GREENIDGE MULTI-POLLUTANT CONTROL PROJECT

U.S. DOE Cooperative Agreement No. DE-FC26-06NT41426

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QUARTERLY PROGRESS REPORT
FOR WORK PERFORMED DURING THE PERIOD
January 1, 2007 to March 31, 2007

April 30, 2007

1.0 Executive Summary

As part of the Greenidge Multi-Pollutant Control Project, CONSOL Energy Inc. (CONSOL), AES Greenidge LLC (AESG), and Babcock Power Environmental Inc. (BPEI) are installing and testing an integrated multi-pollutant control system on one of the nation's smaller existing coal-fired power plants - the 107-MWe AES Greenidge Unit 4 (Boiler 6). The overall goal of this approximately 2.5-year project, which is being conducted as part of the U.S. Department of Energy's (DOE's) Power Plant Improvement Initiative (PPII), is to demonstrate that the multi-pollutant control system being installed, which includes a hybrid selective non-catalytic reduction / selective catalytic reduction (SNCR/SCR) system and a Turbosorp® circulating fluidized bed dry scrubbing system with baghouse ash recycling and activated carbon injection, can cost-effectively reduce emissions of NO_x, SO_2, Hg, acid gases (SO_3, HCl, HF), and particulate matter from coal-fired electrical generating units (EGUs) with capacities of 50 MWe to 600 MWe. Smaller coal-fired units, which constitute a significant portion of the nation's existing generating capacity, are increasingly vulnerable to retirement or fuel switching as a result of increasingly stringent state and federal environmental regulations. The Greenidge Project will demonstrate the commercial readiness of an emissions control system that is particularly suited, because of its low capital and maintenance costs and small space demands, to meet the requirements of this large group of existing EGUs. All funding for the project is being provided by the U.S. DOE, through its National Energy Technology Laboratory (NETL), and by AES Greenidge.

The multi-pollutant control system is depicted in Figure 1. The NO_x control system consists of commercially available combustion modifications (installed outside of the scope of the DOE project), a urea storage system, a urea dilution and injection system (SNCR), and a single-bed, in-duct SCR reactor that is fed by ammonia slip from the SNCR process. The Turbosorp® system for SO_2, SO_3 (visible emissions), mercury, HCl, HF, and particulate matter control consists of a lime hydrator and hydrated lime feed system, a process water system, the Turbosorp® vessel, a baghouse for particulate control, an ash recirculation system to recycle solids collected in the baghouse to the Turbosorp® vessel, and an activated carbon injection system for mercury control. A booster fan is also installed to overcome the pressure drop resulting from the installation of the SCR catalyst, Turbosorp® scrubber, and baghouse.

Specific objectives of the project are as follows:

- Demonstrate that the hybrid SNCR/SCR system, in combination with combustion modifications, can reduce high-load NO_x emissions from the 107-MWe AES Greenidge Unit 4 to ≤0.10 lb/mmBtu (a reduction of ≥60% following the combustion modifications) while the unit is firing >2%-sulfur coal and co-firing up to 10% biomass.
- Demonstrate that the Turbosorp® circulating fluidized bed dry scrubber can remove ≥95% of the SO_2 emissions from AES Greenidge Unit 4 while the unit is firing >2%-sulfur coal and co-firing up to 10% biomass.

- Demonstrate ≥90% mercury removal via the co-benefits afforded by the SNCR/SCR and Turbosorp® circulating fluidized bed dry scrubber (with baghouse) systems and, as required, by carbon or other sorbent injection.
- Demonstrate ≥95% removal of acid gases (SO_3, HCl, and HF) by the Turbosorp® circulating fluidized bed dry scrubber.
- Evaluate process economics and performance to demonstrate the commercial readiness of an emission control system that is suitable for meeting the emission reduction requirements of boilers with capacities of 50 MWe to 600 MWe.

This quarterly report, the fourth to be submitted for the Greenidge Multi-Pollutant Control Project, summarizes work performed on the project between January 1 and March 31, 2007. During the period, project activities transitioned from start-up and commissioning of the multi-pollutant control system to operation and testing of the system, and the project's second (and final) budget period, which is focused on operation and testing, began. Start-up and commissioning of the hybrid SNCR/SCR system, Turbosorp® system, lime hydration system, and activated carbon injection system were completed by the week of March 19, and guarantee testing of the multi-pollutant control system began on the week of March 26. The plant experienced problems throughout the quarter with the accumulation of large particle ash (LPA) on the surface of the in-duct SCR catalyst, which contributed to delays in start-up and forced several outages for catalyst cleaning. A solution to this problem was conceptualized and will likely be implemented during the next quarterly reporting period. Continued operation of the multi-pollutant control system and additional performance testing are also planned for that period.

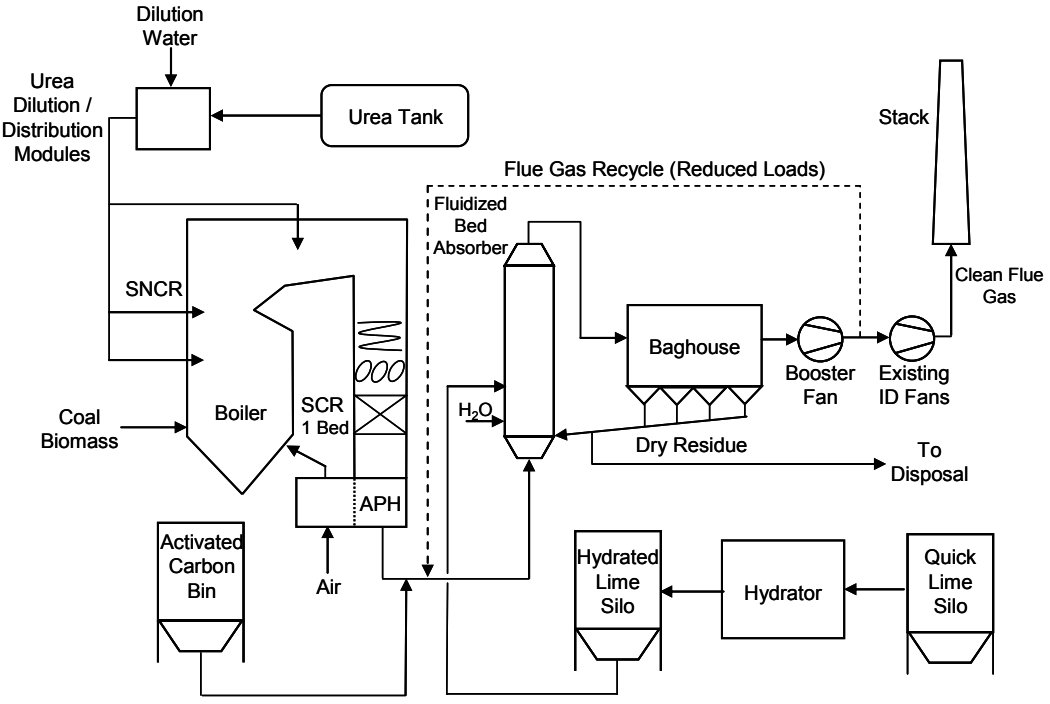

Figure 1. Schematic of the multi-pollutant control system being demonstrated at AES Greenidge.

