost efficiency was estimated to be better than the current and other major new technologies for new plants, according to the 1987 NAPAP report. Pollutant removal was rated at up to 95 percent for SO₂ and 80 percent for NO_x, below pressurized fluidized-bed systems and IGCC systems, which ranked the highest.

The cost of repowering with AFBC is about \$700-\$800 per kilowatt for a 600-megawatt plant, according to the NAPAP study. Power output is increased 10-15 percent.

Fluidized-bed combustion means burning fuel as it is suspended in midair by jets of air blown up from the bottom of the boiler. Limestone in the combustion chamber is used to remove the sulfur while lowered combustion temperatures help control NO_x production. The process dates back to the 1920s but wasn't considered for utility use until 30 years later. About 100 AFBC systems have been built for industrial applications. Large-scale utility use is still awaited.

To promote utility use, DOE has selected two AFBC projects for the clean coal program. The Nucla, Colo., project is estimated to cost \$54 million. The circulating fluidized-bed system will replace three small coal-fired boilers to generate 110 megawatts. More than 4,300 hours of operation have been logged on the boiler in 1988, according to DOE.

The second DOE project is the 250-megawatt repowering of a Southwestern Public Service Co. facility near Amarillo, Texas. The project, which is about twice the size of boilers now under construction, is expected to reduce SO₂ and NO_x emissions by 70 percent and over 80 percent, respectively.

Pressurized fluidized-bed combustion: This modification of atmospheric combustion was first developed by the British in 1969. The main difference is the suspended fuel is under pressure in the range of 8 to 16 times normal atmospheric pressure.

The technology for PFBC has not matured as much as AFBC and IGCC but two DOE clean coal projects are expected to further the demonstration of the technology. The National Coal

Council, using industry predictions, expects it to be ready for commercial use at the 400-megawatt level around 1997, the same as for IGCC and AFBC.

Pollutant removal is up to 95 percent for SO₂ and up to 90 percent for NO_x, according to the NAPAP study, making it better than AFBC but not as good as IGCC. Cost effectiveness was worse than either of the other major technologies.

The cost of repowering for PFBC is slightly more than AFBC (\$800-\$900 per kilowatt versus \$700-\$800/kw). Output is increased up to 50 percent, emission reductions are greater, and conversion efficiency is improved, according to NAPAP. Commercial availability is slated for 1998-2000 with widespread use possible in the 2005-10 time period.

The round one clean coal PFBC project is located in Brilliant, Ohio. The \$185 million project, now expected to be completed in October 1993, will burn 660 tons of coal a day to produce 70 megawatts.

The round two PFBC project is a larger 330-megawatt repowering in New Haven, W. Va. The American Electric Power Service Corp. project, expected to burn nearly 3,000 tons of coal a day, would capture 95 percent of sulfur emissions and limit NO_x emissions to 0.2 lbs. per million Btu, well below the current limit of 0.6 pounds per million Btu.

Origins of the program

The clean coal technology program is conducted under broad authority in the Energy Reorganization Act (PL 93-438) and the Federal Non-Nuclear Energy Research and Development Act (PL 93-577), both signed into law in 1974.

Congress created the Energy Security Reserve Fund for clean coal technologies in 1984 in legislation that set aside \$750 million originally intended for the Synthetic Fuels Corporation (PL 98-473). The legislation directed the Department of Energy to assess private industry interest in emerging clean coal technologies and the extent of federal assistance needed to promote efficient, environmentally sensitive commercial uses of these technologies.

Initial industry response was enormous. DOE received 175 responses with project proposals totaling \$8 billion.

The Reagan administration originally opposed the clean coal program on the grounds that pilot energy projects should be funded solely by the private sector, but Congress nevertheless provided \$397.6 million for shared-cost demonstrations.

The projects originally were selected according to DOE guidelines drawn up to reflect congressional intent. The guidelines stated that the competition should be open to all market applications of clean coal technologies, which included use by utilities, commercial and residential markets, transportation and industry such as steel and iron ore processing. The competition also was open to new and retrofit applications that could use coal more cleanly, efficiently or economically or displace oil and natural gas. All projects were eligible to receive up to 50 percent federal financing.

Reagan turnaround: The January 1986 report of the

U.S.-Canada special envoys on acid rain recommended that the U.S. government spend up to \$2.5 billion to help develop cheaper, more efficient technologies needed for an acid rain control program. The report also recommended near-term reductions in U.S. air emissions that affect Canadian ecosystems.

Responding in March 1987, the Reagan administration reversed its opposition to federally subsidized clean coal demonstrations and recommended spending the \$2.5 billion for such projects, with another \$2.5 billion coming from private industry.

Reagan also:

- directed the secretary of energy to set up a panel of public and private representatives to advise the secretary on clean coal technology activity. The 38-member Innovative Control Technology Advisory Panel, expected to operate for five years, issued a report in December 1987 that recommended criteria to be used in implementing the program.

- requested the Presidential Task Force on Regulatory Relief to examine incentives and disincentives to the deployment of new clean coal technologies. The task force recommended that in the second round of solicitations DOE should consider giving preference to projects located in states that offered regulatory incentives to encourage new technologies.

