IMPLEMENTING THE U.S. DEPARTMENT OF ENERGY'S POWER PLANT IMPROVEMENT & CLEAN COAL POWER INITIATIVES

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I. BACKGROUND

Legislative Background

On October 11, 2000, the Power Plant Improvement Initiative was established under United States Public Law 106-291 for the commercial scale demonstration of technologies to assure the reliability of the Nation's energy supply from existing and new electric generating facilities. As further guidance, the U.S. Congress' conference report provided that the Power Plant Improvement Initiative "will demonstrate advanced coal-based technologies applicable to existing and new power plants.... The managers expect that there will be at least a 50 percent industry cost share for each of these projects and that the program will focus on technology that can be commercialized over the next few years. Such demonstrations must advance the efficiency, environmental controls and cost-competitiveness of coal-fired capacity well beyond that which is in operation now or has been operated to date."

According to the conference report, the law seeks to address concerns about electric power reliability, which might be measured through "increases in performance factors, such as efficiency, cost-competitiveness, and/or emissions removal required for both existing and new facilities." To fund the Power Plant Improvement Initiative, US$95 million in previously appropriated funds were transferred from the U.S. Department of Energy's Clean Coal Technology (CCT) demonstration program. Public Law 106-291 also expanded repayment provisions to

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include foreign, as well as domestic, sales and licensing. Repayments are to be retained for future projects. Lastly, any project approved under the Power Plant Improvement Initiative shall be considered a CCT demonstration project under various federal regulations, such as new source environmental reviews.

USDOE's Clean Coal Technology Programs

The Power Plant Improvement Initiative is a follow-on to the CCT demonstration program that was implemented successfully in the 1980s and 1990s by the U.S. Department of Energy (USDOE). Common features of the two programs include commercial-scale demonstrations of advanced coal-based technologies, a minimum 50% industry cost share, and repayment and other administrative provisions. The CCT Program demonstrated a number of technologies ranging from advanced sulfur dioxide (SO_2) scrubbers to low-NO_x burners and selective catalytic reduction (SCR) technology for nitrogen oxides (NO_x) control. These and other pollution control technologies largely addressed the problem of acid rain, and helped to halve the cost of air pollution compliance technologies–costs that are ultimately borne by the public as electricity ratepayers and as consumers of goods and services. A second major category of technologies demonstrated under the CCT Program involves advanced power generation systems, such as fluidized bed combustion (FBC) and integrated gasification combined cycle (IGCC), that can generate electricity more efficiently and more cleanly than conventional coal-fired boilers.

While a detailed discussion of the CCT Program, including the status of the various projects and accomplishments, is beyond this paper, it has resulted in substantial benefits to human health, the environment, and the economy. For example, CCT projects have helped to reduce emissions of the acid rain precursors, SO_2 and NO_x, even as coal usage increased. The three wet SO_2 scrubbers demonstrated under the CCT Program have reduced emissions by more than one million tons collectively since their debuts in the 1990s. The U.S. Environmental Protection Agency, in its decision making and regulatory processes, utilized data on NO_x control and hazardous air pollutants (HAPS, or air toxics) emissions from the CCT Program. IGCC facilities constructed under the CCT Program near Terre Haute, Indiana, and Tampa, Florida, are providing clean and

affordable electricity, enough to supply roughly 500,000 homes at moderate-load levels. Soon, the world□s largest FBC boiler will start up in Jacksonville, Florida, under the CCT Program, which will generate enough clean coal-based electricity to supply another 250,000 homes. A recent study by the Southern Company estimated that □the DOE coal-based research program related to large-scale power generation are estimated to provide over US$100 billion in benefits to the U.S. economy through 2020 at a cost to the Federal budget of less than US$4 billion." Another study by the Electric Power Research Institute estimated □that the benefits of coal R&D to consumers for the period 2007-2050 are US$1,380 billion." The Air & Waste Management Association, *Power* magazine, *R&D* magazine, and the Society of Professional Engineers have all bestowed national technological achievement awards upon projects in the CCT Program. Even the General Accounting Office has said the (Clean Coal Technology) program has shown that the government and private sector can work together effectively to develop and demonstrate new technologies," citing the program as a model for other government cost-shared programs involving technology development and demonstration. More details on the CCT Program, including project summaries, can be found on the DOE Clean Coal Technology Compendium web page at http://www.netl.doe.gov.