2.0 Work Performed and Results Obtained During the Reporting Period

Highlights of the Greenidge Multi-Pollutant Control Project during the period from January 2007 through March 2007 included the completion of start-up and commissioning of all components of the multi-pollutant control system and the commencement of guarantee testing and routine operation of the system. Operation of the system was hampered throughout the period by the accumulation of large particle ash (LPA) on the surface of the in-duct SCR catalyst, which forced several outages for catalyst cleaning. The project team has developed a solution to the LPA problem; implementation is currently planned for mid-May.

Work performed and results obtained between January 1, 2007, and March 31, 2007, are described below by Statement of Project Objectives task number.

Tasks 1.1 and 2.1 – Project Management

In January 2007, CONSOL countersigned the DOE cooperative agreement amendment authorizing continuation into the project's second budget period. All Budget Period 2 work falls under project Phase 3 – Operation and Testing. Project management activities during the first quarter of calendar year 2007 are summarized below under Task 3.1 – Phase 3 Project Management.

Task 1.2 – Total Process Definition and Design

As discussed in the quarterly progress report for the third calendar quarter of 2006, this task is complete.

Task 1.3 – Procurement

As discussed in the quarterly progress report for the fourth calendar quarter of 2006, this task is complete.

Task 1.4 – Environmental/Regulatory/Permitting

As discussed in the project's first quarterly progress report, all permits and clearances required for construction of the multi-pollutant control facility were obtained. In addition to these permits, AESG must amend its Title V air permit as part of the regularly scheduled renewal process for that permit in order to reflect the emission requirements set forth in its consent decree with the State of New York. During the first quarter of calendar year 2007, AESG submitted comments to the New York State Department of Environmental Conservation (DEC) on a draft working Title V permit; the permit will likely be finalized during the next quarterly reporting period. AESG also began the reapplication process required of all power plants in New York under the Environmental Benefit Permit Strategy, and it is in the process of applying for modifications to the State Pollutant Discharge Elimination System (SPDES) permits for the plant and for its

Lockwood ash disposal site as required to reflect changes resulting from the installation of the multi-pollutant control system. These applications likely will be completed during the next quarterly reporting period. Finally, during the first quarter of calendar year 2007, the plant submitted reapplication paperwork for its solid waste permit, which was due to expire on March 12 and must be modified to reflect changes in the plant's ash profile resulting from the installation of the multi-pollutant control system.

Task 1.5 – Environmental Information Volume

As discussed in the quarterly progress report for the second calendar quarter of 2006, this task is complete.

Task 1.6 – Baseline Testing

As discussed in the quarterly progress report for the second calendar quarter of 2006, this task is complete.

Tasks 2.2 and 2.3 – General Civil/Structural and Process System Construction

The last major milestone associated with Tasks 2.2 and 2.3, which required that BPEI achieve Mechanical Completion of the multi-pollutant control system as defined in their engineering, procurement, and construction (EPC) agreement with AESG, was completed in March 2007. Tasks 2.2 and 2.3 are now complete.

Task 2.4 – Plant Start-Up and Commissioning

All major remaining start-up and commissioning activities for the multi-pollutant control system at AES Greenidge, including completion of combustion system optimization, start-up of the Turbosorp® system, start-up of the lime hydration system, start-up of the hybrid SNCR/SCR system, and start-up of the activated carbon injection system, were completed during the first quarter of calendar year 2007.

Initial optimization of the combustion system, which was performed outside of the scope of the DOE project but had to be finished before start-up of the hybrid SNCR/SCR system could begin, was completed in January 2007. Fuel-Tech representatives returned to the AES Greenidge site during the week of January 22 to begin start-up of the SNCR system, and the first load of urea was delivered to site on January 23. Urea injection tests were performed beginning on January 26, and on February 6, the hybrid SNCR/SCR system was operated in "cascade" mode (i.e., such that the SNCR is used to generate ammonia slip for the SCR) for the first time. This initial, approximately 3-hour test run was successful. The system was able to maintain stable emissions below the target rate of 0.10 lb/MMBtu throughout the test while Unit 4 was operating at ~100 MW. Testing and optimization of the hybrid SNCR/SCR system at full load and at reduced load continued throughout the month of February. Tuning of the system was hindered in late February by high CO concentrations in the furnace, which are indicative of less-than-optimal combustion and can adversely affect SNCR performance.

Adjustments were made to the unit's combustion system to correct this problem, and tuning of the system was completed during the first half of March.

Start-up of the lime hydration system commenced on January 12. However, it was quickly determined that modifications to the system were required to prevent excessive overflow of milk of lime. The system originally included a wet scrubber to remove particulate matter from the hydrator exhaust gas and a milk of lime circuit that was fed partially by the scrubber bottom liquid; the modifications involved eliminating the wet scrubber and milk of lime circuit from the process (although these pieces of equipment have not been physically removed from the lime hydration structure) and routing the hydrator exhaust to the Turbosorp® system. Figure 2 presents a photograph showing installation of the new ductwork used to transport the hydrator exhaust to the inlet of the Turbosorp® absorber vessel. The water required for lime hydration is now fed directly to the hydrator. BPEI completed these mechanical modifications during the second half of January, and they made corresponding required modifications to the control system for the lime hydration system during late January and the first half of February. The lime hydration system was successfully started up during the week of February 19.

Figure 2. Photograph showing the installation of the new ductwork used to transport the hydrator exhaust to the inlet of the Turbosorp® vessel.

