SESSION 2B

U. S. CLEAN AIR ACT AND PARTICULATE CONTROL

THE CONEMAUGH STATION PRECIPITATORS: A TALE OF ALTERNATIVES

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Abstract

During the mid- to late-1980s, the Conemaugh Station's electrostatic precipitators experienced gradual degradation in performance. A number of studies were undertaken and remedies implemented to restore desired performance levels. As the precipitators aged it became apparent that the issue of precipitator emissions had to be revisited. The retrofitting of flue gas desulfurization systems to the two Units added to the decision-making complexity. Studies were performed with the aim of realistically assessing the existing precipitators' capabilities and limitations, examining technological advancements, and establishing life-cycle costs and scheduling requirements for remedial alternatives. The alternatives studied included precipitator internal refurbishment, precipitator casing expansion and conversion to wider-plate spacing, along with new replacement precipitators.

Introduction

The Conemaugh Electric Generating Station consists of two coal-fired units, each capable of generating 850 MWs. The Station is located on the Conemaugh River, approximately thirteen miles from Johnstown, Pennsylvania. The Station is owned by Atlantic Electric Company, Baltimore Gas and Electric Company, Delmarva Power & Light Company, Pennsylvania Power & Light Company, Metropolitan Edison Company, Philadelphia Electric Company, Public Service Electric & Gas Company, Potomac Electric Power Company, and UGI Corporation. The Station is operated by the Pennsylvania Electric Company (Penelec) as an agent for the collective Owners.

Unit 1 went into commercial operation in May 1970, while Unit 2 commenced commercial operation in May 1971. Each year, the Station consumes about 4.4 million tons of Pennsylvania medium sulfur content coal. This coal is delivered by conveyor, rail, and truck.

Each Unit at the Conemaugh Station is equipped with two Buell [now General Electric Environmental Services (GEESI)] electrostatic precipitators configured in a chevron arrangement, typifying designs of the mid-1960s. The precipitators have nine-inch plate spacings, 30-foot-tall collecting plates and utilize a weighted-wire design. Each precipitator has three 9-foot mechanical fields in the direction of gas flow, which are arranged in a four-electrical-field configuration consisting of two 6-foot fields followed by one 9-foot field with the last field six feet deep. There are 344 gas passages in both precipitators associated with each Unit. There are 16 transformer-rectifier (T-R) sets on each precipitator, 32 T-R sets for each Unit. The total collecting plate area is 557,280 square feet, and the total cross sectional area is 7740 square feet for each Unit. The aspect ratio is 0.9. The Specific Collecting Area (SCA) is 168.9 square feet/1000 acfm with a superficial gas velocity of 7.1 feet/second through the precipitator at the design flow of 3.3×10^6 acfm.

Historical Perspective

During the 1980s, the performance of the Conemaugh precipitators gradually degraded. This performance degradation was attributable to the precipitators' inherent limitations, i.e., sizing parameters and inability to keep the collecting plates clean. The relatively small size of the existing precipitators limited their ability to effectively cope with high fly ash resistivity conditions when firing lower sulfur coals. High fly ash resistivity levels limited current densities, thus reducing overall collection efficiency. Further, high superficial gas velocity through the precipitators could contribute to fly ash reentrainment during rapping and by "scouring" the collected fly ash off of the plates. In addition, high gas velocities reduced gas treatment time within the precipitators. These inherent limitations significantly affected the precipitators' ability to satisfactorily respond to changing Unit conditions.

Moreover, in addition to the precipitators' sizing limitations, the precipitators suffered from gradual ash buildups since the electromagnetic vibrators were not 100 percent effective in dislodging the collected ash. As the residual ash accumulated, it changed the vibrational characteristics of the collecting plates which further reduced the effectiveness of the vibrator. Consequently, as ash built up on the plates, the current density was reduced, thus lowering collecting efficiency. In addition to ash buildups attributable to vibrator ineffectiveness, buildups were also associated with high fly ash resistivity conditions. High resistivity conditions increased the electrostatic forces holding the ash to the plates and wires.

