Summary Report EPRI Regional Seminars on the Environmental Control and Combustion Program

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EPRI REGIONAL SEMINARS ON THE ENVIRONMENTAL CONTROL AND COMBUSTION PROGRAM

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Special Report

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NOTICE

ABSTRACT

EPRI held a series of ten regional seminars on the Environmental Control and Combustion (EC&C) Program with member utilities. The purpose of the seminars was first to provide sponsoring companies a firsthand opportunity to review and discuss the EC&C Program. Second, they provided the EPRI technical staff with additional insight into the environmental control problem and research priorities as seen by the power production and engineering/R&D departments of the utility industry.

In addition to expressing support for the Air Pollution Control activities of EPRI, recommendations were provided by the utilities for increased R&D emphasis on problems affecting the near-term operation of existing and planned power generation capacity. Their recommendations focused on improved water quality control technology and improved performance and reliability of combustion as well as environmental control equipment. These recommendations recognized the pressures faced by the utility industry in meeting increasingly stringent performance requirements with generally diminishing fuel quality.

The counsel and recommendations of the utilities received at the regional reviews have been an important consideration in the reorganization of the Fossil Fuel and Advanced System Division.

ACKNOWLEDGEMENTS

EPRI expresses its appreciation to all the member utilities and their representatives who participated and contributed to these regional seminars. These seminars have been an extremely successful step in establishing a close working relationship between EPRI and utility staff in the area of fossil plant environmental control, performance and reliability and in insuring that these programs represent the technical needs and priorities of the utility industry. In this regard, we especially thank the members of the Environmental Control and Combustion Program Committee and the Fossil Fuel Department Task Force for their encouragement in planning, their advice and counsel in implementing and for their active participation in these seminars.

We would also like to recognize the invaluable contributions of Mr. G. J. Lanzolatta in the planning, organization and reporting of these seminars and of Dr. Francis E. Gartrell in the synthesis and summary of the results.

Particular thanks are extended to the following utilities and their staffs who lent their time, resources and facilities as hosts for the seminars:

- Commonwealth Edison Co.
- Dallas Power and Light Co.
- Empire State Energy and Environmental Research Corp. (ESEERCO)
- Georgia Power Co.
- Kansas City Power and Light Co.
- New England Power Co.
- Pacific Power and Light Co.
- Public Service Company of Colorado

TABLE OF CONTENTS

APPENDICES

A. Utilities Represented at EC&C Regional Meetings

B. EC&C Regional Meeting Minutes (Chronological Order)

1. Region IX Palo Alto, CA
2. Region VI Dallas, TX
3. Region I Westborough, MA
4. Region III Washington, DC
5. Region VIII Denver, CO
6. Region VII Kansas City, MO
7. Region II Schenectady, NY
8. Region V Chicago, IL
9. Region IV Atlanta, GA
10. Region X Portland, OR

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SUMMARY REPORT

EPRI REGIONAL SEMINARS

ON

ENVIRONMENTAL CONTROL AND COMBUSTION (EC&C)

PROGRAM

I. Introduction

During the period September 1975 - February 1976 a series of ten regional seminars was held with representatives from EPRI utility membership. The seminars were organized on the basis of U.S. Environmental Protection Agency (EPA) regions. Attached as Appendix A is a listing showing the location, date, and utilities represented at each of the seminars. A total of 71 utilities were represented at the meeting.

The purpose of the meetings was threefold: (1) provide the sponsoring companies a firsthand opportunity to review and discuss the EC and C Program; and (2) provide the EC and C technical staff with firsthand information on the environmental control problems facing the electric utilities at a regional and local level, and (3) establish research priorities as viewed by the power production and engineering/R and D departments of the operating utilities. The purpose of this report is to summarize the comments, suggestions, and recommendations of the utility representatives on technology needs and research priorities and describe EPRI's programs considering this input. The full text of the minutes from each regional meeting is included in Appendix B.

While there was genuine interest in, and support expressed for, research directed toward long term solutions to environmental/energy associated problems, the points of major concern of the utility representatives related to problems for which near term solutions are needed to insure continued operation of existing generating facilities and planned growth capacity in the near future. Broad areas of concern related to (1) water quality control (condenser cooling water systems and other waste water discharges), (2) reliability of environmental control equipment (performance at required efficiency with normal maintenance), and (3) upgrading of existing combustion equipment to meet increasingly stringent performance requirements with, in many cases, fuel quality not contemplated in the original equipment design.

Equipment reliability concerns were related principally to flue gas desulfurization technology and systems for control of particulate emissions. Also, in some regions there were major reliability concerns related to boiler components and to combustion turbines. Other areas of concern related to NO_x control, combustion turbines, use of combustion and particulate control additives, slagging in coal furnaces as related to fuel chemistry, and measurement and instrumentation problems. Intermittent SO_2 control systems, use of atmospheric dispersion models, and use of municipal refuse for power generation were among other items discussed.

Not all items mentioned were discussed nor was the same emphasis placed in each of the seminars. This is a reflection, at least in part, of differences among regions in the patterns of existing and projected generating capacity, as well as differences in regulatory requirements to be met.

The counsel and recommendation of the utilities received at the regional seminars has been an important consideration in the reorganization of the Fossil Fuel and Advanced Systems Division. This reorganization has created the Fossil Fuel Power

Plants Department, specifically mandated to focus research and development efforts on problems of near-term importance to the electric utility industry. Priority is placed on achieving effective and rapid solutions to the interrelated environmental control, fuel quality and plant performance and reliability issues presently facing the utility industry in their use of fossil fuels. These issues are of critical importance to coal and oil fired power plants because of the lack of viable fuel and power generation alternatives over at least the next 10 - 15 years. Thus, these issues become matters of survival for many utilities.

In order to most effectively respond to the industry recommendations for increased EPRI emphasis on water quality and power plant performance and reliability, the Fossil Fuel Power Plants Department is organized into four program areas: (1) Air Quality Control, (2) Water Quality Control and Heat Rejection, (3) Fossil Power Plant Performance and Reliability, and (4) Fluidized Combustion and Coal Cleaning. These four programs have evolved from, and replace, the earlier Environmental Control and Combustion and Direct Utilization Programs. These new program areas are described in Section III of the report.

II. Summary of Utility Comments and Recommendations

A. Water Quality Control

The utilities in all of the regions expressed deep concern about water quality control problems. The two broad areas of concern relate first to control of thermal discharges to conform with requirements of Sec. 316 (a) and (b) of the Federal Water Pollution Control Act - P.L. 92-500 and, secondly to ways of minimizing costs associated with meeting emerging minimum or "zero" waste water discharge requirements imposed under the National Pollutant Discharge Elimination System (NPDES) as prescribed under Sec. 402 of Act.

Sec. 316 (b) of the Act requires "that the location, design, construction and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." In some regions concern was expressed, that because of fish impingement problems associated with conventionally designed condenser cooling water intakes, cooling towers may be required even though not needed for control of thermal effects on aquatic life in the receiving body of water in conformance with Sec. 316 (a). The need for design guidelines for intake structures to control fish impingement was cited frequently in the seminars. In some regions, the need for guidelines for design of off-shore cooling water discharge systems was also mentioned.

Restrictions that have been placed on the use of chlorine for control of condenser fouling is causing problems in most of the regions. Mechanical systems for this purpose reportedly are unsatisfactory. The utilities expressed urgent need for an effective and acceptable biocide that can be used to replace chlorine for this purpose.

With regard to cooling towers, several regions cited the need for improved designs of drift eliminators and for additional research on drift from cooling towers. The need for more efficient designs for dry type cooling towers was also cited for use where such towers might be desirable, for example in water scarce regions. In one water scarce region, a study was suggested of the use of agricultural wastewater, which is generally as saline as seawater, in power plant cooling cycle application. A study of possible use of sewage treatment plant effluent for this purpose was also suggested.

Heated water discharge is only one of a myriad of sources of potential water pollution problems now receiving the attention of power plant operators to develop controls to meet water quality protection requirements. Included among these other sources are ash pond effuents, waste water and sludges from water treatment plants, domestic sewage, coal pile drainage and runoff, roof and yard drainage, cooling tower blowdown, air heater and fireside wash, plant sump drains, and backwash from intake screens. Where wet scrubber flue gas desulfurization systems are installed, additional wastewater and sludge disposal problems require control for water quality protection.

The utilities expressed a need for reliable guidelines and technical specifications for minimizing the cost of flyash and sludge disposal and waste water treatment. Of particular concern are requirements to meet stringent effluent limits for toxic substances, trace elements, dissolved solids, and suspended solids in discharges from power plants. In at least one utility service, the regulations require that each discharge be treated separately.

In several regions it was recommended that a study be made to establish a practical hierarchy of water usage; that is, determine how the water effluents from one part of the overall power generation system can be used as input or makeup water for some other component of the system in order to minimize the total volume of water required. Such a study should aid in achieving overall plant water balance to minimize both discharge and water usage. This presumably would help to minimize water supply and wastewater treatment costs.

B. SO_x Control

Without exception, representatives of utilities with operating flue gas desulfurization systems, expressed concern about the poor performance and reliability of the systems. Problems cited are principally mechanical in nature and considered to be the result of poor quality control and design deficiencies, rather than to the basic technology involved. Corrosion, failure of linings, fan problems due to poor demister performance, expansion joint failures, leaking dampers are some of the problems of this nature that were cited. Concern was also expressed about problems related to storage and disposal of scrubber waste slurry. Despite these problems, flue gas desulfurization systems figure prominently in capacity plans for many of the regions as well as being a retrofit method for meeting SO_2 emission requirements at existing plants.

