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Project Summary

Conceptual Designs and Cost Estimates for E-SO_x Retrofits to Coal-Fired Utility Power Plants

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A conceptual design and cost estimate, based on information available at the beginning of 1987, was done for six cases of a retrofit of the E-SO_x process to a utility. The annualized cost ranged from $301 to $378 per ton of SO_2 removed. The generic cost basis, used for other cost estimates, was used in this study and applied to a 500 MWe utility burning eastern medium sulfur (2.5%) bituminous coal. Capital costs compare very favorably with other retrofit SO_2 removal technologies. Sorbent or reagent cost is the largest single component of the costs.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Background

E-SO_x technology has been proposed as a feasible way to lower SO_x emissions from power plants upon retrofit to an existing electrostatic precipitator (ESP). In a conceptual study to evaluate various retrofit situations, applicable bases were kept identical with those of a similar study in 1983 on Limestone Injection Multistage Burner (LIMB) systems.

The conceptual designs discussed here are based on a generic power plant. All subsystems necessary for a complete E-SO_x system are included in the costs. Equipment and systems were optimized on a limited basis, because this is not a site-specific study. Thus, costs will vary from those presented here, as specific locations are considered. The study provides a point of reference for comparison purposes, and shows where future research and development efforts should be concentrated.

Scope and Approach

After the LIMB study, plant size was selected as 500 MW, with existing particulate control equipment designed to meet the 1971 New Source Performance Standards for particulate matter. The process designs were based on lime stoichiometries and approach temperatures necessary to achieve 50% sulfur reduction for a typical eastern, medium sulfur (2.5%) bituminous coal. Two process conditions were selected using hydrated lime as a reagent, and one using quicklime. For one of the lime hydrate process conditions, four ESP upgrade configurations were evaluated. Six E-SO_x cases were investigated:

Case 1—Hydrated lime reagent, Ca/S = 1.3, approach temperature 4°C, original 218 SCA ESP, retrofitted with precharger and large diameter electrodes.

Case 2—As Case 1, except no precharger, weighted wires instead of large diameter discharge electrodes, and 0.5 m longer collecting plates in each field.

Case 3—As Case 1, except original 150 SCA ESP, plate height increased by 0.9 m, and collecting plates in each field increased in length by 0.5 m.

Case 4—As Case 3, except no precharger, weighted wires instead of large diameter discharge electrodes, and an additional short third active field.

Case 5—As Case 1, except a Ca/S ratio of 1.5 and an approach temperature of 10°C.

Case 6—As Case 1, except pebble quicklime is used as a reagent.

The study consisted of the conceptual equipment selection, equipment arrangement, and capital and first year operating and maintenance cost estimates for the E-SO_x system and all supporting equipment for the above six cases.

Findings

The mechanical equipment used as a basis for these designs is predominantly commercial. Lime receiving and storage and slurry preparation are state-of-the-art for many existing scrubbers, both wet and dry. On the other hand, the two-fluid nozzle arrangement, because of its requirement for a relatively flat and fine droplet size distribution (40-50 μm), requires some developmental work. Also some of the chosen ESP modifications, which use advanced technology to achieve the required particulate removal (e.g., *the precharger and large-diameter* electrodes), require developmental work. Hence, there is more uncertainty in the ESP performance of Cases 1, 3, 5, and 6 than in Cases 2 and 4, which are more conventional ESP upgrades. Because limited laboratory scale process data are available, process uncertainties are associated with reagent stoichiometry, approach temperature, and residence time. Residence time also raises the question of whether adequate spray drying can occur without wetting the ESP.

Concerning ESP performance for the E-SO_x process, computed ESP collection efficiency and particulate mass emissions are tabulated for each case in Table 1. ESP performance was assessed using Southern Research Institute's ESP Mathematical Model. A comparison of Cases 1 and 2 shows that a modest increase in plate length will achieve the same ESP performance improvement as the installation of novel electrodes. With low-resistivity fly ash and reasonable plate area after an E-SO_x retrofit (SCA of 173 ft^2/1000 acfm [571 m^2/1000 m^3/min] prior to ESP modifications), the precharger offers little performance advantage. It quickly charges the dust particles that otherwise would be charged within 0.6 or 0.9 m of travel along a conventional gas passage. The large-diameter discharge electrodes, on the other hand, offer a performance advantage due to the increased interelectrode electric field. In Cases 3 and 4, with a much lower plate area after an E-SO_x retrofit (SCA of 118 ft^2/1000 acfm [391 m^2/1000 m^3/min] prior to ESP modifications), a substantial rebuild of the ESP is required to limit particulate emissions to 0.1 lb/10^6 Btu (0.04342 kg/GJ).

