



CLEAN COAL TODAY

U.S. Clean Coal Technology Demonstration Program

Office of Fossil Energy, U.S. Department of Energy

The Global Opportunity

A Message From Pat Godley, Assistant Secretary for Fossil Energy

The Fourth Annual Clean Coal Technology Conference champions the *Global Opportunity*. Perhaps the plural is more appropriate. Global opportunities are developing across the face of our planet.

Energy remains at the center of this rapidly changing world. Today the security and affordability of energy and the impact of its use are more important than ever. They are central to global progress. As nations seek higher standards of living, their choices of energy supplies—and technologies—will dictate how successful they will be in achieving the aspirations of their citizens while, at the same time, protecting the quality of the world's environment.

In the United States, change is also underway. Our power industry is in the midst of a significant transition. Deregulation continues. Competition is increasing. All of the traditional ways that electric power is bought, sold, and delivered to the consumer are now subject to major change. The industry is being restructured. Yet amid this uncertainty, one thing is clear: those who provide the power in the 21st century will be those who are willing to change—those who are willing to accept new ways of doing business and willing to employ new technologies.

Domestically, and for the global community, the Clean Coal Technology Program has expanded the menu of choices. We have a new generation of technologies being readied for the market—cleaner, more efficient, and more affordable than in the past.

At the Department of Energy, we view the Clean Coal Technology Program as a template for successful government-industry collaboration. It is the product of thousands of farsighted individuals, many in the Department of Energy but the majority in private industry and in State agencies. It is a partnership that is producing results.

Today, eleven years and five solicitations after the program began, 43 pioneering projects in 20 states are in varying stages of design, startup, operation, or completion. We have essentially completed the demonstration of a new array of environmental control options. The program is now moving into its latter phase where advanced power generation projects will come on-line and begin to generate data.

Together, this new menu of maturing energy options truly offers us the opportunity to reshape our future—at a time when new options are needed more than ever.



Welcome—

From Our Sponsors

The U.S. Department of Energy (DOE) would like to welcome everyone to the *Fourth Annual Clean Coal Technology Conference* in Denver, Colorado. This year, the conference has an expanded vision of clean coal technologies—The Global Opportunity. The conference also has gained expanded support, through the co-sponsorship of the Center for Energy & Economic Development (CEED) and the National Mining Association (NMA).

Last year, CEED joined DOE in Chicago, Illinois, at a forum focusing on "The Investment Pays Off." The previous year, Southern States Energy Board cosponsored in Atlanta, Georgia, following on the success of the first CCT Conference, held in September 1992, in Cleveland, Ohio.

The objective of the Clean Coal Technology (CCT) conferences has been to examine the status and role of the Clean Coal Technology Program and its projects within the larger context of environmental needs, sustained economic growth, world markets, user performance requirements, and supplier commercialization activities. This was accomplished by reviewing and discussing: factors affecting domestic and international markets for CCTs, environmental considerations, current status of projects, and the timing and effectiveness of transfer of data to potential users, suppliers, financing entities, regulators, the environmental community, and the public.

Over the past four years, the CCT program has matured, and has experienced notable successes (see article, page 4). Our industrial partners are reaching out to new markets, and all participants are carrying the message that coal represents opportunities for clean, efficient, and environmentally sensitive power generation.

See "Opportunity" on page 2. . .

See "Sponsors" on page 2. . .

... "Opportunity" from page 1

We ended the 1980s with a billion more inhabitants on this globe than were present when we began the decade. We will add another billion in the coming decade. By 2025, 2.5 billion more people will be added to our global population—and 90 percent of them will be born into the developing world.

To truly appreciate what that means for global energy consumption, recognize today that of the world's 5.6 billion global inhabitants, 70 percent have limited, or no, access to commercial energy. Our progress as a global society will be dictated largely by how we address this need.

History is replete with accounts of how national borders were redrawn through conflict, largely because one society sought territory from another. I am convinced, however, that as we move into the 21st century, it will be the quality of life—not the quantity of land—that will motivate change.

It is that quality of life that is at the foundation of the Global Opportunity we will be discussing at this conference. And it is against the backdrop of a changing world shaped by expanding choices and new technologies that I welcome you on behalf of the Department of Energy. We are extremely pleased to join the Center for Energy & Economic Development for the second year in hosting this conference, and we welcome the addition of the National Mining Association as a new co-sponsor.