While some CCT projects are still active, no new projects have been selected under the program since 1993. However, the recent Power Plant Improvement Initiative (PPII) represents an opportunity to demonstrate recent improvements and innovations in clean coal technologies. Building upon lessons learned under the CCT Program, DOE tightened up some of the repayment, site commitment, and project schedule requirements for the PPII.

PPII Public Comment, Solicitation and Evaluation Activities

U.S. Public Law 106-291 was enacted on October 11, 2000, and DOE subsequently issued public announcements of the Initiative in late November 2000. A draft solicitation was issued on December 6, 2000, which was followed by a one-month period during which comments from industry were obtained. DOE issued the final PPII Program solicitation (DE-PS26-01NT41104) on February 6, 2001. Proposal applications were due by April 19, 2001, and 24 applications for funding were received in response to the solicitation. DOE issued a TechLine news release on May 4, 2001,

summarizing all of the applications, including public abstracts. Subsequently, five applications were rejected during preliminary evaluation, and the remaining 19 applications underwent comprehensive evaluation.

Among the mandatory requirements for preliminary evaluation were that (1) the proposed project utilize at least 75% coal, as measured on a fuel heating value (i.e., Btu) input basis, and (2) the applicant must have access and use rights for the proposed demonstration project site for the duration of the project. The first requirement was never really an issue in the prior CCT Program solicitations, which occurred before deregulation of the electric utility industry in the United States. However, after deregulation, power producers are striving to minimize costs and are often considering opportunity fuels, such as biomass or petroleum coke. The 75% coal requirement is intended to keep the projects focused primarily on clean coal technologies, because coal is America's most abundant fossil energy resource and opportunity fuels can often be characterized by very localized economics or market niches. The second requirement, i.e., confirmed site access, was designed to avoid difficulties experienced in some previous projects, where incomplete host site commitments either served to delay the commencement of projects or, in some cases, resulted in collapse of the project, which necessitated a search for a new site to preserve the technology demonstration.

Comprehensive evaluation of the proposals entailed a number of technical, funding and financial, budget, and EH&S (environment, safety & health) evaluation criteria. The technical evaluation criteria and their relative weightings were Technical Merit (40%), Commercial Viability & Market Potential (30%), and Management Approach & Capabilities (30%). Only the technical evaluation criteria were point scored; the other criteria were rated adjectivally. In addition, the following program policy factor was considered: Programmatic Balance: It may be desirable to select one or more projects that represent a diversity of technology approaches and methods. Further DOE reserves the right to select projects that collectively utilize a broad range of U.S. coals." However, this factor was not invoked to influence or alter the selections, as it was deemed that the recommended projects already represented a diversity of technology approaches and methods, and a range of U.S. coals.

Project Selections

On September 26, 2001, eight applications were selected for negotiations leading to the award of cooperative agreements. Six applications were selected for full award, and two for partial award. One of the two partially selected applications was subsequently withdrawn by the applicant company. Negotiations between DOE and the remaining seven private sector project sponsors are under way. It is anticipated that cooperative agreements will result within the next few months.

II. PROJECT IMPLEMENTATION

The seven remaining PPII project selections are described below. DOE project management activities are being performed by the National Energy Technology Laboratory, with guidance from DOE's Office of Fossil Energy.

This project will demonstrate an approach to reduce NO_x emissions to 0.15 lbs/MMBtu or below, without the use of SCR technology, and at a fraction of the capital, and operating and maintenance (O&M) costs. The demonstration will take place on Unit 4, a 340-MW_e cyclone-fired boiler, at the Edgewater Generating Station of the Wisconsin Power & Light Company, a subsidiary of Alliant Energy. NO_x emissions from cyclone boilers tend to be very high as a result of the technology's high operating temperatures, and therefore compliance with NO_x standards poses a major challenge for cyclone boilers. The critical part of low-NO_x combustion is to reduce oxygen (air) availability during coal devolatilization.