In 1989, the Unit 2 average air heater's exit temperature increased by 20° to 40°F. This increase in exit flue gas temperatures further adversely affected precipitator performance. An ammonia-injection system was installed to mitigate the effects of this temperature increase on precipitator performance until the high gas temperatures could be corrected and a long-term solution to precipitator performance could be implemented. Based on the results of ammonia injection on Unit 2, the use of ammonia was extended to the Unit 1 precipitators to assist in suppressing rapping reentrainment.

Prior to the initial economizer replacement on Unit 2, plant personnel combated plate buildups in both Units' precipitators by increasing vibrator-intensity settings to maximum values and operating them from between three to five seconds during each energization cycle. This prolonged vibrator energization coupled with maximum intensity, produced excessive wear of the collecting plate components. Even though these vibrators were operating at their maximum capability, it was insufficient to maintain the plates in a clean condition all the time. As plate buildups increased and current densities consequently decreased, intensive, power-off rapping, "shake downs" were frequently required to restore acceptable performance levels. These shake downs required forced unit-load reductions. Further, during summer operation with high ambient air temperatures, the Units had occasion to reduce load to maintain acceptable flue gas opacity levels.

As part of a performance restoration program, the plant staff embarked upon a series of precipitator inspections, studies, and tests to identify methods to improve plate cleanliness. In addition, a separate undertaking of improving gas flow and temperature distributions to and through the precipitators was implemented to maximize precipitator performance and isolate the effects of inadequate plate rapping. Improvements in flue gas flow and temperature distribution were so significant that the performance of the precipitators went beyond GEESI's data base which would then classify the Conemaugh precipitators as "Best Performers." These efforts culminated in the determination that in order to keep the collecting plates clean, electromagnetic gravity-impact rappers would have to be retrofitted to the precipitator. To assure that sufficient energy could be imparted to the plates, the replacement would be performed on a two-rapper-for-one-vibrator basis. This replacement required the installation of new controls along with the reinforcement of the carrier plate system. In order to assure and maintain correct wire-to-plate alignment, the collecting plates had to be modified and repaired to accommodate (1) a modified "B line" alignment system at the bottom of the plate; (2) new panel alignment clips at the 1/3- and 2/3-height positions; and (3) new mid-height alignment rakes. Consequently, wires would be replaced as well as the lower emitting guide frame. In addition, it was identified that a portion of the roof of the inlet ductwork to the precipitators suffered from corrosion and would have to be replaced.

These modifications (except roof replacement) were undertaken in two test cells in precipitator 2B to gain experience with installation and establish a cost data base for development of an overall cost estimate for the Station. The extrapolated cost was placed at more than $15 million for the implementation of this rapper-conversion program for both Units.

In reviewing this cost estimate, the original goals of the program, and the benefits to be derived therefrom, it was determined that it would be appropriate and necessary to reevaluate the previously developed options to maintain stable and desirable precipitator performance levels. This reevaluation included a review of the background documents, technology/problem assessments, development of independent cost estimates, an inspection of test modifications to precipitator 2B, and discussions with three precipitator suppliers and an independent precipitator consultant.

In early 1989, study activities were also directed toward assessing the impact of the then-pending Acid Rain Legislation. With the enactment of the 1990 Clean Air Act Amendments, Penelec found that the least-cost compliance approach for controlling sulfur dioxide emissions from the Conemaugh Station was the installation of a wet limestone flue gas desulfurization (FGD) system. With this decision made and the identification of FGD system particulate-matter emission characteristics, the study of the existing precipitators and their performance levels could be concluded and a long-term precipitator plan developed for the Conemaugh Station.