In the tradition of past conferences, we will hear about technical accomplishments both within and outside the United States. We will hear about successes achieved and technical challenges yet to be overcome. Through the hospitality of Public Service Company of Colorado and the Energy and Environmental Research Corporation, we hope to have the opportunity to see firsthand two of our showcase clean coal demonstration projects.

In short, we will *talk* about technological achievements. But we must *think* about human progress. We must find ways to take the lessons learned to date and translate them into truly a new global era of clean energy.

The Clean Coal Technology Program is a starting point—but it is only that. Achievement will be measured *not* by the number of demonstration projects but by the capability to deploy these new technologies both within this country and to countries with the greatest needs. Progress will be measured *not* by the data of demonstration plants but by the way these new technologies are used by nations struggling to attain higher levels of sustainable development. And ultimately, success will be seen *not* through the eyes of scientists and engineers present at this conference, but through the eyes of billions of citizens in a world that is cleaner, safer, and more secure.

That is truly the Global Opportunity in front of us.

... "Sponsors" from page 1

DOE would like to take this opportunity to thank everyone contributing to the Denver conference: organizers, moderators, speakers, panelists, technical presenters, exhibitors, and all of those who come to listen and share in this important event. In particular, we would like to thank this year's cosponsors for their support. The following information will give you a brief introduction to our cosponsors, CEED and NMA.

The Center for Energy & Economic Development (CEED) was created in 1992 as a non-profit organization dedicated to preserving the coal option in America. CEED's membership is expanding to include some of the largest railroad and coal companies in the United States. CEED's membership also includes utilities and companies that supply these industries.

CEED is headquartered in Alexandria, Virginia, and has regional offices across the country that provide state government officials, public service commissioners, teachers, and the public with accurate facts about coal's contribution to clean affordable electric power generation. CEED advocates responsible, science-based environmental laws and regula-

tions that recognize the importance of coal use in America's future. CEED also supports the expansion and development of coal plants by working with developers, business groups, and public officials.

CEED has developed booklets, videos, and brochures, and has conducted studies to educate key state and local decision-makers, educators, and the media about the role of coal in job growth, competitiveness, and the environment. For more information about CEED, please call (703) 684-6292.

The National Mining Association (NMA) was established in 1995 as a result of the merger between the National Coal Association and the American Mining Congress. NMA is the single voice for the mining industry. NMA believes that its interests will help to maintain a firm foundation for America's energy and economic security. Its 381 members represent producers of the majority of American coal, metals, and industrial and agricultural minerals; manufacturers of mining and mineral processing machinery, equipment and suppliers; transporters, financial and engineering firms; and many other busi-

nesses related to coal and hardrock mining.

NMA is headquartered in Washington, D.C., and serves as the information center for the U.S. mining industry as well as the political advocate for mining interests in Washington, D.C. NMA works closely with Congress, the Executive Branch, and Federal agencies to ensure establishment of constructive policies that will best enable the mining industry to serve the needs of the nation. Among other things, NMA strives to promote policies and procedures that balance economic, political, and environmental concerns. For more information about NMA, please call (202) 463-2651.

Clean Coal Today

Published quarterly by
The Office of Clean Coal Technology
U.S. Department of Energy
Washington, D.C. 20585

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Comments are welcome and may be
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Site Tours

Arapahoe Station

The Public Service Company of Colorado's Arapahoe Station Unit 4 is the host site for the demonstration integrated dry NO_x/SO₂ emissions control system. The goal of the 100-megawatt project is to achieve up to 70 percent reductions in SO₂ and NO_x through the integration of three technologies: (1) low-NO_x burners with overfire air, (2) in-furnace urea injection for additional NO_x removal using selective non-catalytic reduction (SNCR), and (3) dry in-duct sorbent injection with humidification for SO₂ removal. Both sodium- and calcium-based reagents and flue gas humidification are being tested to control SO₂ emissions. Low-sulfur (0.4 percent) Colorado bituminous coal is being used during all testing.

With operational testing expected to be completed this December, PSC views the demonstration as successful, and plans to continue operation with the low-NO_x burners, overfire air, and the sodium-based dry sorbent injection system. Sodium reagent was found to be more effective than calcium for removing SO₂. A final decision on continuing the SNCR system will be made at the end of the test program.

The combination of low-NO_x burners (Babcock & Wilcox Dual Register Burner-Axially Controlled Low-NO_x, or DRB-XCL[®]) and overfire air (Babcock & Wilcox Dual-Zone NO_x Ports[®]) reduced NO_x emissions by 63-69 percent (to approximately 0.4 lb/million Btu) across the load range. Air toxics removal tests performed at the same time showed that the fabric dust filter removed up to 97 percent of potential trace metal emissions.