While the modifications to the lime hydration system were being made, AES Greenidge purchased pre-hydrated lime to allow start-up of the Turbosorp® system to proceed. Hydrated lime and water injection tests were performed beginning on January 13. The Turbosorp® system was operated for short periods of time on January 15 and 16, and then it was operated during a series of tests throughout the rest of January as BPEI and

Austrian Energy worked to tune its performance. SO_2 removal efficiencies between 90% and 100% were achieved consistently during these optimization tests. Progress on optimization of the Turbosorp® system was hampered during early February by frigid temperatures and weather protection problems that caused frozen lines and valves. These problems were resolved by February 8, and the Turbosorp® system was operated occasionally during the next few weeks using purchased hydrated lime (at a limited injection rate to reduce cost).

The plant also experienced problems during February with failing baghouse cleaning valves. A temporary air compressor was brought in to satisfy the increased demand caused by air leakage from the failed valves, and the design flaw that caused the valves to fail was corrected.

On February 27, AES Greenidge successfully operated all of the components of the multi-pollutant control system, with the exception of the activated carbon injection system, while Unit 4 was running at about 91 MW. The activated carbon injection system was commissioned during the week of March 19. Hence, by the end of the quarterly reporting period, all of the components of the multi-pollutant control system had been commissioned successfully and were ready for normal operation.

Task 3.1 – Phase 3 Project Management

As discussed above under Tasks 1.1 and 2.1, project Phase 3 – Operation and Testing began during the first quarter of calendar year 2007. During the quarter, our abstract titled "Parametric Testing Results from the Greenidge Multi-Pollutant Control Project" was accepted for presentation at COAL-GEN, which will be held in Milwaukee, WI, in August 2007. In addition, we submitted an abstract titled "Mercury Removal Performance of the Greenidge Multi-Pollutant Control System" to the organizers of POWER-GEN, which will be held in New Orleans, LA, on December 11-13. Copies of these abstracts are included as Attachments A and B, respectively, to this report. We also drafted our extended abstract (titled "The Greenidge Multi-Pollutant Control Project: Key Technical and Economic Features of a New Approach for Reducing Emissions from Smaller Coal-Fired Units") for the Air & Waste Management Association's 2007 Annual Conference and Exhibition; the conference will be held in Pittsburgh, PA, in June 2007. A copy of this extended abstract is included as Attachment C to this report.

A first draft of the Preliminary Public Design Report was completed and distributed for review. The report will be revised to incorporate reviewer comments and issued during the next quarterly reporting period. CONSOL also completed a revised economic evaluation of the multi-pollutant control system; results of that evaluation will be presented at the Electric Power conference in May 2007 and in the Final Public Design Report, which will be drafted during the next quarterly reporting period.

Task 3.2 – Plant Operations

Task 3.2 commenced during the quarterly reporting period. As discussed under Task 2.4 above, all major components of the multi-pollutant control system were commissioned by the end of March 2007, and routine operation of the system began during that month. As of March 13, all components of the system, with the exception of the activated carbon injection system, were operating normally, and the system was achieving NO_x and SO_2 emission rates of approximately 0.1 lb/MMBtu and 0.2 lb/MMBtu, respectively, based on measurements made by the plant's continuous emissions monitors. The activated carbon injection system was operated during guarantee testing on the week of March 26; the operating strategy for that system will be better defined once testing results become available.

Our primary concern regarding the operational performance of the multi-pollutant control system during the reporting period was the accumulation of large particle ash (LPA) on the in-duct SCR catalyst, which was a chronic problem for the plant throughout the first quarter of calendar year 2007. On Tuesday, January 2, plant personnel reported concerns about increasing pressure drop across the catalyst. As a result, they decided to take the unit off line for its steam turbine screen outage on January 3, rather than on January 11 as originally scheduled, so that BPEI could inspect the SCR internals and determine the cause of the problem. This inspection indicated that the buildup in pressure drop was caused by refractory and miscellaneous construction debris that remained in the boiler after the tie-in outage and had blocked portions of the catalyst surface, as well as by large particle ash (LPA) that had accumulated on the catalyst. The debris and ash were removed, and the unit returned to service on January 7. It operated normally until January 30, when plant personnel again observed an increase in pressure drop across the catalyst. The catalyst was cleaned and inspected on February 2-4; LPA was identified as the cause of the increase in pressure drop. LPA accumulation on the catalyst continued to hamper plant operations throughout February and March; the catalyst was cleaned during a primary superheater tube leak outage on February 9-10, and outages were held for catalyst cleaning on March 2-4 and on March 22-24. Figure 3 presents a photograph taken during the February 2-4 outage showing the accumulation of LPA on the surface of the catalyst.

BPEI developed a solution to capture the LPA before it reaches the catalyst by using a sloped screen installed between the economizer and the SCR in the section of ductwork containing the static mixers. This solution will be further developed and likely implemented in mid-May 2007, during the next quarterly reporting period.

Task 3.3 – Testing and Evaluation

Task 3.3 began during the quarterly reporting period, as CONSOL conducted field sampling for guarantee testing of the multi-pollutant control system at AES Greenidge during the week of March 26. All sampling was carried out while the plant was operating at high load and firing coal similar to the design coal. Flue gas sampling was completed according to the schedule shown in Table 1. (The grid point NO_x

measurements at the SCR inlet and outlet and the SO_2 measurements at the air heater outlet and baghouse outlet were performed by Clean Air Engineering under contract to CONSOL). Figures 4-6 present photographs showing sampling activities at the SCR inlet and outlet grids, air heater outlet, and stack.

Figure 3. Photograph taken on February 3, 2007, showing the accumulation of large particle ash on the surface of the in-duct SCR catalyst.

Table 1. Flue gas sampling schedule for guarantee testing at AES Greenidge on March 28-30, 2007.