In one region, which normally would use readily available high sulfur coal, coal-fired capacity growth plans indicate increased reliance on Western coal as the preferred option for meeting SO_2 control requirements. However, it was recognized that this preference could be considerably affected if emerging non-degradation requirements result in the need for flue gas desulfurization even when low-sulfur coal is used. This is already the case in some parts of the country. In this same region, which has very large high sulfur coal-fired capacity, existing State Implementation Plans (SIPs) are forcing near term commitment to SO_2 scrubber applications. For example, three utilities in this region are planning a total of 5000 MW of scrubber capacity. To increase reliability and reduce cost, it is planned that some of these sources may combine low-sulfur coal combustion with partial scrubbing. The utilities in this region consider a site specific design basis for alkali wet SO_2 scrubber applications to be a priority need.

In another region, one of the utilities has canceled plans for a limestone SO_2 scrubber at one of its plants and will use a coal cleaning operation to provide fuel that will meet SO_2 emission requirements. The coal cleaning plant will utilize a heavy media process at 1.4 specific gravity and the coal will be crushed to pass a 14-mesh screen. The low sulfur product will meet New Source Performance Standards (NSPS) and will be used on a new capacity addition. The cleaning system will produce approximately 0.5% and 2.2% sulfur coal at a rate of 1200 tons per hour. The raw coal feed will be 2.3% to 2.7% sulfur. The Btu loss is estimated between 5% and 7%.

The burning of low sulfur coal in power plants not designed for this specific type coal presents problems that can seriously affect plant operations. Problems cited by utility representatives at the seminars include adverse effects on electrostatic precipitator performance and especially for Western low-sulfur subbituminous coals, (1) the fouling and erosion of heat transfer surfaces, (2) drying and handling the high moisture coal, (3) carbon carryover which causes severe induced draft fan wear, (4) air heater fires, (5) derating of steam generators (5-10%) because of lack of mill capacity for the lower heat content fuel, and (6) impacts on ash handling systems because of the larger quantity of ash produced.

Much interest was expressed in several of the seminars in intermittent control systems (ICS) for achievement of ambient air quality standards for SO_2. These systems are especially attractive because of the fact that they normally cost only a fraction of the cost of methods employed for continuous emission control to meet ambient standards. Although some utilities in a few regions have initiated ICS at some of their plants, there were no indications from the seminar discussions that extensive use will be made of ICS. Generally regulatory agencies have rejected ICS as an alternative to an SO_2 control strategy involving continuous SO_2 emission limitation. One state is considering allowing such systems in its pending State Implementation Plan. If they are not allowed, a number of generating plants will be forced to operate at considerably reduced load for several years to meet environmental requirements. Sufficient low sulfur coal is not available to fuel the plants and other options to achieve the required continuous control of SO_2 emissions cannot be economically justified.

In one of the seminars, a number of practical as well as regulatory problems related to use of ICS were cited as needing attention. These include the storage and rapid switching between high and low sulfur fuels and furnace slagging as a result of different coal ash fusion temperatures. (Not mentioned but also a potential problem is effect on electrostatic precipitator performance when low sulfur coal is fired.) In another region, the unreliability of existing dispersion models was cited as a fact or that would be particularly discouraging to the use of ICS strategies for several plant locations where this alternative would be by far the most cost effective. The unsatisfactory economics of any other control alternative may thus force premature plant closures in the region.

In only one region was it suggested, however, that high priority be given to development of ICS.

C. Particulate Control

With regard to particulate control, the seminar discussions were directed principally to problems and research and development need related to electrostatic precipitator systems including ash collection and handling equipment. Considerable attention was directed also to use of scrubbers and fabric filters for control of particulate emissions at fossil fuel-fired power plants. In addition to meeting mass emission standards, particulate control equipment must be relied upon to meet opacity requirements.

In one region it was reported that emissions from cyclone boilers violated applicable state opacity standards even when the grain loading emission standard is met. Generally, at plants with properly operating high efficiency particulate control systems, opacity problems are related to startup and load change conditions. Thus, the need for development of procedures for avoiding opacity problems under these conditions was cited in the seminar discussions. Another need cited is the ability to predict opacity based on boiler/collector design and operating conditions plus outlet grain loading, particulate composition and size distribution. The need for resolution of the incompatability between results obtained by in-stack optical instrumentation and outside observers was also cited.

In one region where scrubbers have been operated for particulate removal in connection with flue gas desulfurization systems, the scrubbers reportedly served reasonably satisfactorily, once major mechanical problems were resolved. However, in another region, one major utility reportedly has completely given up on scrubbers for particulate removal. The problem areas identified include: disposal of scrubber sludges; technological limits (and costs) of operating scrubbers in a closed loop configuration; measurement of entrained moisture in scrubber effluents, development of scaling inhibitors, effective demisters, improved understanding of the effects of trace elements on hardware; and generally low scrubber availability plus excessive maintenance requirements.

In some regions, the seminar discussions pointed to increasing interest in and attention to use of fabric filters for control of particulate emissions from coal fired power plants. This appears to be due to the likelihood that a zero plume opacity (invisible plume) requirement may be imposed on new coal-fired power plants in many situations and to the increased attention being given to emissions of fine particulates. Also involved is the major effect that coal quality has had on electrostatic sizing and cost, and its substantially lower effect on fabric filter system sizing and costs. It was reported that a fabric filter system on a coal-fired boiler burning 18% ash coal at Colorado Ute's Nucla Station produces an invisible plume. It was also reported that fabric filters are to be installed as the only particulate removal device at a new coal-fired plant (325 MW) at Amarillo, Texas being built by Southwestern Public Service Co. Several other western utilities, are considering fabric filters in competition with electrostatic precipitators, and are seeking bids on both.

In nearly all regions, major concerns were expressed about electrostatic precipitator efficiency problems. The problems have arisen as a result of the stringent particulate emission limitations that have been imposed by regulatory agencies on power plants plus changes in quality of fuels being burned in many existing power plants. Also, in regions where coal and/or lignite are considered as the fuel of the future for power generation, efforts to improve electrostatic precipitator performance and reliability are considered as increasingly important. Specific priority needs identified included:

- The development of capabilities to upgrade existing electrostatic precipitators to meet current and projected stringent emission requirements and to operate satisfactorily on off-design coals. A related problem is the upgrading of ash handling systems to handle the increased quantities of ash collected.

- Additional research to improve the reliability of existing electrostatic precipitator installations.
- Development of design specifications and operating procedures that utilities can confidently use in purchasing new precipitators and in operating them without significant reduction in performance with operating time.
- Development of methods to avoid reentrainment.
- A comprehensive evaluation of hot-side versus cold-side precipitators, considering all variables involved.

Other items suggested for consideration include:

- Evaluation of effects of coal cleaning processes on the ash characteristics affecting precipitator performance and the composition of the emitted ash.
- Evaluation of agglomerating additives for improving fine particulate collection efficiency.
- Development of the capability to identify and isolate electrode failures.
- Development of improved flyash level controls for ash hoppers.
- Development of the capability to remove flyash from silos without creating fugitive dust problems.
- Definition of the role of trace elements or particulates on particle agglomeration and the condensation of polynuclear organic matter (POM), the latter is an unburned hydrocarbon which may be present in stack gas as an uncondensed vapor.

The strong demand for upgrading electrostatic precipitators provided by the Federal Energy Administration (FEA) coal conversion program was also cited as further support of these foregoing recommendations.

D. NO_x Control

In several regions, a question was raised as to the regulatory justification for existing and potential future NO_x control on power plants in the region, particularly in urban areas. This was reported as directed to control of oxidant levels rather than to ambient levels of oxides of nitrogen, per se. The view was expressed that EPA is apparently dropping the tough stance for automotive NO_x control and shifting emphasis toward power plant NO_x control at the regional level.

There was general concern expressed with NO_x control for combustion turbines. Water or steam injection is one method of NO_x control for combustion turbines. One region reported the cost of water or steam injection on new turbines in 1972 was about $8/KW. In another region, water injection was not considered a satisfactory answer for NO_x control because of the unacceptable water use rate and water treatment costs. Water injection was reported as not acceptable to the City of Philadelphia for NO_x control.

In only one region was there discussion of problems related to NO_x control to meet existing NSPS for new power plant boilers. The problem cited was principally reduction in boiler efficiency. For example, flue gas recirculation fans reduce boiler efficiency and change the excess oxygen levels for stable combustion. Units with steam atomized burners use considerable makeup water (increased demineralizer requirements) and have had 0.5 to 1.5% decrease in overall boiler efficiency.

One utility, faced with NO_x regulations of 125 ppm on gas and 225 ppm on oil, has been required to do trial and error testing on all boilers larger than 200 MW. At one station the amount of gas recirculation to the burners that would be required for NO_x compliance cannot be provided because it would overpressure the furnace and overheat the reheat subsystem. Removing surface to allow the furnace pressure to go down and gas recirculation to go up would defeat the purpose of eventually changing to oil as a main fuel. Other units are not fully in compliance due to NO_x instrumentation problems.

In another region it was reported that the use of European oil burner designs on relatively small boilers, coupled with significant wind box modifications, had produced considerable reductions in emissions. One boiler manufacturer has proposed to one of the utilities in that region that the use of 36 corner fired burners rather than the normal sixteen would substantially control both NO_x and particulate emissions.