Reagan's decision to commit \$2.5 billion, along with the ICTAP and regulatory relief task force reports, all contributed to a significant change in direction for the program prior to the round two phase.

DOE narrowed its focus to reflect a greater emphasis on technologies that would address acid rain concerns as outlined in the envoys' report. This included the demonstration of technologies that would reduce transboundary nitrogen and sulfur oxide pollution from existing U.S. facilities at the lowest cost per ton of pollutant removed.

This represented a significant change of emphasis from the first round, which considered a wide range of technologies that would provide alternatives for the full spectrum of energy markets.

DOE also got additional input from Congress in the fiscal 1988 continuing resolution (PL 100-202). Congress appropriated \$575 million for round two demonstrations and also directed that: non-utility as well as utility applications could be funded; that new, stand-alone applications could not be funded; and that more specific negotiation timetables should be used to expedite the selection process.

Since 1985, when Congress first put up money for the clean coal program, \$2.747 billion has been appropriated, although just \$76 million has actually been spent by the Department of Energy as of June. The total appropriation includes \$600 million in the fiscal 1990 Interior appropriations bill (HR 2788, PL 101-121) for advance appropriations in both fiscal 1991 and 1992 that would complete funding as envisioned in the U.S.-Canada acid rain agreement.

If the 60-40 public-private funding ratio that occurred in the first two rounds of project funding remains constant for the remaining three rounds, DOE estimates that a total of \$6.25 billion will be spent on clean coal demonstration projects during the life of the program.

The selection process

Since selection of the round one projects in 1986, some have been dropped or withdrawn by their sponsors. DOE in July 1986 selected nine out of 51 projects submitted to receive assistance from the clean coal reserve. After a series of substitutions and withdrawals, the department has now completed negotiations for eight projects with four more still active.

In September 1988 DOE picked 16 new project proposals, which were competing for \$536 million in federal funds under the second round of the clean coal technology program. Thirteen of the projects are proposed for retrofitting old coal-fired plants and three for repowering them. Most are located in the East and Midwest, which drew criticism from Western senators.

Clean coal technology funding

(in millions of dollars)

Round	1	2	3	4	5	Total
1986	99.4					99.4
1987	149.1					149.1
1988	149.1	50				199.1
1989		190				190
1990		135	*419			554
1991		200	*156	600		956
1992					600	600
Total	397.6	575	575	600	600	2,747.6

*Reflects shift of \$31 million from fiscal 1990 to fiscal 1991, as stipulated in the fiscal 1990 Transportation Appropriation conference report. *Source: Department of Energy*

The 28 projects in the first two rounds of clean coal competition have a total estimated value of \$2.3 billion, with a 60-40 private-public share. Negotiations on eight of the projects totaling \$677 million have been completed, according to DOE testimony to the Senate Energy and Natural Resources Committee.

Round one selections: DOE in July 1986 selected nine projects to receive \$362 million in assistance from the clean coal reserve (see table). Later, two of the original projects were withdrawn by the sponsors and four proposals from an alternate list were chosen to replace them. In 1988, another project was dropped with three alternates replacing it. By mutual agreement between DOE and the sponsor, another project was dropped in June and a replacement added. Finally another small project was withdrawn in October. The department has now completed negotiations for eight projects with four more still under discussion.

GAO report: The General Accounting Office reported in March 1989 that seven of the nine negotiated round one projects were behind schedule. Sponsors of four of the delayed projects have projected that another \$70 million will be needed to complete the projects, a 26 percent increase above the expected costs at the time they were negotiated, GAO reported. DOE also had to extend the design phase of three of the projects for seven to 15 months.

At a House Energy and Commerce subcommittee hearing in April, J. Allen Wampler, then the DOE assistant secretary for fossil energy, said the delays and other problems come with the ground-breaking nature of the program. "There will be some projects in this program that will succeed and others that will fail," he said. "That is inherent in a program of this type."

Coordination, equipment and financing were the main problems causing the delays, according to the GAO. DOE could not estimate what effect the delays would have on final costs and completion dates for the seven projects. Also the report said it was too early to tell what effect the delay would have on the commercial availability of the technologies.

GAO did warn that if Congress adopted too-strict emission reduction deadlines too soon, it could adversely affect the development of clean coal technologies. "We believe that a major issue is the effect that potential acid rain control legislation could have on the clean coal technology program," said Keith Fultz, who testified for GAO at the House Energy hearing.

In a response to the report, DOE has announced that one project sponsor has withdrawn, two — Energy International Inc. and Ohio Ontario Clean Fuels Inc. — have a deadline of Dec. 31 for achieving certain milestones and a fourth sponsor is trying to downscale its project. The rest are considered to be in relatively good shape, a DOE spokesman said.

Three of the projects that are still being negotiated are expected to complete that phase over the next eight months. Negotiations have just started on the most recent replacement project.