Date	Parameter	Testing Locations	Number of Tests	Testing Method
Wednesday, March 28	NO_x	SCR inlet grid, SCR outlet grid	3	EPA Method 7E
	NH_3	SCR outlet	3	EPA Method CTM 027
	Hg (no ACI)	Air heater outlet, Stack	3	Ontario Hydro (ASTM D6784-02)
Thursday, March 29	SO_2	Air heater outlet, Baghouse outlet	3	EPA Method 6C
	SO_3	Air heater outlet, Stack	3	Controlled Condensation
	HCl, HF	Air heater outlet, Stack	3	EPA Method 26A
	Particulate Matter	Air heater outlet, Stack	3	EPA Method 17
Friday, March 30	Hg (with ACI)	Air heater outlet, Stack	3	Ontario Hydro (ASTM D6784-02)
	SO_3	SCR inlet, SCR outlet	3	Controlled Condensation

Figure 4. Photograph of sampling at the SCR inlet and outlet grids. Grid-point NO_x sampling was performed by Clean Air Engineering.

Figure 5. Photograph of flue gas Hg sampling at the air heater outlet.

Figure 6. Photograph of sampling activities at the stack.

In addition to the flue gas sampling, plant personnel collected solid and liquid process samples throughout the testing period to allow for an assessment of system performance during the period and for the completion of Hg mass balances. AES Greenidge and BPEI also monitored urea, lime, and carbon consumption rates and pressure drop across the system components to determine whether performance guarantees associated with these parameters were satisfied. Laboratory analysis of samples collected during the guarantee testing period is scheduled to be completed in April. Results of the guarantee tests will become available during the next quarterly reporting period. Additional process performance testing is also planned for that period.

3.0 Status Reporting

3.1 Cost Status

Table 2 summarizes the cost status of the Greenidge Multi-Pollutant Control Project through the end of the first quarter of calendar year 2007. As shown in the table, actual incurred costs for the first quarter of 2007 were $1,088,144 less than baseline planned costs for that quarter, and cumulative actual incurred costs were $3,568,217 less than cumulative planned costs as of the end of the quarter.

The negative cost variance for the first quarter of 2007 arose largely because start-up and commissioning of the multi-pollutant control system took longer than expected; hence, costs associated with or contingent upon operation and testing of the system were less than originally budgeted for the quarter. Much of the negative cost variance resulted from missed EPC contract payment milestones (e.g., achievement of substantial completion, issuance of final release and waivers, completion of reliability run, achievement of final completion, submittal of final documents) that had originally been scheduled for the quarter but were dependent upon the completion of guarantee testing, which did not occur until the last week of March. We expect that many of these milestones, which had a combined value of more than $2.8 million, will be achieved during the next quarterly reporting period. Costs for operation and performance testing of the multi-pollutant control system were also about $280,000 less than budgeted for the quarter because of project delays encountered during start-up and commissioning. These negative variances were partially offset in the non-cumulative quarterly total variance by an approximately $2 million cost incurred for the EPC contract's mechanical completion payment milestone, which had been planned for the fourth quarter of calendar year 2006 but was not achieved until this quarter.

Hence, the project's cumulative negative cost variance of $3,568,217 through the end of the first calendar quarter of 2007 results largely from schedule delays that will cause these costs to be incurred slightly later than originally planned, rather than from the project being significantly under budget. The cumulative variance includes the approximately $3.1 million in negative variance identified above for the first quarter of 2007, as well as approximately $0.5 million in negative variance that has persisted from previous quarters. As discussed above in Section 2.0, routine operation and guarantee testing of the multi-pollutant control system both began during the latter part of the current reporting period; we expect that the magnitude of the project's cumulative variance will decrease during the upcoming quarter as milestones contingent upon the completion of guarantee testing are able to be achieved and costs associated with operation and testing of the system are incurred.

3.2 Milestone Status

The critical path project milestone plan (from the Statement of Project Objectives) and status for the Greenidge Multi-Pollutant Control Project are presented in Table 3. As shown in the table and discussed under Task 3.3 in Section 2.0 above, the third of the project's six critical path project milestones ("Begin guarantee/performance testing") was achieved as planned during the current quarterly reporting period. CONSOL began field sampling for guarantee testing of the multi-pollutant control system at AES Greenidge on March 28, 2007. The next critical path project milestone calls for routine plant operation and data collection for long-term testing to begin during the next quarterly reporting period (second quarter of calendar year 2007). We do not anticipate that any changes to the project schedule will be required to complete this critical path milestone.

Table 2. Cost plan/status for the Greenidge Multi-Pollutant Control Project.

Baseline Reporting Quarter	YEAR 1 Start: 1/1/2006 End: 12/31/2006				YEAR 2 Start: 1/1/2007 End: 12/31/2007				YEAR 3 Start: 1/1/2008 End: 12/31/2008			
	Q1	Q2[a]	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Baseline Cost Plan By Calendar Quarter												
Federal Share		$7,276,205	$1,806,841	$2,135,468	$1,581,828	$365,626	$239,208	$228,040	$235,068	$292,521	$176,448	$4,170
Non-Federal Share		$9,336,136	$2,318,366	$2,740,030	$2,029,651	$469,137	$306,930	$292,599	$301,617	$375,335	$226,402	$5,351
Total Planned (Federal and Non-Federal)		$16,612,341	$4,125,207	$4,875,498	$3,611,479	$834,763	$546,138	$520,639	$536,685	$667,856	$402,850	$9,521
Cumulative Baseline Cost		$16,612,341	$20,737,548	$25,613,047	$29,224,525	$30,059,288	$30,605,426	$31,126,065	$31,662,750	$32,330,606	$32,733,456	$32,742,976
Actual Incurred Costs[b]												
Federal Share		$6,610,049	$1,878,193	$1,644,001	$1,105,221							
Non-Federal Share		$8,481,387	$2,409,918	$2,109,425	$1,418,114							
Total Incurred Costs-Quarterly (Federal and Non-Federal)		$15,091,436	$4,288,111	$3,753,426	$2,523,335							
Cumulative Incurred Costs		$15,091,436	$19,379,547	$23,132,973	$25,656,308							
Variance[c]												
Federal Share		($666,156)	$71,352	($491,467)	($476,607)							
Non-Federal Share		($854,749)	$91,552	($630,605)	($611,537)							
Total Variance-Quarterly (Federal and Non-Federal)		($1,520,905)	$162,904	($1,122,072)	($1,088,144)							
Cumulative Variance		($1,520,905)	($1,358,001)	($2,480,074)	($3,568,217)							

Notes: Some numbers may not add perfectly because of rounding. [a]Costs for Q2 2006 include costs for that quarter as well as pre-award costs incurred beginning in January 2002. Unallowable direct costs totaling $359,077 and indirect costs totaling $25,135 that were applied to these direct costs have been removed from the baseline costs for Q2 2006, consistent with Amendment No. A002 to Cooperative Agreement DE-FC26-06NT41426. [b]Actual incurred costs are all costs incurred by the project during the quarter, regardless of whether these costs were invoiced to DOE as of the end of the quarter. [c]Negative variance, ( ), means that actual incurred costs are less than baseline planned costs.