Noell's urea-based SNCR system reduced NO_x formation by 11-45 percent over the load range. The combination of the SNCR and low-NO_x combustion systems resulted in reducing full-load NO_x emissions by more than 80 percent, exceeding original expectations. At lower loads, 30-40 percent NO_x reduction can be achieved.



To reduce SO₂, a combination of dry sorbent injection technologies is being demonstrated. Two long-term dry sorbent tests completed thus far showed SO₂ removal of 43 percent and 68 percent.

This \$27.4 million Integrated Dry NO_x/SO₂ Emissions Control project, a CCT-III selection, is supported by the Public Service Company of Colorado and the Electric Power Research Institute, in addition to the CCT Program.

Cherokee Station

The Public Service Company of Colorado's Cherokee Station Unit 3 is the host site for the project evaluating gas reburning and low-NO_x burners (GR-LNB) on a 172-megawatt wall-fired boiler. Energy and Environmental Research Corporation is the industrial participant. Long-term testing, begun in April 1993, was completed in January 1995.

The low-NO_x burner system, when used without gas reburning, typically reduced NO_x by 30-40 percent, cutting emissions to 0.47 lb/million Btu. The combined GR-LNB system reduced NO_x by 60-73 percent, reducing levels to an average of 0.26 lb/million Btu in the long-term demonstration and as low as 0.20 lb/million Btu in the parametric optimization testing. NO_x reduction was as high as 60-65 percent even at relatively low natural gas heat inputs of 5-10 percent of the total fuel.

In early 1995, the boiler was modified with a second-generation gas-reburning system designed specifically for low gas heat inputs for operation without flue gas recirculation, and with improved overfire air ports. The second-generation gas-reburning evaluation established that flue

gas recirculation was not necessary to achieve the desired NO_x reductions. This resulted in decreased construction time, and reduced estimated costs from \$16-40 per kilowatt to \$10-20 per kilowatt.

The Cherokee system operated for more than 4,200 hours. The boiler is a balanced draft pulverized-coal unit supplied by Babcock & Wilcox. The gas reburning system, including overfire air system, was designed and installed by Energy and Environmental Research Corporation. The low-NO_x burner was designed and installed by Foster Wheeler.

The \$17.8 million GR-LNB project, a CCT-III selection, is supported by the Public Service Company of Colorado, Electric Power Research Institute, Gas Research Institute, Colorado Interstate Gas Company, and Energy and Environmental Research Company, in addition to the CCT Program.

Operational testing was completed in January 1995. The final technical report and economic evaluation are expected to be completed in December 1995.



- ▲ Cherokee Station— Evaluation of Gas Reburning and Low-NO_x Burners on a Wall-Fired Boiler
- ◀ Arapahoe Station— Integrated Dry NO_x/SO₂ Emissions Control System

Progress and Achievements

The Clean Coal Technology Program continues to make major strides in the progress of demonstrations. By mid-1995, 17 projects had completed operational testing; 6 were in operation, 7 in construction, 12 in design, and 1 in negotiation. A number of major 1995 milestones are highlighted below.

NO_x Control: *Southern Company Services'* project at Georgia Power is testing low-NO_x burners with advanced overfire air on the wall-fired boiler, with early results showing NO_x reductions of 69 percent. Another SCS project, at a Gulf Power plant in Florida, is completing operational testing. Several commercially available catalysts were tested to determine whether SCR will work with U.S. coals under utility operating conditions. Tests have shown the catalysts to perform within or exceed expectations.

Super Scrubbers: In June 1995, *Pure Air* completed operational testing of its super scrubber at Northern Indiana Public Service Company's Bailly Generating Station outside Gary, Indiana. The unit removes 95 percent of the SO₂ and produces gypsum as a by-product. *Pure Air* has contracted with Florida Power & Light to provide 1,600 megawatts of SO₂ scrubbing capability at its Manatee power plant.

New York State Electric and Gas Corporation's project at Milliken Station began integrated operation this July and is designed for "total environmental and energy management," a concept encompassing low emissions, low energy consumption, improved combustion, upgraded boiler controls and reduced solid waste. Using technologies such as the S-H-U wet limestone scrubber, low-NO_x burners, and NO_xOUT[®] urea injection system, the system is expected to remove 95-98 percent of the SO₂ and up to 70 percent of the NO_x.