E. Noise Control

The need for consideration of the problem of power plant noise control was cited in three of the regions. It was recommended that EPRI consider establishing a noise evaluation and control effort. This effort, along with related industry efforts, should be directed toward development of dependable noise specifications for power plant hardware. The need for utility industry guidelines on the control of noise is rapidly emerging because of promulgation of noise control regulations at the state level. One state, New Jersey, already has noise standards and noise control reportedly is a matter of general concern in the whole region. Areas requiring attention are combustion turbines, draft fans, transformers, pulverizers, feedwater pumps, circuit breakers, coal handling systems, cooling towers and construction noise.

F. Combustion Turbines

In all regions it was generally recognized that, because there are not suitable alternatives available, combustion turbines will continue to be utilized for peaking generation in the foreseeable future. Combustion turbines may also be used increasingly for repowering existing boilers.

In one region, it was pointed out that dependence on combustion turbines for peaking may be reduced if fast start coal generation capabilities can be developed. In another region it was reported that gas turbine power plant facilities are the last resort when all other site plans fail. Most utilities in that region reportedly do not favor construction of simple cycle (peaking) turbines unless the system is designed for future retrofit of combined cycle (intermediate load equipment) and a reliable source of fuel. The reasons cited for this position are the maintenance costs and reliability problems associated with combustion turbines, especially the larger capacity machines. One utility reported operation of a 100 MW repowered system in which the combustor turbine exhaust is fed to a steam boiler. It is used only as a peaking facility. Reliability has been particularly limited due to expansion joint failures.

There was general consensus in most regions that research and development efforts to improve turbine reliability or availability should continue to be emphasized, along with the development of practical synthetic fuel technologies and environmental controls. However, in one region it was recommended that further research and development on gas turbine performance be given low priority because of their low availability, high maintenance, and high fuel costs. It was the view utility representatives in that regional seminar that technological development of combustion turbines should be tied directly to the availability of synthetic fuels as a reliable fuel source.

The problems and research and development need identified in the discussions include the following:

- Development of a reliable fuel source. It was suggested that methanol might be the most easily achievable synthetic source.
- Develop wider range of peaking fuel capability including consideration of a pulverized coal burner for combustion turbine application.
- Better definition of the fine particulate emission factors, and their composition, associated with combustion turbines.
- Development of practical alternatives to water injection for NO_x control.
- Develop improved information base on performance and cost of additives and their impact on turbine reliability.
- Reduce noise levels. Definition of noise control specifications for lower frequency turbine noise emissions.
- Minimize internal corrosion. Specifically, efforts should be directed to investigating the hot corrosion (sulfidation) problem, which appears to be a problem with all GE Frame 7000 gas turbines. One company reported that after 2000 hours operation of a turbine of this type, they were required to replace the first stage.
- Develop operating procedures to minimize maintenance and extend time between overhauls. One utility reported maximum benefits from washing the turbine during shutdown, coupled with operation of both stringent air and fuel cleaning techniques.
- Development of smokeless turbine combustors.
- Improvement of combustion turbine stack design to avoid ground level impingement close to the plant during high velocity winds.

G. Boiler Combustion Performance and Reliability

Boiler component reliability was an area identified in some regions as needing a great deal of investigation, which potentially could be of major economic value to utilities. A variety of problems was identified that resulted in forced outages, such as internal corrosion on the heaters of once-through systems not found in subcritical systems. It was considered that part of this problem may be traceable to water treatment procedures and the low pH which is often encountered in the water circulation system. There was criticism of burner designs which were not providing optimum air-coal distribution for maximum burning efficiency. Fuel deterioration was reported as having created slagging problems resulting in shut down, which was cited a basis for needed efforts to determine the role of fuel chemistry as a factor in equipment reliability. One utility reported on work done with the Babcock and Wilcox Company in the area of flux treatment for raising the fusion temperature of low sulfur coals so that such coals can be used in cyclone furnaces. In general there was no consensus on specific deficiencies which are causing the excessive outages now being experienced by many power plant units. It was suggested that EPRI undertake investigations to identify the specific problems involved in excessive unit outages and to determine which ones might merit special research efforts and those due to design and operational deficiencies for which additional research would not be indicated.

Another problem area identified is the need for development of design and operating characteristics for boilers which will be used for swinging or peaking loads. It was indicated by several utilities at one of the seminars that they would meet swinging loads with coal-fired plants.

The need was cited for evaluation of fuel additives for boilers, as well as turbines, to determine their real impact on emissions as a function of fuel and combustion conditions and their side effects on performance and reliability.

A number of utilities reported on cooperative projects directed toward the use of municipal refuse as a source of fuel for power generation. There is need for development of criteria for this use of municipal refuse, which might be of considerable economic and public relations importance in many urban areas.

In one region the need was expressed for a cost/benefit study of pressurized furnaces versus balance draft furnaces. The study should relate I.D. fan cost savings versus increased maintenance costs unit outages, and particulate handling problems.

H. Measurement and Instrumentation

Many utility representatives expressed the opinion that EPA is using outdated emission factors. It was urged that emphasis be placed on developing improved analytical techniques as input to EPA and ASTM and on the use of these techniques to achieve improved emission factors for all types of fossil fuel-fired power plants, including those with flue gas desulfurization systems.

Concern was expressed about the validity of dispersion models used by EPA and EPA contractors to define allowable emission levels for generating stations. Need for verification of these dispersion models was suggested because of their use in local regulation and SIPs.

It was recommended that increased emphasis be placed on defining analytical guidelines for determining the elemental and chemical state of particulate emissions. The problem of submicron particulate characterization is particularly difficult, but extremely important to defining the potential role of these particulates in atmospheric chemistry and health and environmental effects.

A need was expressed for real time sulfur and heating value measurement techniques to determine how well the coal being burned relates to sulfur emission regulations. A related need is for better guidelines on the fate of coal sulfur to determine how much is removed in the pulverizer, the furnace, and the particulate removal system.

Accurate guidelines are needed for relating the performance of opacity instrumentation to actual stack grain loading and particulate size distribution.

A number of specific measurement and instrumentation needs were identified by utility representatives. These include:

- Means to measure entrained water in gas scrubber emissions.
- Monitors to determine opacity in gas containing entrained water.
- Methods to measure acid sulfates and nitrates in ambient air.
- Standardization of laboratory leachate procedures for flyash and sludge, with particular emphasis on trace metals.
- Fast, simple procedure for determining oil and grease in water discharges.
- Monitoring instrumentation for liquid effluents, with sensitivity and reliability required by EPA permits.

- Instrumentation for continuously measuring water quality, with particular emphasis on monitoring heavy metals from ash settling ponds.
- Simplified ground water monitoring techniques that would be satisfactory to both utilities and regulatory agencies.
- Improved method for measurement of polynuclear organic matter (POM) in stack gases.
- Improved particulate measuring instrumentation - both optical and in-site particulate sizing.

Concern was expressed over the EPA regulation for stack testing which requires that testing be done high in the stack. It was recommended that EPRI evaluate the technical problems and variables affecting less expensive, less time consuming, and less hazardous breech testing.

III. EPRI Program

A. Fossil Fuel Power Plants Department

Overview of the Department Program

This recently organized department in the FF & AS Division will focus its research and development efforts on problems of near-term importance to the electric utility industry. Priority is being placed on achieving effective and rapid (one to five year) solutions to the inter-related environmental control, fuel quality, combustion hardware and plant performance and reliability issues presently facing the utility industry in their use of fossil fuels. These issues are of critical importance to the operation of conventional fossil fueled power plants because viable alternatives do not exist over the next 10-15 years and, thus, become survival issues for many utilities.

The department includes four programs: Air Quality Control; Water Quality Control and Heat Rejection; Fluidized Combustion and Coal Cleaning; and Fossil Power Plant Performance and Reliability.

In order to assure the success of our efforts in these areas, the programs are dependent upon a high degree of effective utility interface and members of the industry advisory committees are intimately involved in identifying problems to be focussed upon. While many of the research projects will be carried out at specific utility sites, the problems addressed will be of a generic type and the results will be applicable to an array of electric utilities. The findings of these projects will be reported through workshops, seminars, guidelines and quick response services.

Major Objectives of the Department Program

Air Quality Control Program: This program is made up of five subprograms; SO_x, NO_x, Particulates, Instrumentation and Measurement, and Combustion and is directed at the following technical objectives:

- Develop a specific design basis for lime/limestone scrubbing technology by 1978.
- Develop an economic and reliable regenerative flue gas desulfurization technology to reduce potential pollution, solids disposal and limestone consumption.
- Develop reliable NO_x control for coal-fired steam generation plants which will minimize the impact of environmental standards on utility operations, reduce steam generator maintenance and outage rates, and define the practical limits for combustion and post-combustion control of NO_x.
- Develop, by 1978, technology to reduce the cost associated with the collection of high resistivity fly ash by at least 30% and reduce outage rates by at least 50%. These efforts can result in a $1.5 billion savings to the utility electrostatic precicipator investment between 1978 and 1985; result in a substantial savings in maintenance and outage costs; avoid obsolescence of electrostatic precipitators created by more strict environmental standards.
- Establish alternative fabric filter technology for high resistivity ash and fine particulate control applications.
- Evaluate and develop air pollution emmission measurement techniques by 1978. Included will be a continuous real time assay for coal plants; a guideline to the utilities for the accurate measurement, sampling and

analysis of fine particulate and related trace substance emmissions.

- Insure the compatibility of synthetic and other nonconventional fuels with existing and future utility boiler combustion facilities.