Table 3. Milestone plan / status report.

Critical Path Project Milestone Description	Project Duration - Start: 5/19/06 End: 10/18/08												Planned Start Date	Planned End Date	Actual Start Date	Actual End Date	Comments (notes, explanation of deviation from baseline plan)
	2006				2007				2008								
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4					
Initiate scrubber system installation		A	P										9/30/06	9/30/06	5/30/06	5/30/06	
Commence tie-in outage			A	P									12/31/06	12/31/06	9/29/06	9/29/06	
Begin guarantee/performance testing					P A								3/31/07	3/31/07	3/28/07	3/28/07	See text under Section 3.2.
Begin routine plant operation and data collection for long-term testing						P							6/30/07	6/30/07			
Begin follow-up testing										P			6/30/08	6/30/08			
Complete analyses of process performance and economics											P		9/30/08	9/30/08			

NOTE: “A” indicates actual completion; “P” indicates planned completion.

4.0 Significant Accomplishments during the Reporting Period

Significant progress-related accomplishments during the first quarter of calendar year 2007, which are described more fully in Section 2.0 above, were as follows:

- Completion of Tasks 2.2 and 2.3 – General Civil / Structural and Process System Construction
- Completion of start-up and commissioning of the hybrid SNCR/SCR system
- Completion of start-up and commissioning of the Turbosorp® system
- Completion of start-up and commissioning of the lime hydration system
- Completion of start-up and commissioning of the activated carbon injection system
- Commencement of Budget Period 2
- Commencement of Task 3.2 – Plant Operations
- Commencement of guarantee testing of the multi-pollutant control system

5.0 Problems/Delays and Actions Taken/Planned to Resolve Them

As described in detail under Section 2.0 above, several problems were encountered during start-up and commissioning of the multi-pollutant control system. These included a problem with excessive overflow of milk of lime from the lime hydration system, which required that modifications to the system be made in late January and February, weather protection problems that were encountered during a stretch of cold weather in February, and a problem with failing baghouse cleaning valves that required correction of a design flaw. All of these problems were resolved during the quarterly reporting period; however, when coupled with the booster fan soft start grounding problem experienced during the fourth quarter of calendar year 2006 and the LPA problem discussed below, they contributed to overall schedule slippage of just over two months. As a result, field sampling for guarantee testing began in late March rather than in mid-January as originally planned.

The most serious problem encountered during the quarter was that posed by the accumulation of large particle ash on the surface of the in-duct SCR catalyst, which forced several outages for catalyst cleaning. As discussed under Task 3.2 in Section 2.0 above, the project team plans to implement a solution to this problem, consisting of a sloped screen installed in the ductwork above the SCR to filter the LPA before it reaches the catalyst, during mid-May 2007. Additional periodic disruptions in plant operation are likely until this is completed.

6.0 Products Produced and Technology Transfer Activities Accomplished During the Reporting Period

As discussed in Section 2.0 above, abstracts on the project and on the performance of the multi-pollutant control system were submitted to the organizers of the COAL-GEN and POWER-GEN conferences, which will be held in Milwaukee, WI, in August 2007

and in New Orleans, LA, in December 2007, respectively. Copies of these abstracts are included as Attachments A and B, respectively, to this report.

In addition, we completed a first draft of the Preliminary Public Design Report for the project, and we submitted our extended abstract titled "The Greenidge Multi-Pollutant Control Project: Key Technical and Economic Features of a New Approach for Reducing Emissions from Smaller Coal-Fired Units" to the organizers of the Air & Waste Management Association's 2007 Annual Conference and Exhibition, which will be held in Pittsburgh, PA, in June 2007. The Preliminary Public Design Report will be released during the next quarterly reporting period. A copy of the extended abstract is included as Attachment C to this report.

ATTACHMENT A

Parametric Testing Results from the Greenidge Multi-Pollutant Control Project

Accepted for presentation at COAL-GEN, August 1-3, 2007, Milwaukee, WI

Parametric Testing Results from the Greenidge Multi-Pollutant Control Project

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There are about 440 coal-fired electricity generating units in the United States with capacities of 50-300 MW that currently are not equipped with SCR, FGD, or mercury control systems. These smaller units are a valuable part of the nation's energy infrastructure, constituting about 60 GW of installed capacity. However, with the onset of CAIR, CAMR, and various state environmental actions requiring deep reductions in emissions of SO_2, NO_x, and mercury, the continued operation of these units increasingly depends upon the ability to identify viable air pollution control retrofit options for them. The large capital costs and sizable space requirements associated with conventional technologies such as SCR and wet FGD make these technologies unattractive for many smaller units.

The Greenidge Multi-Pollutant Control Project, which is part of the U.S. Department of Energy's Power Plant Improvement Initiative, seeks to demonstrate a solution for these units. As part of the project, an innovative combination of technologies including combustion modifications, a hybrid SNCR/SCR system, and a Turbosorp® circulating fluidized bed dry scrubbing system with recycled baghouse ash and activated carbon injection, were installed on the 107 MWe AES Greenidge Unit 4 in Dresden, NY. Babcock Power Environmental Inc. served as the engineering, procurement, and construction contractor for the project. The overall goal of the Greenidge Project is to show that this multi-pollutant control system, which has a capital cost of about $330/kW and occupies a <0.5-acre footprint for the Greenidge application, can achieve full-load NO_x emissions of ≤0.10 lb/MMBtu, reduce SO_2 and acid gas (SO_3, HCl, and HF) emissions by ≥95%, and reduce Hg emissions by ≥90%, while the unit is firing a 2-4% sulfur eastern U.S. bituminous coal and co-firing up to 10% biomass.

Start-up and commissioning of the multi-pollutant control system at AES Greenidge were completed in early 2007. This presentation is the first to communicate the results of parametric tests exploring the performance of the system as a function of load, fuel, and other key operating variables. Particular attention is given to mercury removal, which is accomplished via the combination of the in-duct SCR, activated carbon injection, circulating fluidized bed dry scrubber, and baghouse. Data from this program are useful for evaluating the applicability of the multi-pollutant control system to the large fleet of existing, smaller coal-fired units.