In the Combustion Initiative, air is supplied at lower than the stoichiometric ratio (0.75 to 0.90). Additional air is added later as over-fire air to complete combustion. To control air and fuel flow in the burner lines, Alliant plans to install air flow straighteners, windbox modifications, new split dampers, mill tuning, and new crusher feeders. Alliant will also rely heavily on combustion modeling techniques to simulate and optimize the overall plant performance. Extensive combustion fluid dynamic software will be developed that includes cyclone models, flue gas cleanup chemistry, air flow monitoring, coal flow path models, roping effects, particle size distributions, and multiple coal flow balancing. After the combustion approach is implemented, the last increment of NO_x reduction, if needed, can be obtained by selective non-catalytic reduction (SNCR) utilizing urea as the reagent.

This project will develop a protocol and approach that can be utilized for any cyclone-fired power plant. The

instrumentation, modeling, coal processing improvements, and increased boiler efficiencies are all expected to be directly transferable to other plants.

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If combustion modifications alone cannot keep pace with tightening NO_x reduction requirements, this project will demonstrate a hybrid NO_x control system consisting of three parts: (1) fuel lean gas reburning/selective non-catalytic reduction (FLGR/SNCR), (2) an intermediate SNCR step, and (3) a compact SCR. FLGR and SNCR are intermediate in cost between combustion modifications and SCR systems, but neither alone can achieve the levels of NO_x reduction offered by SCR. SCR, on the other hand, can achieve maximum NO_x reductions, but usually at high costs and with greater retrofit space requirements. The proposed hybrid offers the potential to achieve greater NO_x control than either FLGR or SNCR, at a lower cost than a full SCR system. Utilization of the FLGR/SNCR and SNCR steps allows for the installation of a smaller SCR system, with a smaller amount of costly catalyst. The hybrid system also mitigates some of the narrow temperature window and ammonia slip difficulties associated with stand-alone SNCR systems.

The objectives of this project are to demonstrate the hybrid as a lower cost alternative to SCR to achieve 0.15 lbs/MMBtu emission levels, and to operate the hybrid system to improve performance and reduce compliance costs. The triple NO_x control system cost-effectively provides up to 70% reduction in NO_x and offers great flexibility to the operator, which is critical in the peak summer months. The system will be retrofitted in February 2003 and tested and optimized during the 2003 ozone season. Long-term performance and emission monitoring will be done during the 2004 ozone season. Fuel Tech, Inc., a supplier of reburning and SNCR systems, will be a member of A.D. Little□s project team, along with the host site provider.

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This project will demonstrate a set of pollution control technologies for NO_x, SO_2, acid gases, mercury, and fine particulate emissions. The demonstration technologies are a Circulating Dry Scrubber (CDS) and a

single-bed in-duct SCR System. The CDS will capture (1) 95% of SO_2 at half the cost of a conventional scrubber, (2) up to 90% of mercury through the introduction of activated carbon into the CDS, at one-tenth the cost of in-duct carbon injection, and (3) 95% of SO_3 and other acidic gases (HCl and HF), which are precursors to PM2.5 and have caused visible emissions from wet scrubber installations.

O&M costs are less, and reliability is better, for the CDS system because it is less complex mechanically than a conventional flue gas desulfurization (FGD) system. Activated carbon injection into the CDS unit is projected to use 5 to 10 times less carbon than direct injection into the flue gas duct for a given level of mercury control, because the carbon has a greater average contact time in the CDS bed than in the flue gas duct. Reducing the carbon feed rate results in substantial mercury control cost savings. The single-bed, in-duct SCR system will remove up to 60% of NO_x emissions at about one-third the capital cost and one-fourth the O&M cost of a full SCR or SNCR system.

These technologies are especially well suited to pollution control at smaller, older coal-fired power plants where either space is too limited or the economics will not support the installation of wet scrubbers and/or conventional SCR systems. The demonstration will be conducted at the 104-MW_e AES Greenidge Unit 4, along Lake Seneca near Dresden, New York. This unit is representative of 492 coal-fired electricity generating units in the United States with capacities of 50-300 MW_e. Another feature of this project is that Greenidge utilizes biomass to provide up to 10% of the heat input to the boiler. This project will help determine the impact of biomass co-firing on SCR, mercury control, and FGD performance. In addition, biomass firing reduces CO_2 emissions from the boiler while reducing fuel cost.