Water Quality Control and Heat Rejection Program: This program is made up of three subprograms; Heat Rejection, Chemical Water Quality and Solid Waste Disposal, and is directed at the following technical objectives:

- Reduce plant water requirements and develop an integrated design approach for plant water systems.
- Improve the control of scaling, corrosion and biofouling and develop improved water treatment process options.
- Construct and test an enhanced dry cooling system which potentially costs one-half that of conventional dry cooling systems.

Fluidized Combustion and Coal Cleaning: This program is made up of four subprograms; Fluidized Bed Combustion, Coal Cleaning, Solid Waste Utilization, and Direct Use of Fossil Fuels, and is directed at the following technical objectives:

- Demonstrate an economical fluidized bed boiler at a utility commercial scale by 1982.
- Investigate fast or circulating bed boiler technology as an alternative to conventional fluidized bed combustion.
- Assess the feasibility of limestone regeneration by 1979.
- Develop physical and chemical coal cleaning for utility fuel processing.

- Provide sound information on solid waste utilization as a utility fuel.

Fossil Plant Performance and Reliability: The program is made up of three subprograms; Turbine/Generator System, Steam Generator System; and Ancillary Systems, and is directed at the following technical objectives:

- Identify and solve generic fossil power plant reliability and performance problems. Efforts will be directed at reducing the average forced outage rate for fossil plants by approximately 10%, and increasing the average availability of installed fossil plants to approximately 80%.
- Assist utilities in achieving longer operating periods between major overhauls and improve overall-thermal performance.
- As warranted, recommendations for plant specifications and improved maintenance practices will be issued based on the results of research efforts.

Achievement of these broad objectives is dependent upon our success in attaining the specific program objectives detailed in the following materials.

B. Air Quality Control

Program Description

The fundamental objective of the Air Quality Control Program is to provide technical and engineering support to the electric utility industry in effectively responding to control requirements with minimal operational and economic impact on fossil fuel plants. The objective is particularly critical to the operation of conventional coal fired power plants for which no viable alternatives exist over the next 10-15 years and thus becomes a survival issue for many utilities. In order to achieve this objective, the program will: a) determine, on a continuing basis, the state of the art and associated cost of air quality control technology. This information, coupled with that produced by the Environmental Assessment Program in Energy Systems, Environment and Conservation Division, will permit the utility industry and the nation to objectively evaluate the cost/benefit trade-offs associated with various levels of control. b) based on these evaluations, develop technologies and operating procedures to meet environmental requirements with minimum impact on the utility industry's productivity and cost.

The Air Quality Control Program encompasses specific subprograms in SO_x, NO_x, particulate control as well as emission instrumentation and measurement technology. It also includes a combustion subprogram designed to increase combustion efficiency and to insure the compatibility of new control techniques and synthetic fuels with utility combustion processes. These subprograms are described as follows:

Importance of the Program

This program is driven by two primary considerations:

1. There are no commercial alternative fossil fuel technologies to conventional coal fired power plants over the next 10-15 years.

2. Federal and local environmental standards exist and can be expected to become more stringent. They will require positive air pollution control capabilities for both new and existing fossil fuel plants. The total cumulative annual cost of this control to the utility industry is estimated to be at least $160 billion between 1975 and 1990.

This EPRI program is designed to produce at least a 1% savings ($1.6 billion) in air pollution control operating and maintenance costs alone. Since the EPRI Air Quality Control Program budget in the next five years is $82 million, this savings alone results in a conservative cost-benefit ratio of 20:1.

Subprogram Structure

1. SO_x Control

The basic objective of the EPRI SO_x control subprogram is to support the utility industry in determining and developing the most cost-effective technologies for controlling SO_x emissions to the degree required by environmental regulations as forecast over the remainder of the century (about 90-95% emission control for coal fired sources).

The EPRI SO_x control subprogram provides a central support capability designed to promote the success of the large, and growing, capital commitment by the utility industry to flue gas desulfurization technology. Unless much more stringent control levels are required flue gas desulfurization (FGD) is, and is expected to remain, the least expensive option for the continuous control of SO_2 emissions. The EPRI investment in the area will be directed primarily at compiling and evaluating the massive industry data base in F&D technology and providing test design and hardware development advice to the industry based on the central evaluation.

This program will initially emphasize providing the site specific design and operating basis which will allow the utility industry to successfully implement its current $4 billion (40,000 MW) lime/limestone scrubbing commitment.

Longer term emphasis is on: a) supporting the development and demonstration of improved flue gas desulfurization systems which minimize by-product disposal and land use impact, at a capital cost in the range of $100 to $200 per kWe (1975$); and b) maintaining data on the state-of-the-art and associated cost of SO_x control technology so that the utility industry can evaluate the cost/benefit trade-offs associated with various levels of control.

Specific objectives to be achieved are:

A. Develop by the second quarter of 1978, the design and operating support basis which will allow the utility industry to confidently purchase large-scale, closed loop, lime/limestone scrubber and associated by-product disposal systems for high sulfur coal combustion. This effort will help protect the utility commitment to FGD technology, which, by 1980, will be on the order of 40,000 MW at a capital cost of at least $4 billion. The total EPRI investment in achieving this objective will be $6.5 million. The payoff to the utility industry is estimated to include at least a one-third reduction in annual scrubber maintenance charges which typically now are in the range of 10-15% of capital investment per year. Such an improvement would produce at least a $200 million annual savings to the utility industry.

B. Complete by 1980 the pilot scale (20-50 MW) development, test and evaluation of candidate advanced regenerable stack gas desulfurization processes on coal-fired facilities. This development effort will provide technical and economic data, supporting the utility industry response to requirements under the Clean Air Act for positive control of most coal-fired sources by 1985. Environmental, economic, and land availability constraints on the utility industry, particularly in the eastern U.S., combine to create a potential 1980-1990 market for regenerable scrubbering of at least 200,000 MW with a corresponding capital commitment of $20-40 billion.

C. Establish and operate by 1978, prototype scale scrubber development and evaluation centers for both eastern and western coal. These centers, using existing facilities where possible, would be located at operating utility sites and would be designed to 1) satisfy the prototype scale scrubber development and evaluation needs of the utility industry; 2) provide solutions to the specific problems associated with the startup of new scrubber installations; 3) train utility scrubber engineering and operating personnel.

2. Particulate Control

A principal constraint on the firing of pulverized coal in utility boilers is in the collection and disposal of large quantities of fly ash. The magnitude of the problem may be gauged by the fact that a modern 2000 MW station, firing around 20,000 tons of coal per day, generates flue gas carrying several thousand tons of fly ash per day. Of this quantity, current control technology, i.e., electrostatic precipitators, removes as much as 99%, leaving about 25 tons per day of relatively small sized particulates to be emitted from the stack.

The submicron portion of these emissions are under close scrutiny by the regulatory authorities because their high surface area/unit mass can preferentially retain adsorbed pollutants, and because they can penetrate and be retained by the lower respiratory system. The submicron particles are also efficient light scatterers, which results in plume opacity and reduces atmospheric visibility.

Traditionally, the electrostatic precipitator has been used by utilities to remove particulates. However, there are technological limitations on precipitators for satisfying the new requirements of improving collection efficiency from typically 95% to about 99.5%. At the same time the shift toward low sulfur coal leads to a low-conductivity ash which interferes seriously with precipitator performance. These two factors together require large and expensive precipitators whose efficiency cannot be predicted with satisfactory accuracy, and whose reliability is seriously reduced causing forced plant outages and increased purchased power requirements.

The objectives of this subprogram are to reduce the size and cost of particulate control apparatus and to increase its collection efficiency and reliability for a given collection efficiency. Much of the development effort will be performed at the EPRI/ Utility Industry Particulate Control Development and Evaluation Center located at the Arapahoe Station of Public Service of Colorado in Denver. This $4 million facility is capable of testing all particulate control devices at temperatures between 300°F and 1800°F and at flow rates from 5,000 to 50,000 CFM. Specific objectives to be accomplished in 1975-1981 are:

A. Provide the capability to double, no later than 1978, the reliability of conventional electrostatic precipitators with corresponding avoidance of boiler load limitations. This improved design basis will also include more accurate sizing capability for conventional electrostatic precipitators to reduce capital cost. This will include development of retrofit apparatus such as the high intensity ionizer and methods to improve the performance of existing undersized electrostatic precipitator installations at minimal cost. The total EPRI investment in achieving this objective is $9,000,000. This will result in at least a $5-7/kw savings in both new and retrofit precipitator costs and can reduce the present outage rate by 50%. A $1 billion savings in new utility precipitator investment between 1978 and 1985 alone, and at least a $50 million per year industry-wide reduction in ESP maintenance and outage costs would result.

B. Establish by 1978, laboratory methods and a data bank to predict the collection properties of fly ash based on coal core sample analyses. This will provide a reliable design basic, for new particulate control devices thus eliminating performance and cost uncertainities.

C. Demonstrate, by 1978, fabric filtration for high efficiency collection of fine particulates. This technology has the potential to provide a more reliable and less costly alternative to electrostatic precipitation for the combined problems of fine particulate emission control and high resistivity fly ash.

3. NO_x Control

This subprogram is directed at understanding, from the utility industry context, the reliability, performance and cost implications of emerging standards and the associated control technologies assumed by regulatory agencies. This will provide the utility industry an informed basis for not only responding to, but also influencing, the future course of NO_x control requirements.

Of the three major pollutants (SO_x, particulates and NO_x) emitted by power plants, only NO_x is limited to a control efficiency of 30-50%. EPRI is therefore actively pursuing a significant NO_x program to assure that emissions of oxides of nitrogen are not a future factor in limiting the construction or operation of fossil fueled power plants.