Coal Characteristics

In order to establish a range of coal characteristics for the study, Penelec reviewed its historical data and projections of those coals which could be fired in the Units over the next 20 years. The goal of this effort was to select a range of coal characteristics which was broad enough to provide source flexibility and the ability to respond to changing coal prices. However, the range of characteristics had to realistically represent those coals that would be fired when the Units' FGD systems became operational in the 1994-1995 timeframe. Accordingly, the range in coal characteristics were:

	Minimum	Maximum
I. Ultimate Analysis, Percent by Weight (As Received)		
Carbon	63.0	77.1
Moisture	3.5	10.5
Hydrogen	3.1	5.3
Oxygen (By Difference)	1.7	9.4

	Nitrogen	0.8	1.5
	Chlorine	-	0.25
	Fluorine	-	0.016
	Ash	6.0	15.0
	Sulfur (lb/MBtu)	1.20	2.25
	Heating Value, Btu/lb	11,896	13,820
		Minimum	Maximum
II.	Ash Mineral Analysis, Percent by Weight on an Ignited Basis		
	Phosphorus Pentoxide, P_20_5	.1	1.1
	Silica, $Si0_2$	45.4	53.1
	Ferric Oxide, Fe_20_3	12.4	22.2
	Alumina, $A1_20_3$	22.0	30.4
	Titania, $Ti0_2$	1.0	1.7
	Lime, Ca0	.8	8
	Magnesia, Mg0	.5	1.9
	Sulfur Trioxide, SO_3	.7	1.8
	Potassium Oxide, K_20	1.07	2.4
	Sodium Oxide, Na_20	.2	.6

From a precipitator-sizing perspective, the lower sulfur contents had a significant effect on fly ash resistivity, thereby increasing collecting area requirements or with constant collecting areas, increased emissions. The predicted worst-case fly ash resistivity for these coals was 3.0×10^{11} ohm-cm.

Potential Solutions

Several approaches were utilized in identifying and evaluating potential solutions to the Conemaugh precipitator performance problem. These approaches included (1) precipitator theory, (2) technical feasibility, (3) practical field experience, (4) limitations inherent with equipment inspections and testing programs, (5) results of 22 previous studies and test reports, (6) discussions with precipitator suppliers and EPRI, and (7) outage requirements. Accordingly, a broad spectrum of potential solutions were identified, recognizing the plant impacts and requirements of the flue gas desulfurization system to be installed. The essential elements of these potential solutions can be summarized by the following descriptions.

Option I - Refurbish the Existing Precipitators

This option involved retaining the existing precipitators and replacing the internal components with new, modern weighted-wire parts; new plate-and-wire-rapping systems; new transformer-rectifier sets with upgraded automatic voltage controls; new insulator-purge system; retaining the casing, roof, and weather enclosure; and replacement of the inlet chevron roof and the expansion joint which have been adversely affected by long-term corrosion. These modern parts could be provided by a number of suppliers.

This option did not alter the capabilities or limitations of the existing precipitators except to keep the plates in a cleaner condition and provide improved alignment between internal components which would stabilize performance levels. The precipitators still had a small SCA of about 167. High fly ash resistivity conditions also make it increasingly difficult to keep weighted wires in a clean condition and reduce current densities to avoid back ionization. Further, the precipitators would still experience high gas velocities, in excess of seven fps, although the continued use of ammonia as a flue gas conditioning agent would mitigate much of the effects of such high gas velocities. This option did not provide additional operating margins other than that individual components will have higher reliabilities than the original components. The precipitators would still be subject to discharge electrode failure, although at a lower rate than experienced to date.

The precipitator suppliers would not offer a performance guarantee because the existing precipitators' performance level lies beyond their data base; in essence, the Conemaugh precipitators are "Best Performers." The real question is whether a performance guarantee engenders more expensive solutions? In essence, this option stabilizes the precipitator's performance at its current level which can be very good.

With the installation of the FGD system, there will be the ability to fire coals with relatively high sulfur contents. Therefore, at that point in time, it was difficult to quantify the amount of low sulfur coal to be fired at the Conemaugh Station. Accordingly, in economically analyzing the effects of high resistivity fly ashes, it was not appropriate to give it full weight. The refurbished precipitators would operate at a level equal to or slightly better than the existing precipitators from an emission standpoint with medium sulfur coals. Since this option did not require the precipitators' gas distribution system to be modified, there would be a reduced-risk level associated with achieving current emission levels under present conditions and less chance that the Unit outage requirement would be extended.