Table 2 summarizes the capital and operating and maintenance (O&M) costs for the six E-SO_x cases. The capital costs compare very favorably with other retrofit SO_2 removal technologies. This is attributed to the maximum use of existing equipment and minimal new equipment requirements. First year O&M costs are largely influenced by lime consumption and delivered cost.

As a way to compare overall costs of the systems, Table 3 presents total first year costs on an annualized basis, as well as costs per ton of SO_2 removed. The costs per ton of SO_2 removed indicate that E-SO_x technology, if it can be successfully commercialized, should compete very favorably with other retrofit SO_2 removal technologies.

In summary, the following conclusions can be drawn:

- The mechanical system design for the most part utilizes commercially available equipment. The only items that pose developmental problems are the two-fluid nozzle spray system, the ESP precharger, and the ESP large diameter electrodes.
- From an operating point of view, the greatest concern is adequate spray drying in the (gutted) first field of the ESP to minimize tenacious deposits in subsequent ESP fields.
- ESP performance on this type of particulate needs to be verified. In particular, the mass loadings and size distribution of the particulate at the end of the spray section, the ESP *electrical properties (secondary* voltages and currents), and gas distribution device requirements need to be established.
- The capability of a vacuum type fly ash handling system to continuously remove hopper material needs to be demonstrated. Additional equipment requirements (for example a delumper to prevent oversize material) need to be defined.
- Retrofit capital costs will be very site specific, particularly if conventional ESP modifications (taller plates or an outlet field) are required.
- The largest single component affecting the operating cost is reagent consumption. Therefore, process stoichiometry is critical to cost. Also, pebble lime shows a distinct economic advantage over lime hydrate.
- Future research efforts should be concentrated on optimizing the process parameters, in particular, slurry droplet size, Ca/S ratio, approach temperature, and residence time requirements.
- Because of the performance advantages indicated by the precharger and large diameter electrodes, these technologies should be further demonstrated at an appropriate equipment scale.

Table 1. *Precipitator Performance*

	Case No.					
	1	2	3	4	5	6
SCA, $ft^2/1000$ acfm[a]	173	201	163	148	171	172
Outlet Emissions, $lb/10^6$ Btu[b]	0.08	0.08	0.08	0.07	0.08	0.08
Collection Efficiency, %	99.59	99.56	99.57	99.62	99.57	99.58

[a]1 $ft^2/1000$ acfm = 3.32 $m^2/m^3/min$
[b]1 $lb/10^6$ Btu = 0.4342 kg/GJ

Table 2. *Cost Summary (January 1987 Dollars)*

	Capital Cost		First Year Operating and Maintenance Cost	
Case No.	$1000	$/kW	$1000/yr	Mills/kWh
1	19,100	38	6,800	2.39
2	23,700	47	6,980	2.45
3	22,700	45	6,940	2.44
4	19,400	39	6,890	2.42
5	19,100	38	7,480	2.62
6	15,900	32	6,070	2.13

Table 3. *First Year Annualized Costs (January 1987 $1000/yr)*

	Case No.					
	1	2	3	4	5	6
Annualized Capital Cost	3,440	4,260	4,090	3,500	3,440	2,870
First Year O&M Cost	6,800	6,980	6,940	6,890	7,480	6,070
Total First Year Annualized Cost	10,240	11,240	11,030	10,390	10,920	8,940
$/ton SO_2 Removed	345	378	371	350	368	301

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The complete report, entitled "Conceptual Designs and Cost Estimates for E-SO_x Retrofits to Coal-Fired Utility Power Plants," (Order No. PB 88-143 995/AS; Cost: $14.95, subject to change) will be available only from:
National Technical Information Service
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