NO_x emissions can result from both the fixation of atmospheric nitrogen and the conversion of nitrogen in the fuel. Currently NO_x from boilers is controlled by combustion modifications which minimize the availability of oxygen and lower flame temperatures. These techniques have been successfully applied to natural gas and oil-fired systems. However, many questions about their effectiveness and operating reliability still exist, particularly for coal fired boilers. In addition, these techniques often cannot be practically retrofit.

Specific objectives to be achieved by the subprogram include:

A. Complete prototype development and evaluation by 1979 of advanced NO_x combustion controls for coal-fired steam generators. This objective will be accomplished cost-sharing projects with the boiler manufacturing industry and will involve an EPRI investment of about $3 million. The effort will focus on combustion control burner designs capable of controlling fuel nitrogen conversion. The payoff to the utility industry will 1) define the practical limits of low-cost combustion control for NO_x and 2) minimize steam generator maintenance and outage rates associated with achieving NO_x control requirements.

B. Complete prototype development and evaluation by 1979 of staged combustion technology for combustion turbines. It is only recently that gas turbines and combined cycles have been required to control emissions of NO_x. For the conventional turbine fuels (natural gas and distillate oils), the current method of NO_x control is water or steam injection into the combustion chamber. The technique is effective but is expensive and has high water consumption rates. Capital costs vary, but typically are at least $10/kw. Less capital intensive NO_x combustion control technology utilizing a catalytic and/or premixed, fuel lean, primary combustion zone is a likely alternative. Because this technology has important implications not only for current combustion turbine technology but also for the emission compatibility of synthetic fuel/combined cycle power systems, the effort is being planned and implemented in coordination with the Power Generation Program of the Advanced Power Systems Department.

C. Evaluate, by 1981, the engineering, operational and economic feasibility in the utility context of alternative post-combustion NO_x control processes. The imposition of post combustion control technology is currently being considered by regulatory agencies as the vehicle for achieving stringent (80-90%) NO_x control on coal fired power plants and is expected to eventually form the basis for utility emission standards. It is clear that the conversion of nitrogen compounds bound within the fuel molecule to NO_x is a key problem in both gas turbine and boiler power generation systems. For this reason, a high priority is placed on preventing conversion to NO_x, since resolution of this fundamental question is likely to define the extent to much more expensive post-combustion control processes may be required. Emphasis is being placed on evaluating the effectiveness and economics of post-combustion control processes, particularly the selective catalytic reduction and homogeneous decomposition processes which presently are at an early stage of development for use on coal fired combustion sources.

4. Combustion

EPRI is actively pursuing a Combustion subprogram designed to assure that technology, and application methods, are available to accommodate synthetic fossil fuels as they become available for use in power generating devices. Accordingly, the scope and schedule of this effort is being planned and implemented as a supporting activity to the Advanced Power Systems Department. Emphasis is being given to evaluation of synthetic fuel properties for retrofit and new applications as sufficient quantities of fuel become available. Also, the subprogram is directed to increasing effective generating capacity through improved efficiency. Considerable effort is therefore directed toward techniques to increase power generating capability from existing capacity. Objectives to be achieved by this subprogram are:

A. Assure, on a continuing basis, the compatibility of synthetic fuels with power generating hardware. In order to retrofit synthetic fuels or solid wastes to conventional boilers, it is necessary to consider several aspects of the system. The fuel must be stored, transported, prepared for combustion and fired with as few modifications as possible. In addition, the effect of the products of combustion on the boiler heat transfer surfaces must be considered, together with their potential emission characteristics.

B. Retrofit studies and advanced combustor evaluations will be performed by 1979 to assure that low and intermediate Btu gases can be successfully applied to power generation devices as they become available.

C. Evaluation of the concept of gas turbine repowering of conventional steam boilers will be complete by 1979. This effort will address the anticipated capacity shortages in the 1980-1981 time period. The advantages of such a concept including potential for an increase in plant generating capacity, no additional impact on emissions, and low cost compared to other techniques. Other methods for improving performance are also being pursued such as studies and field test programs to determine 1) optimum cycles for pollution control and performance and 2) reducing stack gas temperatures and condenser heat rejection. Such improvements in efficiency appear especially attractive in view of the present situation of drastically escalating fuel costs.

5. Instrumentation and Measurement

The Instrumentation and Measurement subprogram is structured to perform three interrelated functions:

First, existing and developing air pollutant emission measurement technology is being evaluated. The performance, cost and reliability of continuous measurement techniques as well as specific sampling and analysis approaches will be determined in operating utility environments. These evaluations will incorporate the separate, but often related ambient monitoring technology development efforts of the Environmental Assessment Department.

Second, based on the evaluation of existing technology, new instrumentation and measurement techniques will be developed and commercialized as required. An ongoing example of this type of effort by EPRI is the development of in-situ fine particulate sampling techniques for utility application.

Third, the best available instrumentation and measurement technology as evaluated and developed by EPRI will be applied to define realistic pollutant emission factors for existing and developmental utility combustion and conversion systems. EPRI will provide support for the design of instrumentation and measurement specifications to be applied in EPRI field test programs, as well as providing emission measurement support to the Environmental Assessment Department in determining the ultimate environmental impact of utility sources. Specific objectives to be achieved include:

A. Provide comparative evaluation of alternative state-of-the-art particulate measurement techniques by mid-1977.

B. Develop, by mid-1977, alternative impactor/diffuser methods for continuous stack measurement of submicron particulate matter.

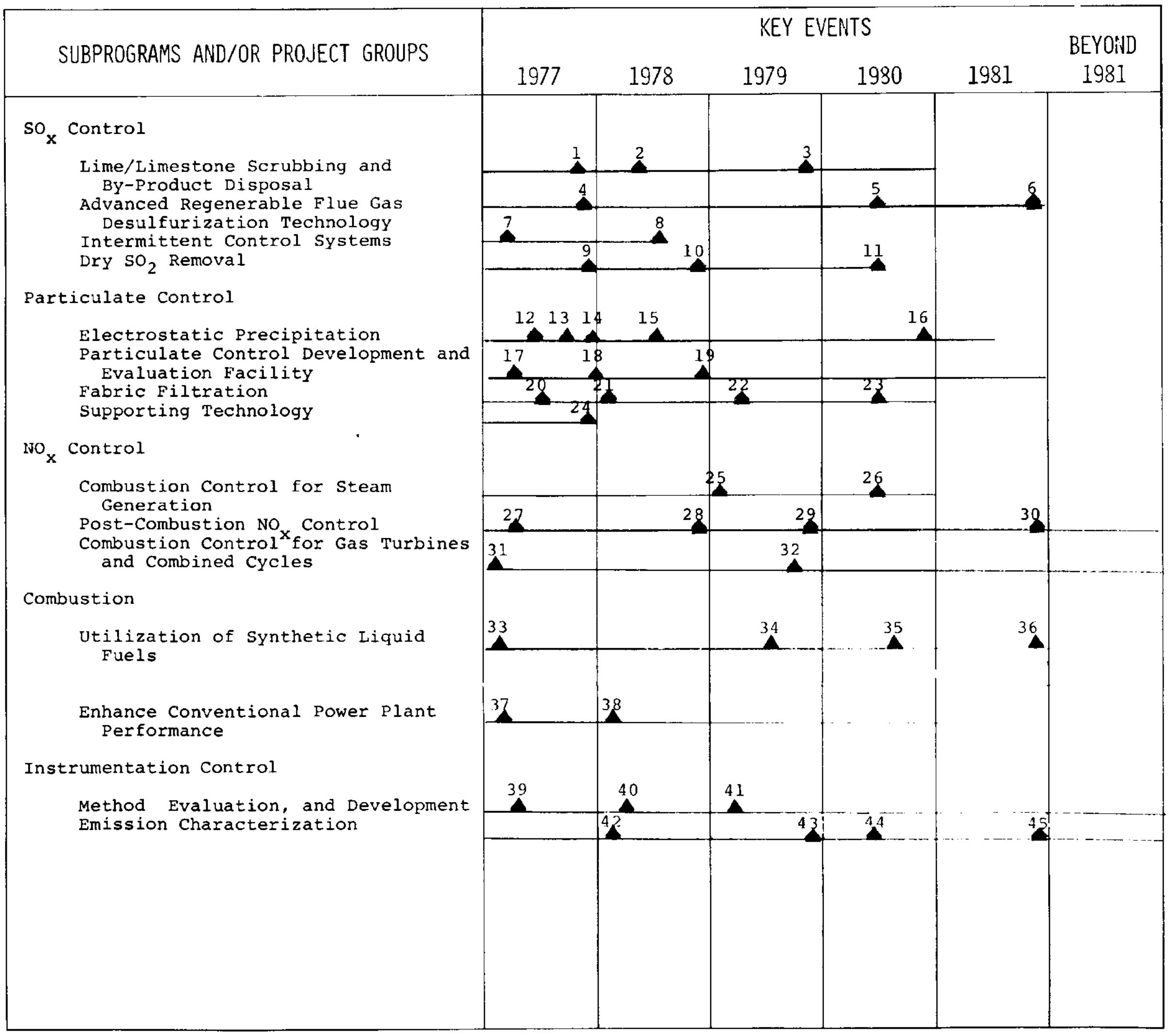
C. Complete, as necessary pollutant measurement support by the end of 1978, to determine the real contribution of the utility industry to potential regulatory issues including sulfates, nitrates, POM, and hazardous trace elments.