The Unit outage duration associated with this option was estimated to be eight weeks. This option offered the ability to control the outage time by performing the work within each casing on an individual-chamber basis which permitted the monitoring of progress on a daily basis. Further, this option offered the ability to be performed on a single-casing-per-unit-outage basis, although there would be added costs associated with additional mobilization/demobilization and escalation.

The estimated total direct cost for this option was \$16.6 million (1991 dollars). The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that experienced by the existing precipitators.

Option II - Existing Precipitator Refurbishment With Sulfur Trioxide Gas Conditioning

This option embodied the same elements of Option I along with the addition of sulfur trioxide flue gas conditioning. This option provided two advantages over Option I relative to coal sulfur variability and rapping reentrainment. With respect to coal sulfur variability, sulfur trioxide gas conditioning will moderate the fly ash resistivity to a level no higher than 10^9 ohm-cm, which is consistent with current precipitator operation on higher sulfur content coals and the results of precipitator computer model predictions. Further, the continued injection of ammonia would principally reduce rapping reentrainment by increasing collected ash cohesiveness; increase the effectiveness of the sulfur trioxide; and improve precipitator operating conditions by increasing operating voltages by ammonium bisulfate fume formation. The combination of a controlled fly ash resistivity with the effects of ammonia would promote more consistent precipitation process conditions. However, the precipitator suppliers again would not offer a performance guarantee because this precipitator performance level lay outside of their data base and because of their concern over high gas velocities within the precipitators.

The Unit outage duration for this option was estimated to be eight weeks, which was governed by the number of internals to be installed and the labor required for their installation by virtue of the weighted-wire design. This option also offered the same Unit outage time flexibility of Option I.

The estimated total direct cost for this option was \$23.9 million (1991 dollars). The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that for the existing precipitators. However, there would be additional operating and maintenance costs associated with the gas conditioning system.

Option III - Rebuilding the Existing Precipitators With 36-Foot Collecting Plates and Retaining Weighted-Wire Design

This option retained the existing precipitators' casing and vertically extended it along with the inlet and outlet ductwork to accommodate the use of 36-foot-tall collecting plates. Otherwise, this option had the features of Option I. This option resulted in a 20 percent increase in SCA to the 200 level and reduced the gas velocity through the precipitator to the 6-fps level. The increase in SCA and reduction in gas velocity would be beneficial in overall precipitator performance. However, the taller collecting plates reduced the aspect ratio to 0.75, which can increase rapping reentrainment. The continued use of ammonia would help to reduce reentrainment, but the use of taller plates would require increased collecting plate rapper densities. Retaining the weighted-wire design did not overcome the effects of high fly ash resistivity conditions, making it more difficult to keep the wires in a clean condition. Again, although regression and theoretical model analyses and experience with the existing precipitators indicated that the emissions with medium sulfur coal would be less than 0.10 lbs/MBtu, the precipitator suppliers would not guarantee performance, especially with lower sulfur coals. Therefore, this option had the features of Option I but had the added complications of requiring the roof to be removed and the inlet and outlet ducts as well as the gas distribution devices to be significantly modified to accommodate the taller collecting plates. There was significant risk in modifying the gas distribution devices because there was the possibility that the existing degree of gas distribution uniformity could not be duplicated with this option. In addition, use of taller collecting plates and heavier wire weights (an increase from 25 to 36 pounds representing modern practice) would increase the weight of the precipitators by at least 20 percent. The additional weight and increased overturning moment due to additional wind loads would raise the level of stress within the existing supporting structural steel and their foundations. Normally, these structures are not designed to withstand such stress increases without extensive modifications.