DOE officials said that several problems plagued negotiations: financing, inability of the sponsor to recover preaward costs, fear of public disclosure of a project's technical data, and a stipulation that the government would recoup its investment

through paybacks from the private sponsor within 20 years of commercialization of the technology. For most of these projects, these problems more than doubled the eight-month DOE estimate of the time it would take to complete negotiations.

Round two selections: Of the 55 proposals received by DOE by the May 23, 1988, cutoff, two-thirds involved flue-gas clean-up, fluidized bed combustion or coal preparation techniques. They were competing for \$538 million in federal funds, which represented the \$575 million appropriation minus federal program management costs.

DOE in September 1988 picked 16 of the projects (see table). The first contract, a \$45 million coke oven gas project with Bethlehem Steel, is expected to be signed in early November, a DOE spokesman said.

Thirteen of the projects are proposed for retrofitting old coal-fired plants and three for repowering them.

As in the first round, few Western projects were submitted; in the second round, fewer were picked, which drew fire from Western senators and others. Although 55 percent of the nation's demonstrated coal reserves are west of the Mississippi River, only one project from the region (Texas) was picked. In round one, eight of 51 projects submitted were Western, as were three of the 13 chosen. In round two, 10 of 55 projects were Western, with the Texas project as the sole Western project among 16 selected. In an effort to improve Western participation, DOE advised Westerners in a December meeting in Wyoming on issues that kept previous projects from being selected.

While round one projects represented a wider variety of applications, round two projects were aimed at retrofitting or repowering.

Round three selections: DOE received 47 proposals by the Aug. 29 deadline for round three clean coal projects. Total value of the projects exceeds \$3.9 billion. DOE will select up to 15 projects by late December for the \$545 million in federal funding that is available.

DOE said that for the first time it will be interested in projects that might contribute to reducing global warming. DOE will consider carbon dioxide emission reductions in determining which of two otherwise equally qualified projects is selected, a DOE spokesman said.

The solicitation will foster technologies that more efficiently convert coal into useful energy or reduce carbon dioxide emissions as well as acid rain causing emissions such as sulfur- and nitrogen oxides.

Guidelines for round three projects also change government payback requirements for sponsors, require U.S. coal usage and make clear that the program is for demonstrating technologies that are not commercially available.

To ease industry concerns, DOE proposed up to a five-year repayment grace period or forgiveness of 10 percent of sales from the technology. Repayments to the government would end after 20 years even if money were still owed. The department also dropped payment to 0.5 percent from 2 percent for profit made by the company from sales or leases of the technology. But fees paid to the government for licensing of the technology would rise to 5 percent from the current 3 percent under the guidelines.

The clean coal technology program: selections under rounds 1 and 2

(dollars in millions)

<i>Sponsor/location</i>	<i>Technology</i>	<i>Local/federal funds</i>
Round 1		
Ohio Power Co., Brilliant, Ohio	PFBC	\$124.8/60.2
Babcock&Wilcox Co., Lorain, Ohio	LIMB	\$11.8/7.6
Coal Tech. Corp., Williamsport, Pa.	Cyclone combustor	\$0.5/0.5
Energy and Env. Res. Corp., Illinois	Gas reburn/sorbent injection	\$15/15
Energy Int'l Inc., Rawlins, Wyo.	Underground coal gasification	\$101.4/11.8
Ohio Ontario Clean Fuels, Warren, Ohio	Coal/oil coprocess	\$180.7/45
Colorado-Ute Electric Assoc., Nucla, Colo.	CFBC	\$34.2/19.9
TRW Inc., New York, Ohio	Slagging combustor	\$25.5/23.5
Total		\$493.9/183.5

Under negotiation:

Foster Wheeler, Virginia or West Virginia	IGCC	—
Western Energy Co., Colstrip, Mont.	Adv. coal cleaning	—
Combustion Engineering, Windsor, Conn.	Coal cleaning	—
City of Tallahassee, Fla.	CFB boiler	—

Round 2 *(all under negotiation)*

Pure Air, Gary, Ind.	Advanced flue gas scrubber
Southern Co. Serv., Lynn Haven, Fla.	Advanced NOx control
Southern Co. Serv., Coosa, Ga.	Advanced NOx control
Passamaquoddy Tribe, Thomaston, Maine	Cement kiln gas cleaning
Babcock & Wilcox, Cassville, Wis.	Coal reburning for NOx control
Bethlehem Steel, Sparrows Point, Md.*	Coke oven gas cleaning
Southern Co. Serv., Newnan, Ga.	Advanced flue gas desulfurization
Combustion Engineering, Springfield, Ill.	IGCC
TransAlta Resources, Marion, Ill.	Advanced slagging combustor
Southwestern Public Service, Amarillo, Texas	CFB
Otisca Industries, New York	Advanced coal cleaning
American Electric Power, New Haven, W.Va.	PFBC
Combustion Engineering, Yorktown, Va.	Sorbent injection
Southern Co. Serv., Pensacola, Fla.	Selective catalytic reduction
Babcock & Wilcox, Dills Bottom, Ohio	Advanced flue gas cleanup
Combustion Engineering, Niles, Ohio	Advanced flue gas cleanup

*Contract expected to be signed in early November.