Fluidized-Bed Combustion: DOE has been receiving repayment checks from the *Tri-State Generation and Transmission Association, Inc.* for the now commercial Nucla Station (Colorado), where the first utility circulating fluidized-bed (CFB) unit was tested. As a result of the Nucla project, the technology supplier, Pyropower Corporation, saved three years in establishing a commercial line of atmospheric CFB boilers.

The test program at *Ohio Power Company's* Tidd project officially ended this March. The Tidd Plant in Brilliant, Ohio, is the

nation's first large-scale pressurized fluidized-bed combustion (PFBC) power plant. Today, the unit is one of only five PFBCs worldwide. The pioneering 70-megawatt demonstration unit has verified PFBC's superior environmental performance—more than 95 percent SO₂ capture and NO_x emissions, well within air quality limits—with no need for add-on pollution controls. The success of the project has led Babcock & Wilcox, the technology supplier, to acquire domestic licensing rights for this technology.

Integrated Gasification Combined Cycle (IGCC): Construction is nearly complete, and operational testing of the demonstration unit is scheduled to start in September at *PSI Energy's* Wabash River Generating Station in West Terre Haute, Indiana. The repowered demonstration unit will generate 262 megawatts using *Destec's* two-stage coal gasifier, which produces medium-Btu gas from high-sulfur coal. The project will be the largest single-train IGCC plant in operation in the United States.

In February 1995, *Sierra Pacific Power Company* began construction of an IGCC demonstration at its Tracy Station near Reno, Nevada. The 99-megawatt unit is using the KRW air-blown pressurized fluidized-bed gasifier, which produces low-Btu syngas, with hot gas cleanup.

Advanced Combustion Technologies: The *Alaska Industrial Development and Export Authority* began construction in May 1995 of the 50-megawatt Healy Clean Coal Project that will use innovative combustor and flue gas technologies to demonstrate combined removal of SO₂, NO_x, and particulates. The project will use TRW's advanced slagging combustor, staged combustion to reduce NO_x, and Joy Technologies' spray dryer absorber with sorbent recycle.

Coal Processing for Clean Fuels: The *ENCOAL* demonstration plant near Gillette, Wyoming, has been attracting a large number of international visitors, especially from Pacific Rim countries, interested in either using the technology with their own coal supplies or purchasing products. Using mild gasification of low-rank coal, the plant converts the coal into a clean liquid that can be substituted for boiler fuel, and into a dry compliance coal. SGI International (developer of the process) and Mitsubishi Heavy Industries are

studying the feasibility of a plant in China's Shandong province. Feasibility studies also are being conducted for two 5,000-metric-ton-per-day plants—one in East Kalimantan, Indonesia, and one in Kemerova, Russia.

More than 400,000 tons of SynCoal[®] product (upgraded subbituminous coal) has been delivered to industrial and utility customers from the Rosebud Syncoal[®] project, in Colstrip, Montana. The industrial participant, the *Rosebud SynCoal[®] Partnership*, is also working on three potential semi-commercial SynCoal[®] projects located in Wyoming, North Dakota, and Montana.

In a study for Minnkota Power Cooperative, the partnership found positive results by applying the coal processing technology to a commercial plant integrated into an existing power plant site. A team from SynCoal[®] also has visited Indonesia to investigate applying the technology to Sumatran low-rank coals.

Clean-burning fuels can also be made from high-heating-value, high-sulfur coals. *Custom Coals International* is taking precombustion beneficiation to an advanced state. The plant, near Central City, Pennsylvania, is nearing completion and will produce Carefree Coal[™] and Self-Scrubbing Coal[™]. Following the demonstration, Custom Coals plans to build several commercial plants throughout the nation. Custom Coals also led a U.S. consortium, which signed an agreement with China to build a coal-cleaning plant, a 500-mile underground slurry pipeline, and a port facility. The company is aggressively marketing the technology in Eastern Europe, and has received letters of intent from three Polish coal mines to build two 10-million-ton-per-year coal preparation plants.

Industrial Applications: *Bethlehem Steel Corporation* has installed an innovative "coal injection" technology, which substitutes granulated coal for coke, at two high-capacity blast furnaces located at Burns Harbor site on Lake Michigan. Operational testing is scheduled to begin in November 1995. Sulfur pollutants from coal-burning are captured by limestone, and the gases leaving the furnace contain virtually no SO₂ or NO_x emissions. Also, blast furnace production is increased by maintaining high raceway temperatures.

For more information see: *Program Update 1994; Project Fact Sheets*, updated in July 1995; and *The Investment Pays Off*.