The Unit outage duration associated with this option would be at least ten weeks and most probably twelve weeks because of the time required to remove the precipitator roof, modify the ductwork, and install the weighted-wire components. Due to the modification of the ductwork associated with the taller collecting plates, this option required that both precipitator casings for each Unit be modified at the same time. The estimated total direct cost for this option was $24.3 million (1991 dollars). The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be essentially at the same level of that of the existing precipitators.

Option IV - Rebuilding the Existing Precipitators With 36-Foot Collecting Plates, Retaining Weighted-Wire Design and Sulfur Trioxide Flue Gas Conditioning

This option involved all of the elements of Option III and added a sulfur trioxide flue gas conditioning system. The concerns for Option III were still in effect except that the sulfur trioxide gas conditioning system would moderate fly ash resistivity and produce more uniform precipitation process conditions. Further, the continued use of ammonia would act to suppress rapping reentrainment which could increase due to the poorer aspect ratio (0.75) associated with this option. To further offset the potential rapping reentrainment effects of the poorer aspect ratio, no more than two collecting plates would be rapped at any single point in time. The precipitator suppliers again would not offer a full performance guarantee for this option.

The Unit outage duration associated with this option would be at least ten weeks and most probably twelve weeks due to the extensive modifications required by this option. Due to the ductwork modifications required by this option, it required that both precipitator casings for each Unit be modified at the same time.

The estimated total direct cost for this option was $32.7 million. The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that of the existing precipitators. However, there would be additional operating and maintenance costs associated with the gas conditioning system.

Option V - Refurbishment of Existing Precipitators With Rigid Discharge Electrodes

This option was essentially Option I except that a rigid discharge electrode (RDE) system was to be utilized in lieu of a weighted-wire system. The rigid discharge electrode concept was fostered by the need to keep electrodes clean when operating with high and very high resistivity fly ashes. The advantages of the RDE system were that they (1) virtually eliminated electrode failures; (2) maintain internal alignment while being less sensitive to misalignment than nine-inch spacings; and (3) can withstand high rapping forces applied to both the discharge and collecting electrodes to maintain them in a clean condition under the most adverse operating conditions. From a performance standpoint, the precipitators would perform no worse than the current precipitators but would still suffer from an inability to cope with high ash resistivity conditions producing back ionization thus limiting power inputs. In spite of the advantages of the RDE system, precipitator suppliers would offer a material warranty but not a meaningful performance guarantee.

The Unit outage duration associated with this option was at least ten weeks and most probably twelve weeks. The estimated total direct cost for this option was $20.3 million. The operating cost for this option in terms of electric power consumption and flue gas pressure drop would not significantly differ with those of the existing precipitators.

Option VI - Refurbishment of Existing Precipitators With RDE Components and Use of Sulfur Trioxide Gas Conditioning

This option had all the elements of Option V with the addition of a sulfur trioxide gas conditioning. As with the other options, gas conditioning would moderate fly ash resistivity. Due to the high gas velocities within the precipitators, precipitator suppliers again would not offer a performance guarantee.

The Unit outage duration for this option was estimated to be at least ten weeks. The estimated total direct cost for this option was $28.2 million. The operating cost for this concept in terms of electric power consumption and flue gas pressure drop would be no greater than that for the existing precipitators. However, there would be additional operating and maintenance costs associated with gas conditioning.

Option VII - Rebuilding of Existing Precipitators With 36-Foot Collecting Plates and Rigid Discharge Electrodes

This option was similar to Option III with the exception that rigid discharge electrode components were used in lieu of weighted-wire internals. Since the RDE components were on 12-inch centers, the additional weight associated with the internal components for 36-foot-tall collecting plates would be offset and not pose a significant problem to the existing supporting structure and foundations on a first-order basis. This option had the same features and limitations of Option III with the exception that the RDE design virtually eliminated electrode failures and could maintain internal alignment better than a weighted-wire design. Again, the precipitator suppliers would not offer a performance guarantee but would offer material warranties.

The estimated Unit outage duration associated with this option was at least ten weeks and most probably twelve weeks. The estimated total direct cost for this option was $22.6 million. The operating cost for this concept in terms of electric power consumption and flue gas pressure drop would be no greater than that of the existing precipitators.