ATTACHMENT B

Mercury Removal Performance of the Greenidge Multi-Pollutant Control System

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Mercury Removal Performance of the Greenidge Multi-Pollutant Control System

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As part of the Greenidge Multi-Pollutant Control Project, which is being conducted under the U.S. Department of Energy's Power Plant Improvement Initiative, an innovative combination of air pollution control technologies was retrofitted on the coal-fired, 107-MWe AES Greenidge Unit 4 in Dresden, NY. The technologies, which include combustion modifications, a urea-based hybrid SNCR/SCR system with an in-duct, single bed SCR, and a Turbosorp® circulating fluidized bed dry scrubber with baghouse ash recycling and activated carbon injection, are being demonstrated as an affordable means for coal-fired electrical generating units with capacities less than 300 MWe to achieve deep air emissions reductions and improved dispatch economics in an environment of increasingly stringent emissions regulations. The multi-pollutant control system at AES Greenidge, which was installed in 2006 at an EPC cost of $339/kW$_{net}$, is designed to reduce full-load NO_x emissions to ≤0.10 lb/mmBtu, SO_2, SO_3, HCl, and HF emissions by ≥95%, and Hg emissions by ≥90%, while the unit is firing >2%-sulfur eastern U.S. bituminous coal and co-firing up to 10% biomass.

This presentation focuses on the mercury removal performance of the system. From a mercury control perspective, the Greenidge multi-pollutant control system resembles in many ways a conventional air pollution control configuration comprising an SCR, spray dryer, and baghouse. Measurements have demonstrated that this configuration, when applied to plants firing bituminous coals, often achieves >90% mercury removal without the need for any mercury-specific control technology. Thus, it is likely that the Greenidge system, with its combination of an in-duct SCR, $Ca(OH)_2$-based scrubber, and baghouse, will result in high mercury removals without any activated carbon injection when applied to bituminous coal-fired units. To ensure ≥90% Hg removal efficiency, the demonstration also includes an activated carbon injection system. Relative to simple duct injection, very effective utilization of the activated carbon and high mercury capture are expected to result from the long solids residence time and low temperature (~170°F) provided by the circulating fluidized bed dry scrubber and baghouse.

Key uncertainties regarding the performance of the system include the extent of Hg oxidation across the single bed SCR, the amount of co-benefit capture afforded by the SCR, scrubber, and baghouse, and the relationship between activated carbon injection rate and mercury removal. Results from a series of speciated Hg measurements taken at AES Greenidge using the Ontario Hydro method are presented here to resolve these uncertainties. The system's incremental cost of mercury capture is also discussed.

ATTACHMENT C

The Greenidge Multi-Pollutant Control Project: Key Technical and Economic Features of a New Approach for Reducing Emissions from Smaller Coal-Fired Units

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The Greenidge Multi-Pollutant Control Project: Key Technical and Economic Features of a New Approach for Reducing Emissions from Smaller Coal-Fired Units

Extended Abstract # 386

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INTRODUCTION

A new approach to multi-pollutant control is being demonstrated at the coal-fired, 107 MW_e AES Greenidge Unit 4 (Boiler 6) in Dresden, NY, as part of the Greenidge Multi-Pollutant Control (MPC) Project. The project, which is part of the U.S. Department of Energy's (DOE) Power Plant Improvement Initiative, is being conducted by a team including CONSOL Energy Inc. as prime contractor, AES Greenidge LLC as host site, and Babcock Power Environmental Inc. as engineering, procurement, and construction (EPC) contractor. All funding for the project is being provided by the U.S. DOE, through its National Energy Technology Laboratory, and by AES Greenidge. The MPC system, which was installed in 2006 and is being tested while the unit fires 2-4% sulfur eastern U.S. bituminous coal and co-fires up to 10% biomass, includes a hybrid selective non-catalytic reduction (SNCR) / in-duct selective catalytic reduction (SCR) system to reduce NO_x emissions by ≥60%, followed by a Turbosorp® circulating fluidized bed dry scrubber system to reduce emissions of SO_2, SO_3, HCl, and HF by ≥95%. Mercury removal of ≥90% is also targeted via the co-benefits afforded by the in-duct SCR, dry scrubber, and baghouse and by injection of activated carbon upstream of the scrubber, as required. The objective of the project is to substantiate that this combination of technologies can cost-effectively provide deep emissions reductions when retrofitted on existing coal-fired electrical generating units (EGUs) with capacities less than 300 MW_e.

There are currently about 440 coal-fired EGUs in the United States with capacities of 50-300 MW_e that are not equipped with SCR, flue gas desulfurization (FGD), or mercury control systems, and plans for air pollution control retrofits have not been announced for a majority of these units. These 440 smaller coal-fired units represent more than 60 GW of installed electric generating capacity; hence, curtailment or loss of their generation would exacerbate electricity supply and distribution problems throughout the United States. However, these EGUs are subject to progressively more rigorous environmental regulations such as the Clean Air Interstate Rule (CAIR), Clean Air Mercury Rule (CAMR), and various state actions. Conventional control technologies being installed on newer, larger EGUs are capable of achieving these rigorous regulations, but entail large capital investments and large space requirements that make them unattractive for this fleet of older, smaller EGUs. Hence, there is a strong need to demonstrate and commercialize technologies specifically designed to meet the environmental

compliance requirements of these smaller coal-fired units. The Greenidge Multi-Pollutant Control Project responds to this need.

This paper summarizes the design of the MPC system being demonstrated at AES Greenidge and highlights important technical and economic differences between this system and more conventional retrofit options (i.e., SCR, SNCR, wet FGD, spray dryer) as applied to smaller coal-fired units.