D. Support, on a continuing basis, determination of the emission factors associated with the various emission control and fuel conversion options developed for utility application. This effort would include: 1) selection of optimal measurement techniques and 2) advisory services to insure that the procedures and results achieved permit correlation among options.

E. Develop, by 1979, a nondestructive, real-time assay instrument capable of determining the heating value of coal as well as its sulfur, ash and moisture content. A major application of such a device is to more accurately correlate emission performance with fuel quality and thus minimize the external cost of high quality fuel contracts and fuel blending systems. The device will be designed for continuously monitoring pulverized coal prior to combustion as well as during mining and preparation.

PROGRAM NO. 15 AIR QUALITY CONTROL DATE October 8, 1976

SUBPROGRAMS	FUNDING ($000) 1977	1978	1979	1980	1981	TOTAL 1977-81
SO_x Control	4,400	4,400	4,500	6,000	8,000	27,300
Particulate Control	3,300	2,800	3,000	3,000	3,500	15,600
NO_x Control	1,700	2,600	3,700	4,200	6,000	18,200
Combustion	600	700	700	700	800	3,500
Instrumentation Control	1,400	1,600	1,800	2,000	2,000	8,800
TOTAL	11,400	12,100	13,700	15,900	20,300	73,400



PROGRAM NO. 15 AIR QUALITY CONTROL

KEY EVENT No. — KEY EVENT DESCRIPTION

SO_x Control

1. Complete initial state-of-the-art design and operating guidelines for lime/limestone scrubbing.
2. Establish prototype scrubber development and evaluation centers at utility sites.
3. Complete hardware and chemistry modifications to improve reliability and reduce cost of existing scrubber designs.
4. Complete competitive design of advanced processes.
5. Complete prototype construction and testing of advanced processes.
6. Complete construction of commercial demonstration of advanced processes.
7. Complete intermittent control design and operating guidelines.
8. Complete demonstration scale engineering evaluation of intermittent control systems in multi-source regions.
9. Complete assessment of commercial feasibility for various alkaline reagents. This will include optimization of removal efficiency and utilization rate as well as by-product disposal.
10. Complete pilot-scale development of improved controls for use with lime or limestone.
11. Complete commercial demonstration of dry SO_2 removal with reagent regeneration.

Particulate Control

12. Complete experimental investigation of flue gas conditioning of enhanced fly ash precipitation.
13. Complete plate rapping and reliability model.
14. Complete laboratory-scale development of fine particulate agglomerator and new fluid dynamic collector.
15. Retrofit application of high-intensity ionizer on commercial coal-fired utility plant.
16. Complete utility commercial-scale demonstration of advanced ESP technology for fine particulate control on high-resistivity fly ash.
17. Complete construction of 5000-50,000 CFM test facility at Arapahoe Station of Public Service of Colorado.
18. Complete pilot scale (35,000 CFM) development of high-intensity ionizer and first generation hot-gas clean-up technology.
19. Complete pilot-scale development of fine particulate agglomerator and new fluid dynamic collector.
20. Complete economic evaluation of fabric filter vs. ESP for high-efficiency particulate control.
21. Complete demonstration testing of commercial (120 MW) fabric filter installation on pulverized, low-sulfur western coal boiler.
22. Complete pilot-scale investigation to ascertain optimized air/cloth ratios, fabric materials, filter cake dynamics, and cleaning mechanisms for low-sulfur western coal fly ash (pulverized coal).
23. Complete commercial scale demonstration of optimized fabric filtration systems.
24. Complete development and verification of a mini-combustor for field testing coal quality in support of electrostatic precipitator site-specific design.

NO_x Control

25. Complete 50 million Btu/hr development and evaluation of advanced low-NO_x emission burner/boiler concepts.
26. Complete prototype evaluation of advanced burner/boiler concepts on coal-fired utility steam generator.
27. Complete technical/economic evaluation of NO_x post-combustion alternatives.
28. Complete pilot-scale engineering testing of homogeneous gas phase NO_x decomposition process on coal-fired combustors.
29. Complete pilot-scale engineering testing of catalytic and scrubbing NO_x control processes on coal-fired combustors.
30. Complete commercial-scale demonstration of integrated combustion/post-combustion NO_x control system on coal-fired system generators.
31. Complete one-tenth flow-scale evaluation of premixed combustors for conventional fuels.
32. Complete development of commercial premixed combustors for conventional fuels and initially apply to synthetic fuels/combined cycle combustion.

KEY EVENT No.	KEY EVENT DESCRIPTION
	Combustion
33.	Complete 25 MW utility combustion evaluation of solvent-refined coal (SRC).
34.	Complete SRC/gas turbine compatibility testing, including handling, firing, and emission characterization.
35.	Complete H-Coal handling and combustion compatibility testing on commercial-scale utility power generation hardware.
36.	Complete Exxon process and CDF distillates compatibility testing on commercial-scale utility power generation hardware.
37.	Feasibility of coupling gas turbine to existing boiler (reprocessing) evaluated.
38.	Complete environmental/economic systems analysis of pulverized coal boilers. This will provide basis for accurate performance and cost comparison between conventional and advanced coal combustion/conversion systems.
	Instrumentation and Measurement
39.	Complete development and commercialize in-stack fine particulate sampling methods and issue fine particulate utility source sampling guidelines.
40.	Issue emission characterization guidelines describing and comparing alternative analytical procedures for determining the composition of particulate and gaseous emissions.
41.	Complete development of, and commercialize, nondestructive techniques for the continuous real-time monitoring of coal and ash composition.
42.	Field evaluation of the efficiency of alternative particulate collection hardware (ESP, fabric filter)/PC boiler system as a function of particle size and elemental composition.
43.	Field evaluation of the efficiency of alternative scrubber/boiler/coal systems as a function of particle size and elemental composition.
44.	Complete emission measurement program design and analysis support for the Powerton project.
45.	Continue measurement support for determining the utility impact on health and welfare issues. This will consider both existing and developmental coal combustion/conversion technology.

C. Water Quality Control And Heat Rejection

Program Description

The Water Quality Control and Heat Rejection Program provides technical and engineering support to the utility industry in the areas of (1) power plant cooling and thermal discharges; (2) in-plant water use and water-borne effluent control; and (3) solid waste by-product handling and disposal. The broad program objectives are: (1) to reduce the water use and consumption requirements for electric power generation; (2) to insure the industry's ability to comply with present and future environmental regulations governing thermal, liquid, and solid discharges at acceptable cost; and (3) to make available cost-effective technologies and equipment for plant cooling, water treatment, and solids disposal systems.

Activities are closely coordinated with related research at EPRI and elsewhere. At EPRI, close liaison is maintained with the Air Quality Program to insure that an integrated approach is taken to power plant emissions problems. Also, joint project planning and review is carried on with the Environmental Assessment Department to maintain the link between the physical and ecological effects of plant emissions and to insure that the proper environmental criteria are applied to the design of emissions control technologies.

Plans are developed to supplement and complement related activities in the Federal agencies. Cooperative efforts have enabled EPRI to carry out costly environmental field studies and large hardware demonstrations of great benefit to the industry which would have been beyond the scope of this Program alone. Examples include the Chalk Point Cooling Tower Project (with ERDA, EPA, and the State of Maryland), and the demonstration of an advanced dry cooling tower (with ERDA's Dry Cooling Tower Project).

On-site demonstration of specific technologies is carried out jointly with individual utilities whenever possible as in the case of the wet/dry tower demonstration at Southern California Edison and the testing of ozonation as an alternative to chlorination for biofouling control at Public Service Electric and Gas of New Jersey.

Motivations for the activities derive from (1) a projected lack of water available for power plant use in many areas of the country; (2) increasingly stringent environmental regulations; and (3) high capital and operating costs of cooling and pollution control equipment. The Program's scope includes the many plant subsystems and operations relating to cooling, water treatment, and solids disposal. The technology bases supporting the research are, therefore, numerous and diverse, ranging from dry cooling to ash sluicing, from the turbulent mechanisms of plume dispersion to the kinetics of chemical reactions, and from the structural design of cooling towers to the control of biofouling in condensers.

Importance of the Program

Water usage in fossil fuel power plants, in the power loop as well as for cooling, cleaning, and solids transport, is a major part of plant operation and maintenance. A few statistics will serve to illustrate the importance of water-related problems to utility costs and operations.

Water Consumption. The total electric industry water requirement is currently 10% of the Nation's fresh water run-off. While much of this water is simply curculated and returned to the source, evaporative consumption in cooling alone for a 1000 MWe plant exceeds 10,000 gpm. This requirement for water is the major siting constraint on utilities and may limit total power growth in arid regions.

Capital Costs. Water use subsystems account for up to 10% of total plant cost.

Operating Costs. Cooling systems strongly influence plant heat rates. Closed-cycle cooling reduces generation efficiency by 3-15% compared to once through cooling.

Environmental Constraints. Demonstration of compliance with Effluent Guidelines and Standards of the Federal Water Pollution Control Act of 1972 is a major source of delay in plant approval and construction.

Solids Disposal. Solid waste by-products of plant operations, primarily fly ash and scrubber sludges, amount to 20-30% by mass of the coal input.

The major benefits from this work will accrue in the following areas: (1) reduction in water requirements, (2) reduction in siting approval delays, and (3) reduction in cost of compliance with chemical and thermal discharge regulations. Recent projections of water demand for all sectors of society indicate that shortages are expected in large regions in the country including the Texas Gulf, Rio Grande, Upper and Lower Colorado, Great Basin, and California by 2000 AD. Within these regions over 450,000 MW of new installed capacity are also projected by then. The development of cost-effective technologies for dry or wet/dry cooling, for the substitution of dry for wet processes in the solids transports or stack gas clean up areas, and for cascaded or recycled water uses can remove a major constraint on power growth and plant siting in those regions.