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This project will demonstrate the Advanced Hybrid Particulate Collector (AHPC) technology that was originally developed by the University of North Dakota Energy and Environmental Research Center (UND/EERC) and subsequently tested on a 2.5-MW_e slipstream at Otter Tail's Big Stone Plant near Milbank, South Dakota. The AHPC technology consists of fabric filter bags interspersed with perforated electrostatic precipitator (ESP) plates and electrodes in the same housing. The filter

bags can achieve much greater collection of very fine particles than can the ESP plates, while those ESP plates can capture dust that is re-entrained as a result of back pulsing of the fabric filter bags; thus, the two technologies will complement each other. The AHPC technology offers the potential to increase fine particulate (0.01 to 50 microns) collection efficiency by one or two orders of magnitude (i.e., up to 99.9999% removal), at a cost that is comparable to conventional particulate control technology. These fine particles are often associated with hazardous air pollutant emissions.

Comparing the AHPC to existing particulate control technologies also shows that it solves the problem of higher emissions from conventional baghouses when the air-to-cloth (A/C) ratio is increased. This allows the AHPC to operate at very high A/C ratios, where conventional fabric filters are limited. AHPC requires significantly less total collection area than conventional ESPs or baghouses and solves the problem of chemical attack that limits application of baghouses to low-sulfur coals by using PTFE (polytetrafluoroethylene) fabric.

A 450-MW_e demonstration will be conducted on a cyclone boiler firing coal from Wyoming's Powder River Basin. Powder River Basin i.e., subbituminous) coal produces fly ash that is among the most difficult to collect with ESPs. This technology can be implemented on a wide range of coal sources and boiler types. Seventy-five percent of the existing ESPs on coal-fired utilities are over 30 years old, and many are operating with very marginal performance. There are a growing number of deratings occurring because the existing ESP cannot operate efficiently and effectively at peak load. The present performance of these ESPs limits the type of fuels that can be burned in the boiler. Challenging PRB coals, which are cheaper and contain significantly lower amounts of sulfur, in many cases cannot be burned because existing ESPs cannot effectively capture the high-resistivity dust that is generated. The installation of the AHPC technology will significantly improve the overall reliability of the air pollution control system. There is great potential that the AHPC, with its superior collection of fine particulate in a cost-effective, compact-sized control device, will capture a significant share of the ESP upgrade market, which is at least 161,070 MW_e.

Another application for the AHPC would be the control of heavy metals. Generally, heavy metals are directly condensed or adsorbed onto particles in the gas stream. Because fine particles have a much greater surface area than larger particles, for the

same amount of mass, they adsorb a greater percentage of these heavy metals. AHPC's superior capture of fine particulates will effectively control emissions of heavy metals that are not substantially in the vapor phase. Those elements in the vapor phase (e.g., mercury and selenium) will require sorbents. It is expected that the AHPC will be compatible with any of the proposed sorbents for mercury control. Otter Tail Power's team members include UND/EERC (technology developer), W.L. Gore, Inc. (fabric filter supplier), and ELEX AG (ESP contractor).

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Sunflower Electric Power Corporation will demonstrate ultra low-NO_x burners in combination with a neural network for optimized boiler operation using Powder River Basin coal in a 360-MW_e wall-fired unit in Garden City, Kansas. The goal is to reduce NO_x emissions to 0.13-0.14 lbs/MMBtu. Because combustion stage modifications generally represent the lowest cost approach to controlling NO_x emissions from coal-fired boilers, this demonstration will establish a lower baseline for this technology. Even if these modifications can only approach but not achieve the target level(s), they may be able to be followed up with lower cost, polishing versions of SCR or SNCR systems, thereby lowering total NO_x reduction costs compared to SCR and SNCR. An important feature will be individually controlled coal and combustion air feedlines to each burner. Usually, entire banks of burners utilize the same coal and air feed lines, without individual burner flow controls. This feature alone offers the potential to greatly enhance burner, and boiler performance. The project seeks to demonstrate that integrating various combustion-stage technologies into a boiler fired with Powder River Basin coal will result in a 50% reduction in NO_x emissions. Emission reductions to levels anticipated in the current New Source Performance Standard (NSPS) for utility boilers (about 0.15 to 0.22 lbs/MMBtu) are possible with this technology integration. Costs are estimated to be on the order of 15-25% of those for SCR.