Option VIII - Rebuilding of Existing Precipitators With 36-Foot Collecting Plates, Conversion to Rigid Discharge Electrodes With Sulfur Trioxide Gas Conditioning

This option was essentially the same as Option VII except that sulfur trioxide gas conditioning was added to moderate fly ash resistivities. This option had all the features of Option VII but had the added benefit that the precipitator suppliers would now be able to offer a meaningful performance guarantee as well as a material warranty. The performance guarantee would encompass the concept of a "make-good" guarantee with the contract value as the limit of the precipitator supplier's liability. In essence, the make-good concept requires the supplier to, for example, add an extra field if needed to achieve the required emission level. As such, from a performance standpoint, this option offered an essentially risk-free solution to the problem.

The Unit outage duration for this option would be at least ten weeks and most probably twelve weeks. The estimated total direct cost for this option was $30.4 million. The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that for the existing precipitators. However, there would be additional operating and maintenance costs associated with the gas conditioning system.

Option IX - Rebuilding of Existing Precipitators With 42-Foot Collecting Plates With Rigid Discharge Electrodes and One Extra Nine-Foot Field

This option utilized 42-foot tall collecting plates and four 9-foot mechanical fields along with rigid discharge electrodes. This option produced an SCA of 271, a gas velocity of 4.4 fps, and a gas treatment time of 8.1 seconds. This precipitator sizing would support a guaranteed emission rate of 0.10 lbs/MBtu without the use of gas conditioning. However, this option entailed significant structural reinforcement to the precipitator casing; extensive modification of the inlet and outlet ductwork; and substantial redesign of the existing supporting structures and foundations. These reinforcements and modifications were due to increases in both the dead weight of the structure and the wind load overturning moment. In addition, the inlet and outlet ductwork would be significantly altered to accommodate the taller collecting plates and the additional nine-foot field. The ash handling system would have been extended by eight additional pick-up points for each Unit.

The Unit outage duration for this option would be at least sixteen weeks due to the extensive modifications required. The estimated total direct cost for this option was $38.0 million. The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that for the existing precipitators.

Option X - New RDE Precipitators (0.10 lbs/MBtu), Abandon Existing Precipitators

This option involved abandoning the existing precipitators and installing new rigid discharge electrode precipitators. The new precipitators would be located in a position outboard of the existing precipitators and be erected prior to the Unit outages, with the exception of relatively small sections of tie-in ductwork for the air heaters and induced draft fans. The outage time for ductwork tie-in activities would be four weeks, well within the time planned for Unit outages. The new precipitators were sized with an SCA of 306 and a gas treatment time of more than 9 seconds. This sizing could accommodate the entire range of study coal characteristics. If dual gas conditioning were added to this option, the resulting emission rate could be significantly lower. As part of the costs associated with this option, the cost of removing the existing precipitators and adding a new fly ash handling system was excluded for a first-order approximation of costs.

The estimated total direct cost for this option was at least $58.0 million. The operating cost for this option in terms of electric power consumption would be near the same level of that of the existing precipitators. However, the flue gas pressure drop would increase by approximately 1½ inches of water.

Option XI - New RDE Precipitators (0.03 lbs/MBtu), Abandon Existing Precipitators

This option was essentially the same as Option X except that the new precipitators had an SCA of 429 and would produce an emission rate 0.03 lbs/MBtu without the use of gas conditioning.

The estimated total direct cost for this option was at least $69.1 million. The operating cost for this option in terms of electric power consumption would be greater than that for the existing precipitators. The flue gas pressure drop would increase by approximately 1½ inches of water.

Option XII - Maintain and Repair With a Phased Approach to Refurbishment

This option involved the precipitators undergoing their normal maintenance and repair activities until the FGD systems are operational. After that period of time, then during four subsequent Unit outages, the precipitator internals would be refurbished as described in Option I. This refurbishment would be performed on one-half of a precipitator casing during each Unit outage. Such an approach assured that the work can be accomplished well within planned outage times. Therefore, the use of overtime was eliminated for all practical purposes, thus reducing costs. However, these savings were offset by the additional site mobilizations required by this option.