The capital costs to the industry for retrofit of existing plants to closed cycle cooling, plus retrofit of plants for which once through cooling had been planned, have been estimated at $12 billion by 1985. Total capital requirements for new cooling systems for the year 2000 may approach $50 billion. Similar estimates of the capital cost of compliance with the proposed chemical limitations, range from \$7.5 billion by 1977 to over \$30 billion by 1990. Cumulative operating costs attributable to reduced plant efficiency and auxiliary power requirements are comparable. In this context, potential savings are large. For example, enhancement of cooling system performance by only 5% through either advanced designs or improved standards and acceptance procedures can result in over \$350,000 per year in fuel savings at a single 1,000 MW plant.

Research results are expected in the near to midrange. Improved processes and predictive modeling tools can be applied to plant design or retrofit, or used in regulatory hearings immediately. Significant water savings through the use of dry cooling is to be demonstrated in the early 1980s.

Subprogram Structure

The Program is organized into three subprogram areas: (1) Reject Heat Management; (2) Chemical Water Quality; and (3) Solid By-Product Waste Disposal.

1. Reject Heat Management

Thermal power generation cycles have a fundamental thermodynamic requirement to reject heat to their surroundings. This subprogram is concerned with the hardware needed to accomplish this cooling and with the environmental effects of the discharges. The major subprogram objectives are (1) to reduce the water requirements for plant cooling; (2) to improve the industry's ability to predict and mitigate the environmental effects of cooling; and (3) to improve the performance of cooling equipment at acceptable cost.

The conventional approach to plant cooling has been the rejection of heat to water either in the form of a temperature rise (once-through cooling) or in the form of evaporation (wet cooling towers). These systems are low in capital cost and provide high plant efficiency, but use or consume large amounts of water.

Federal prohibitions on once-through cooling and projected lack of water for evaporative cooling could force the use of dry or wet/dry systems. These systems, with their inherently poorer heat transfer characteristics and higher heat rejection temperatures, are not available today at acceptable cost. An objective of this subprogram is to develop and demonstrate a dry cooling system incorporating advanced heat transfer augmentation techniques and low-cost air-cooled surface configurations that will maintain the low condensing pressures (less than 5" Hg_a) required for conventional turbines at a total evaluated cost within a factor of two of conventional wet cooling.

The inability to predict the environmental effects of plant cooling systems adversely affects the industry in two ways. First, environmental impact hearings leading to plant site and design approvals are drawn out when postulated impacts cannot be refuted definitively. Second, more costly and less efficient cooling systems are imposed in the absence of a clear proof that they are necessary. The major technical impediment to improving the industry's ability to predict the effects of atmospheric plume discharges from cooling towers and thermal/hydraulic discharges from once-through cooling is the lack of field data for model verification. The environmental impact element of the subprogram is built around the acquisition of field data leading to model validation and the publication of recommended modeling procedures for discharge plumes and of design guidelines for intake/discharge structures.

The bulk of the industry's heat rejection at new plants for the next several decades will be achieved through the use of closed-cycle evaporative cooling. It is, therefore, an appropriate objective of this subprogram to develop more cost-effective wet cooling systems through the solution of generic problems. For example, spray systems designed on the basis of single module performance tests have shown promise of low capital and operating cost, minimum environmental impact, and desirable operating flexibility. Full-scale systems have fallen far short of expected performance. An objective of this subprogram element is to determine whether spray systems can achieve their hoped-for cost and performance targets, and if so, to develop and publish field-validated spray system design guidelines.

2. Chemical Water Quality

This subprogram deals with water in and about fossil fuel power plants. The broader concerns are with the quantities of water and chemical constituents entering and leaving plant sites as liquids, solids, or gases. The in-depth concerns are with in-plant use; quantity and quality requirements; quality alteration during use; in-plant treatment facilities necessary to meet internal use and reuse needs as well as discharge limitations; and the associated cost and performance of the alternatives. The plant water use systems of interest are the boiler system, cooling systems, flue-gas cleanup and residuals transport, area run-off, and low-volume wastes.

New constraints on discharges (gas, liquid, and solids) and the diminishing availability of high quality water supplies places a premium on dry vs. wet power plant subsystems, water conservation, reuse, recycle, and water treatment.

The subprogram effort ranges from the planning of integrated water systems for power plants in light of constraints, needs, and costs to the development of a sensing-readout system for monitoring and controlling biofouling in primary condensers.

Specific subprograms objectives include:

1. Publication of comprehensive water management system design guidelines by 1980. The development of an integrated approach to water system design will evolve from specific case studies and will serve not only utilities and A & E's, but also the EPRI staff in the identification of critical questions for further research.

2. The development of improved water treatment options for control of toxic metals, scaling constituents, and dissolved salts which limit further reuse. Demonstration of selected technologies is planned for 1978-79.

3. The demonstration of improved biofouling control methods, including the detection and control instrumentation, minimization of chemical dosage requirements, and the assessment of environmentally preferred alternatives to chlorination is planned for 1979-80.

3. <u>Solid By-Product Waste Disposal</u>

Coal-fired power plants generate enormous quantities of solid by-products, as residuals of the combustion of coal and the stack gas cleanup operations, which must be transported, stored, and eventually disposed of in an environmentally acceptable manner at reasonable cost. Four aspects of the problem define the relevant technologies and the significance to industry; (1) the quantities of material involved, (2) the potential for water pollution from the disposed solids, (3) the potential for rendering land unsuitable for many uses, and (4) the effect of solids disposal on the plant's water consumption.

Quantities. The primary sources of solid residuals are combustion ash (fly and bottom ash) and flue gas desulfurization scrubber sludges. For a 1000 Mwe plant burning 3% sulfur, 12% ash coal and equipped with lime-limestone scrubbers, the combined volume generation rate of fly ash, botton ash, and scrubber sludge exceeds 25 acres per year at a storage depth of 20 feet, amounting to approximately 25% of the mass of the input coal.

Potential for Pollution. While most of the residual mass consists of inert, silicate and oxide materials, the simple physical handling problems and the control of drainage and dust from large storage areas are formidable. Additionally, many of the water soluble salts, trace element, and potential toxins which enter the plant is the coal, water, or air are segregated in the ash or the sludge. From there, they may be redissolved and reenter the environment in the groundwater through ash pond drainage, storage pile runoff, or other pathways which are difficult to predict or control.

Land Use. Except in cases of mine-mouth power plant siting, return of residual solids to the point of extraction is rarely feasible because of transportation and handling costs, and specific solids disposal sites are required. In the case of lime-limestone desulfurization sludge, the site may become permanently unsuitable for habitation because of the structural instability and water-retentive characteristics of the solids.

Effect On Plant Water Consumption

The principle of nondegradation of waterways may constrain power plants to discharge water at qualities equal to or better than the receiving waters. Since water clean enough to discharge would then be as clean as the plant supply and since a power plant is a net consumer of water, it follows that no water would leave the plant except as water vapor or as moisture in the disposed solids. Therefore, reclamation of water from wet solids is the major element in a water conservation program, and the technology and cost of such reclamation and cleanup is an important area for research.

The subprogram plan focuses on the following facets of the solid waste disposal problem, specifically related to combustion ash and scrubber sludge.

a. Identification of trace contaminants in solids.

   (i) Control possibilities through plant process modification
   (ii) Opportunities for pretreatment cleanup or segregation

b. Fate of contaminants studies.

   (i) Pathways for residuals to environment
   (ii) Effects of climate, geology, hydrology, etc.

c. Methods for fixation of contaminants.

   (i) Technology assessment
   (ii) Advanced process development

d. Water recovery from solid residuals.

e. Evaluation/development of dry vs. wet processes.

f. Solid residual storage.

   (i) Site selection
   (ii) Site preparation

g. Solids handling and transport equipment.

PROGRAM NO. 16 WATER QUALITY CONTROL AND HEAT REJECTION DATE October 8, 1976

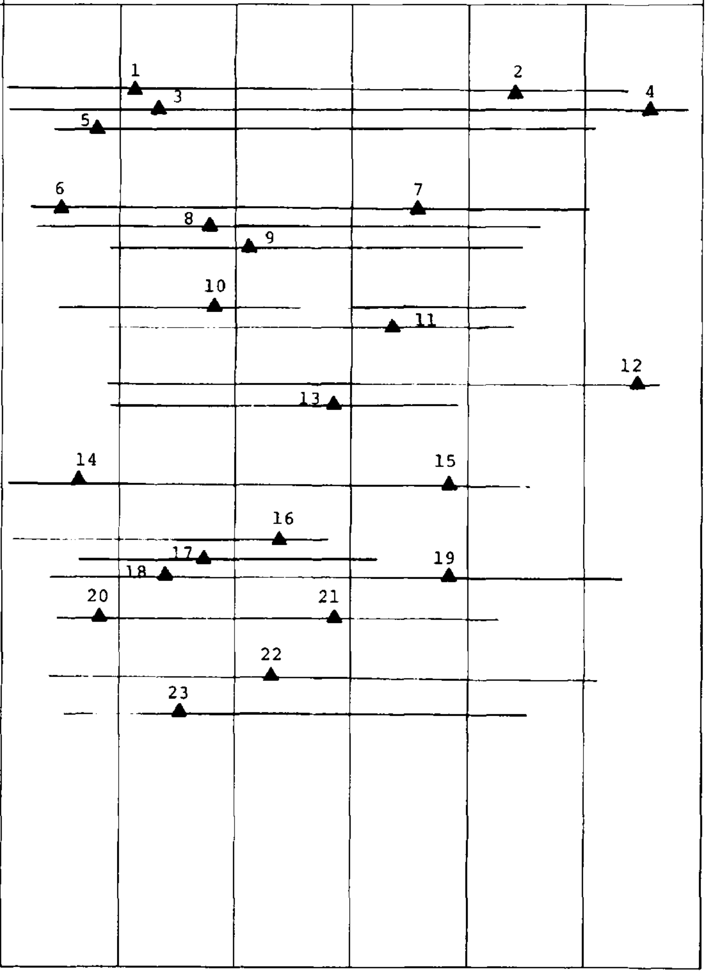
SUBPROGRAMS	FUNDING ($000) 1977	1978	1979	1980	1981	TOTAL 1977-81
Reject Heat Management	1,800	2,100	2,800	3,000	3,200	13,200
Chemical Water Quality	800	400	1,000	1,000	1,000	4,900
Solid By-Product Waste Disposal	300	300	300	300	400	1,600
Total	2,900	3,300	4,100	4,300	4,600	19,200