PROCESS DESIGN

Figure 1 presents a schematic of the MPC process that is being demonstrated. The design for AES Greenidge Unit 4 is based on the use of a 2.9%-sulfur bituminous coal and a baseline NO_x emission rate of ~ 0.30 lb/MMBtu. NO_x control is the first step in the process and is accomplished using urea-based, in-furnace SNCR followed by a single-bed SCR reactor that is installed in a modified section of the ductwork between the unit's economizer and air heaters. The SCR process is fed by ammonia slip from the SNCR process; static mixers located just upstream of the SCR are used to homogenize the velocity, temperature, and composition of the flue gas to promote optimal ammonia utilization and NO_x reduction across the relatively small SCR catalyst. The hybrid NO_x control system at AES Greenidge Unit 4 also includes combustion modifications to achieve further reductions in NO_x emissions and to improve the performance of the hybrid SNCR/SCR system. Hence, a full-load NO_x emission rate of ≤0.10 lb/MMBtu results from the combination of the combustion modifications, which are designed to produce NO_x emissions of 0.25 lb/MMBtu, the SNCR, which is designed to reduce NO_x by ~42% to 0.144 lb/mmBtu, and the SCR, which is designed to further reduce NO_x by ≥31% to ≤0.10 lb/MMBtu.

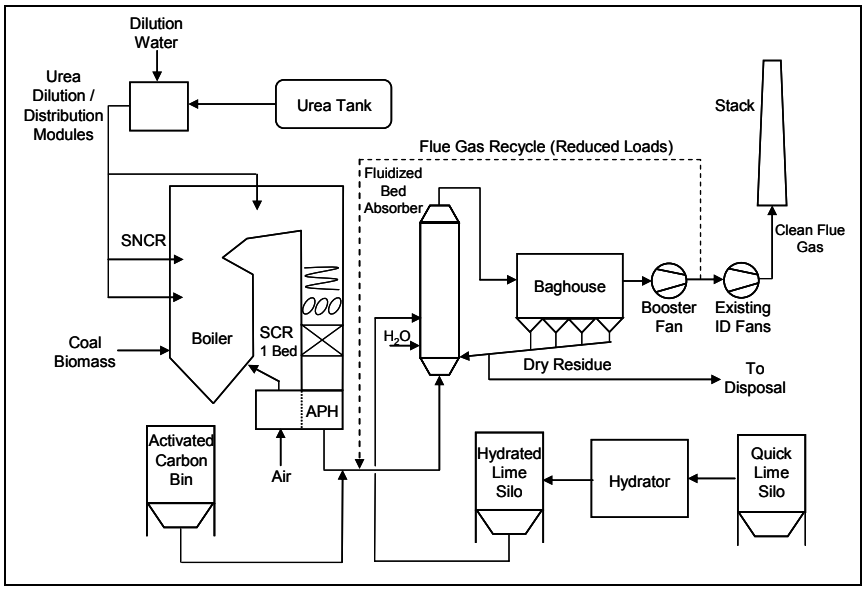

Figure 1. Schematic of the multi-pollutant control process being demonstrated at AES Greenidge Unit 4.

Emissions of SO_2 and other acid gases are reduced by ≥95% in the Turbosorp® circulating fluidized bed dry scrubber system, which is installed downstream of the air heaters. In the Turbosorp® system, water and dry hydrated lime, which is supplied from an on-site hydrator being installed at AES Greenidge, are injected separately into a fluidized bed absorber, where the flue gas is evaporatively cooled and brought into intimate contact with the hydrated lime reagent in a fast fluidized bed. The hydrated lime reacts with the acidic constituents of the flue gas (i.e., SO_2, SO_3, HCl, and HF) to form dry solid products, which are separated from the flue gas in a new baghouse and recycled to the absorber via air slides at a

high ratio to the inlet solids in order to maximize pollutant removal and lime utilization. An activated carbon injection system is also installed upstream of the Turbosorp® scrubber for Hg control.

COMPARISON WITH OTHER RETROFIT OPTIONS

To illustrate key technical and economic aspects of the MPC system being demonstrated at AES Greenidge, this system was compared with more conventional post-combustion retrofit options. All comparisons were performed using the AES Greenidge Unit 4 design basis. Capital costs for the hybrid SNCR/SCR system and Turbosorp® system are the approximate EPC costs for the AES Greenidge installation; EPC costs for the other technologies were estimated using the Integrated Environmental Control Model (IECM).[1] Highlights of the comparisons are summarized below.

NO_x Control

As shown in Table 1, the hybrid SNCR/SCR system that is part of the Greenidge MPC process provides a compromise between the deep NO_x removal capability of full-scale SCR and the low capital cost of stand-alone SNCR. By using a single-bed, in-duct SCR reactor, the hybrid SNCR/SCR system avoids much of the capital cost associated with the multi-bed reactor, structural support steel, foundations, and new ductwork runs required for a conventional stand-alone SCR system. As a result, the capital costs for the hybrid SNCR/SCR at AES Greenidge are estimated to be at least 40% less than the capital costs for a full-scale, stand-alone SCR. (The EPC cost of about $140/kW shown in Table 1 for SCR may be low; capital costs of $150-$175/kW have been reported for SCR retrofits on 100-399 MW units).[2] In exchange for its substantially reduced capital costs, the hybrid SNCR/SCR system has substantially greater reagent costs (because of its lower reagent utilization and its use of urea rather than ammonia) and lower NO_x removal efficiency than a conventional full-scale SCR system. Whereas this tradeoff may be unattractive for large coal-fired EGUs, it is consistent with the needs of operators of smaller units, who in many cases cannot afford the large capital costs (per unit of electrical output) needed to retrofit with conventional technologies for deep emissions reductions.

Table 1. Comparison of NO_x control retrofit options for AES Greenidge Unit 4.

	Hybrid SNCR/SCR	**SCR**	**SNCR**
Approx. EPC Capital Cost ($)	$9,000,000	$15,000,000[a]	$2,000,000[a]
NO_x Removal Efficiency	≥60%	80-90%	20-35%
Reagent	Urea	Ammonia	Urea
Reagent Cost ($/ton NO_2 removed)[b]	$827	$93	$891

[a]Estimated in IECM using design specifications for AES Greenidge Unit 4 and assuming a retrofit factor of 1.4 and 2005 dollars. [d]Assumes costs of $410/ton for urea and $250/ton for ammonia.