This option permitted the construction activities associated with the FGD system to progress unimpeded and then permitted the precipitator refurbishment to be performed unencumbered. The estimated total direct cost of this option would be $16.6 million (1991 dollars). In addition to the capital expenditures for refurbishment, there would be $1.6 million in maintenance and repair costs. These costs were for (1) collecting plate alignment; (2) vendor service and Station engineers; (3) vibrator maintenance; and (4) precipitator cleaning. The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that experienced by the existing precipitators.

Option XIII - Maintain and Repair With Refurbishment in 1999 and 2000

This option involved the precipitators undergoing their normal maintenance and repair activities until the precipitators were refurbished in 1999 for Unit 2 and 2000 for Unit 1. In essence, this option blended the features of Options I and XII. The precipitators' refurbishment would be accomplished on a Unit basis. This option postponed major capital investments in the precipitators to their reasonable maximum limit of about 30 years of operation which would be a reasonable limit. Such a period of time is not inconsistent with electric utility experience. Beyond such a point, failure to refurbish the precipitators could make them subject to significant failures and, therefore, unwise to delay refurbishment further.

The estimated total direct cost of this option would be $16.6 million (1991 dollars). The estimated maintenance and repair costs were $1.5 million. The operating cost for this option in terms of electric power consumption and flue gas pressure drop would be no greater than that experienced by the existing precipitators.

Reality-Based Decision-Making

In evaluating each of these potential solutions, one had to balance theoretical considerations, proven performance, commercial reality, and practicality. When actual test data were used in theoretical performance models, the performance level of the Conemaugh precipitators could be reasonably explained. However, precipitator suppliers found that reliance on theoretical models and optimized performance conditions have not served them well in the past. Accordingly, their approach today tends to be more pragmatic by taking conservative positions regarding performance guarantees and basing such guarantees on their own data bases and regression analysis models. Therefore, even though the current performance level of the Conemaugh precipitators can be simulated and explained, it is also understandable that in order for suppliers to have acceptable technical- and commercial-risk levels, substantial modification to the existing precipitators would be required. When considering the sums to be expended on stabilizing the performance of the Conemaugh precipitators, it was reasonable to expect to have confidence that the emission goal can be reliably achieved. However, when evaluating potential solutions, one must take a practical approach.

Considering that the Conemaugh precipitators achieve such low emission levels when acceptable fly ash resistivity conditions exist, it was appropriate to weigh the risks associated with those potential solutions that significantly departed from the precipitators' current design concept. These departures involved changing ductwork configurations, hence, affecting gas distribution which is a major contributing factor to the precipitators' performance; use of taller collecting plates which required roof removal and structural reinforcement of the casing, supporting substructure, and foundations; use of wider plate spacings with limited experience on low SCA and high gas velocity precipitators; and modifications requiring lengthy Unit outages. In addition, the true value of a performance guarantee had to be considered. A performance guarantee provides comfort that potential solutions will work but at what price.

The existing precipitators' performance level is the best indicator of what a refurbished precipitator can accomplish. In essence, by just utilizing modern weighted-wire design components, the performance of the precipitator will be no worse than that when the precipitator is operating near peak performance with clean plates and wires and acceptable resistivity fly ashes.

In balancing the risks and benefits associated with each of the potential solutions for the Conemaugh precipitators with the actual performance of the existing precipitators, it is appropriate to consider a "least disturbance approach to what works" as the basis for decision making. Moreover, with the installation of FGD systems, the precipitators and FGD system as an integrated air quality control system. This permits the Station to use the FGD systems to moderate fly ash emissions and assure continual compliance with particulate-emission standards. This integrated system approach along with good precipitator maintenance and repair practices produced a most-cost-effective way to maintain compliance.