Sunflower has identified 88 U.S. power plants totaling 36,000 MW_e where the technologies demonstrated in this project might be replicated to reduce the average NO_x emissions rate from an average of 0.37 lbs/MMBtu to 0.15 to 0.22 lbs/MMBtu. These units operate at an average 73%

annual capacity factor, and collectively emit 498,000 tons/yr of NO_x.

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This project will demonstrate the use of neural networks to optimize sootblower operation on a 445-MW_e unit in Apollo Beach, Florida. Sootblowers in coal-fired power plants are normally operated through observations that can only be gleaned through years of operator experience. Buildup of soot and slag in the upper portions of a boiler can adversely impact heat transfer to the boiler tubes, unit efficiency, and emissions. This project is expected to improve heat rate by up to 2%, reduce NO_x emissions by up to 30%, and reduce particulate emissions by up to 5%. This technology can become a highly cost-effective approach to allow the utility industry to control emissions while improving unit performance.

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Universal Aggregates, a joint venture of CONSOL and SynAggs, LLC (which is affiliated with Trumbull Corp., P.J. Dick, Inc., and Lindy Paving, Inc.), will demonstrate a patented method for converting spray dryer ash into lightweight aggregate building materials. The demonstration site will be the 250-MW_e Birchwood Power Facility in King George County, Virginia. According to an industry survey conducted by the American Coal Ash Association (ACCA) in 1999, just 18% of FGD by-products are recycled commercially in the United States. While the ACCA did not further breakdown the FGD by-product category, most of the recycled material is recycled wet FGD by-products, such as FGD gypsum, which can be used in cement and wallboard manufacture. The recycling figure for waste materials from dry scrubbers or spray dryers is probably much lower. This demonstration will address that market segment. In fact, Universal Aggregates process can be used to manufacture lightweight aggregate building materials from wet or dry FGD by-products or from fly ash, thereby avoiding the costs and environmental impacts associated with landfill disposal.

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III.CLEAN COAL POWER INITIATIVE

The Clean Coal Power Initiative (CCPI) is a government/industry partnership to implement President Bush's National Energy Policy (NEP) recommendation to increase investment in clean coal technology. This recommendation, one of several dealing with electricity, addresses our National challenge of ensuring the reliability of our electric supply while simultaneously protecting our environment. The CCPI is a cost-shared partnership between the government and industry to demonstrate advanced coal-based, power generation technologies. The goal is to accelerate commercial deployment of such technologies to ensure that the United States has clean, reliable, and affordable electricity. This ten-year initiative is tentatively funded at a total Federal cost share of US$2 billion with a matching cost share from the private sector of at least 50%. The CCPI will help to redefine clean coal technologies for power generation and coproduction applications, and will likely be implemented through five competitive solicitations issued over a ten-year period. The first of these program solicitations, entitled "Clean Coal Power Initiative" (DE-PS26-02NT41428) was issued on March 4, 2002. Proposal applications are due by August 1, 2002. DOE will provide approximately $300-$400 million for funding demonstration projects under this solicitation. The CCPI program solicitation, along with other information pertinent to the CCPI, can be found NETL's website at http://www.netl.doe.gov where a web page has been devoted to the CCPI. It is hoped that proposal evaluations will be completed, and that project selections will be made, by late 2002 or early 2003.

IV. SUMMARY

Taken together, the seven projects in the USDOE's Power Plant Improvement Initiative represent a suite of emissions control (i.e., NO_x, SO_x, mercury, fine particulate, HCl and HF), byproduct utilization and advanced control system technologies. In particular, a variety NO_x emission control technologies are featured, in anticipation of more stringent NO_x emission standards. The Power Plant Improvement Initiative builds upon many of the lessons learned in DOE's Clean Coal Technology (CCT) Program of the 1980s and 1990s and, hopefully, will provide additional lessons that can be improved upon under the new Clean Coal Power Initiative (CCPI).