Other strengths of the hybrid SNCR/SCR system are its small space requirement and its turndown capability. The SNCR portion of the MPC process requires only a small amount of space for a urea storage tank, urea circulation module, and several small urea distribution skids. Moreover, unlike a conventional stand-alone SCR reactor, the single-bed SCR reactor requires essentially no new land area, as it is installed in a modified ductwork section between the economizer and air heater and needs only a few new support beams. The in-duct SCR being installed at AES Greenidge is designed to fit within the existing boiler building in a space with horizontal dimensions of 52 ft x 27 ft and a vertical height of 23 ft. Another strongpoint of the hybrid NO_x control strategy is its load following capability. Although operation of the single-bed SCR must be discontinued (by restricting NH_3 slip from SNCR to <2 ppmv) at operating loads that produce economizer outlet temperatures below ~600°F, NO_x removal capabilities of 20-25% are still achievable at these reduced loads via continued operation of the SNCR. For smaller units that regularly cycle loads based upon electricity demand, the load following capabilities of the hybrid SNCR/SCR process can help to contribute to lower NO_x emission averages.

SO_2 and Acid Gas Control

Table 2 compares key technical and economic features of the Turbosorp® system that is part of the Greenidge MPC process with those of two conventional FGD technologies: a wet limestone forced oxidation (WLFO) scrubber and a spray dryer. When applied to low-sulfur coals, the Turbosorp® scrubber offers slightly lower capital costs, better SO_2 removal efficiency, and better reagent utilization than a spray dryer. Moreover, in spray dryer systems, lime and water are injected into the absorber vessel together as a slurry, rather than separately as in the Turbosorp® system. As a result, spray dryers are only capable of achieving deep (e.g., 90%) removal efficiencies when applied to units that fire coals containing less than ~2% sulfur, because greater concentrations require slurry injection rates so high that the water cannot be completely evaporated. In the Turbosorp® system the lime injection rate is controlled solely by the pollutant loading and desired emission reduction, without being limited by the temperature or moisture content of the flue gas; hence, the system can be operated to achieve deep emission reductions for a wide range of fuels, including high-sulfur coals. This is an important distinction, because greater than 80% of the coal-fired units that are candidates for the multi-pollutant control process being demonstrated at AES Greenidge are located east of the Mississippi River, where high-sulfur bituminous coal is an economically attractive fuel source.

Table 2. Comparison of SO_2 control retrofit options for AES Greenidge Unit 4.

	Turbosorp® System with New Baghouse	**Wet Limestone Forced Oxidation Scrubber**	**Spray Dryer Absorber with New Baghouse**
Approx. EPC Capital Cost ($)	$25,000,000	$43,000,000[a]	$31,000,000[a]
SO_2 Removal Efficiency	95%	98%	90%
SO_3 Removal Efficiency	95%	50%	95%
Reagent	Lime	Limestone	Lime
Ca/S for 2.9%-S Coal	1.6[b]	1.03[c]	Not Feasible
Reagent Cost for 2.9%-S Coal ($/ton SO_2 removed)[d]	$155	$42	Not Feasible

[a]Estimated in IECM using design specifications for AES Greenidge Unit 4 and assuming a retrofit factor of 1.2 and 2005 dollars. [b]Based on moles of inlet SO_2. [c]Based on moles of SO_2 removed. [d]Assumes delivered costs of $100/ton for lime and $25/ton for limestone, with 95% reagent purity.

WLFO scrubbers are capable of achieving high SO_2 removal efficiencies when applied to units that fire high-sulfur coal. However, these scrubbers, which are mechanically complex and must be constructed from corrosion-resistant materials, have large capital costs when applied to smaller coal-fired units. As shown in Table 2, the EPC cost for the Turbosorp® system at AES Greenidge is estimated to be more than 40% less than the EPC cost for a WLFO retrofit. The difference in cost is likely even larger than that portrayed in the table, because WLFO scrubber retrofits generally entail the installation of a new corrosion-resistant stack, which can add several million dollars to the capital cost. Other advantages of the Turbosorp® system over a WLFO scrubber are its greater SO_3 removal capability and comparatively small space requirements and low maintenance requirements. The arrangement of the circulating fluidized bed dry scrubber, baghouse, and associated equipment is compact. The various pieces of equipment are vertically tiered to permit gravity-assisted transport of solids where possible and, as a result, require only about 0.4 acres of land for a 110 MW installation. Also, compared to WLFO scrubbers, which require pumps for slurry introduction and recirculation as well as dewatering equipment, the Turbosorp® system is expected to afford substantially reduced maintenance costs. Because the process introduces the hydrated lime reagent as a dry powder and produces a dry solid product, it avoids the problems with plugging, erosion, abrasion, and scaling that can result from pumping and handling slurries in other types of scrubbing systems. In exchange for these advantages, the Turbosorp® system has substantially greater reagent costs (the largest component of variable O&M

costs) than a WLFO scrubber. Again, however, this trade-off is consistent with the needs of many smaller coal-fired EGUs, as it allows owners to tailor SO_2 removal according to market conditions, while substantially reducing their need for capital.

Mercury Control

From a mercury control perspective, the Greenidge MPC process is very similar to a conventional air pollution control configuration comprising an SCR, spray dryer, and baghouse. Ontario-Hydro measurements have demonstrated that this configuration, when applied to plants firing bituminous coals, achieves a high level of mercury removal (i.e., 89-99%) without the need for any mercury-specific control technology.[3] (For comparison, Hg removal in bituminous coal-fired units equipped with wet FGD typically ranges from 70-97% with SCR and from 41-91% with no SCR).[3] Thus, it is likely that the Greenidge MPC process, with its combination of an in-duct SCR, $Ca(OH)_2$-based scrubber, and baghouse, will result in high mercury removals without any activated carbon injection when applied to bituminous coal-fired units. To ensure ≥90% Hg removal efficiency, the MPC demonstration also includes an activated carbon injection system. Relative to simple duct injection, very effective utilization of the activated carbon and high mercury capture are expected to result from the high solids/gas ratio, long residence time, and low temperature (~170°F) provided by the circulating fluidized bed scrubber and baghouse.

SUMMARY

In conclusion, the Greenidge MPC process, with its combination of relatively deep emission reduction capabilities, low capital costs, small space requirements, operational flexibility, and mechanical simplicity, is designed to meet the needs of coal-fired EGUs with capacities less than 300 MW_e. The Greenidge Project seeks to demonstrate that this process (including combustion modifications) can reduce emissions of NO_x by ≥67%, SO_2 and acid gases by ≥95%, and Hg by ≥90% when applied to a ~110 MW unit firing 2.9%-sulfur coal, while having a capital cost of only $330/kW and a footprint of <0.5 acre. Testing is now underway to confirm the technical and economic performance of the system.

ACKNOWLEDGMENT AND DISCLAIMER

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