SUBPROGRAMS AND/OR PROJECT GROUPS — KEY EVENTS: 1977, 1978, 1979, 1980, 1981, BEYOND 1981

Reject Heat Management
- Water Conserving Cooling Systems
  - Dry Cooling Tower
  - Wet-Trimmed Dry Cooling
  - Waste Water for Wet Tower Make-Up
- Environmental Impact
  - Atmospheric Tower Plumes
  - Once-Through Hydraulic Plume
  - Intake-Discharge Structures
- Current Technology
  - Cooling Towers
  - Sprays
- Advanced Systems
  - Reject Heat Recovery
  - Cooling of Advanced Energy Sources

Chemical Water Quality
- Integrated Water Management
- Water Treatment Process Development
  - Trace Element Control
  - Dissolved Salts Removal
  - Scale Removal/Inhibition
- Biofouling Control

Solid By-Product Waste Disposal
- Ash Disposal
- Scrubber Sludge Disposal



KEY EVENT No.	KEY EVENT DESCRIPTION
	Reject Heat Management
1	Selection of dry tower design for demonstration.
2	10-20 MW dry tower demonstration.
3	Complete field test of 200 x 10^6 Btu/hr wet/dry tower module.
4	Publish performance data on full-scale wet/dry tower.
5	Pilot test of wet tower using irrigation runoff for makeup.
6	Publish field data on drift and vapor plumes from natural draft wet tower.
7	Publish recommended models for atmospheric plume prediction.
8	Publish field-verified models for hydraulic plume prediction.
9	Establish ecologically-based design criteria for intake/discharge structure.
10	Verify hydraulic modeling methods for mechanical-draft tower siting.
11	Publish field-verified spray system design procedure.
12	Complete engineering assessments of waste heat recovery schemes (with EA&E).
13	Publish cooling system selection guidelines for advanced power systems. (solar, geothermal).
	Chemical Water Quality
14	Scope integrated water management program.
15	Complete integrated water system design manuals.
16	Demonstrate selected trace element control process.
17	Complete detailed capability/cost process guidelines for TDS reduction.
18	Demonstrate scaling removal process.
19	Demonstrate cooling and liquid transport system scale control/inhibition alternatives.
20	Identify biofouling detector alternatives and practices.
21	Complete utility guidelines for optimal biofouling control.
	Solid By-Product Waste Disposal
22	Publish disposal site selection/preparation guidelines.
23	Complete technology assessment of alternate dry processes.

D. Fossil Plant Performance And Reliability

Program Description

The decision to establish a program in Fossil Plant Performance and Reliability highlights the fact that for the next two decades, at least, the majority of the generating load will be carried by fossil fired power plants of conventional design, and the performance and reliability of these plants will be fundamental to overall industry performance. Performance, in the context of this program, refers to the ability to meet load demand safely, quickly, and efficiently at any time; to this end operating flexibility and maintainability, as well as thermodynamics, need to be considered.

Data collected by EPRI indicates that fossil fired power plants over 600 MW in size are currently returning availabilities between 50% and 90%, with an average below 70%, discounting shake down periods; forced outage rates range between 5% and 35% and average 15%. Average availability of smaller plants is about 80%. The factors behind these statistics are not merely size related; plant maturity, steam conditions, operating conditions, control techniques, design features and other considerations contribute to lower performance but their contribution can not be quantified.

One important factor in reduced performance is that plants which were originally specified and selected for base load operation on good quality fuel are now required to burn cheaper fuel or fuels selected for environmental reasons, and to operate under load following conditions. Existing plants, plants under construction, and plants to be specified in the near future must be able to perform reliably and economically under increasingly severe load cycling conditions and with a range of fuels which may be dictated by future supply and environmental restrictions.

The overall objectives of the program are to:

- Investigate the factors affecting reliability and performance of power plants, as a whole, and on the basis of the various plant components.

- Initiate projects which will improve plant reliability by providing a better working environment for critical components; better inspection and quality control; improving operating conditions and control techniques; and developing better materials and designs.

- Develop standards of performance which can be used as a basis for plant and component specifications.
- Provide for testing critical plant components.

The interface between this program and the utilities is extremely important, since the program focuses on current practice and experience. The subprograms are therefore based on equipment subassemblies, which is in line with the subdivision of expertise within the industry. Any resulting overlap of scientific disciplines can be dealt with by internal controls and communications, including coordination with the Nuclear Power Division.

At the present time federal activity in this area is mainly concerned with the compilation of data affecting the safety and reliability of nuclear plants. However, FEA and the state regulatory commissions regard availabilities of existing and new plants as important elements in the planning and authorization of new capacity and are probing utility performance from this point of view. ERDA has staff dealing specifically with utility applications, and EPRI is in contact with their staff. ERDA regards EPRI as the logical center for any program which is concerned with utility plant performance, and is looking to EPRI in formulating its own programs. A strong EPRI program is thus important not only in its own right, but in ensuring the most appropriate and best use of federal resources.

Importance of the Program

It cannot be overstressed that the contribution of overall power production of conventional power plants, during the near term and intermediate term, outweighs, by an order of magnitude, those from the new technologies. This fact was recognized in the Electric Research Council Report date June, 1971, when by far the greatest part of the industry's research budget was allocated to improvements in present methods of power generation.

A survey by Power Engineering (April 1976) indicated that 238 new fossil plants of over 128 GW total capacity have been committed for operation by 1990. The total commitments (fossil plus nuclear) over this period are little more than half of what will be required to achieve the growth rate projected in Dr. Starr's introductory remarks, and it is likely that a total of some 250 GW of new fossil plant capacity will eventually enter service before 1990. A substantial part of this will be in the form of large units over 600 MW. There are over 80 such units presently in service having an average availability below 70%. A 5% improvement in availability on operations of this scale is equivalent to a saving of over $12 billion in capital investment at present worth. Even greater improvements are not unrealistic. By concentrating on improved operation, more flexibility and basic design principles, the cost of achieving better availability can be minimized. Also, improved designs need not cost more to produce. The R & D investment is relatively small while the chances of success, based on experience with older plants, are good with potentially substantial benefit to the industry.

As progress is made in problem solving emphasis will shift to the definition of design criteria, leading to recommended guidelines for plant specifications, which will be backed by in-service testing of critical components and structures, including improved materials. These will impact mainly on new plants to be operating in the 1980's.

Subprogram Structure

The program is structured around major plant systems - the turbine/generator system, the steam supply system and ancillary systems. Emphasis during the next year is on providing better insight into the root causes of failures and substandard performance. There is no single data source from which this information is available, although records compiled over the years by EEI provide valuable statistical background. These records are being examined using agreed EPRI/EEI interfaces and by participating in EEI Prime Mover Committee meetings.

More up-to-date and detailed information has been obtained from six informal meetings held with utilities in different parts of the country to discuss their most pressing concerns affecting plant reliability. These are being followed by surveys of utility experience in specific plant components, subsystems, or failure mechanisms, to provide a much more detailed data base by the end of 1977. Projects will then be established to address important, generic operating and reliability problems, to reduce planned outage, and to improve the design standards for new plants.

1. Turbine/Generator System

An increasingly important feature of fossil plant operation during the next two decades will be increased load following and cycling, which will require better predictive capability in regard to dynamic behavior, and a better understanding of the impact of thermal stress on mechanical integrity. Better dynamic plant models will be needed for specification, design, evaluation, and control. These will be developed by manufacturers with EPRI direction to ensure that they meet utility needs, and will form the basis of the more advanced control and operating guides after 1980.

The turbine/generator system, in general, is more sensitive to cycling damage than the steam supply system. The most common cause of outages are low pressure blade failure and high pressure blade errosion, the latter being related to the exfoliation problem of the steam supply system. Low pressure blade failure is usually caused by fatigue, and an appreciable amount of fatigue damage may occur at speeds below synchronous operation. Corrosion mechanisms aggravate fatigue failure. Controlling the turbine atmosphere, and behavior of blade materials under combined corrosion and steady, plus cyclic, stress conditions, will be studied. At the same time tests are to be run under cycling conditions to obtain data for the validation of thermal stress models. These studies should provide important information in the development of operating guidelines and control systems that will appreciably reduce risk of plant damage while ensuring high performance capability. The first operating guideline will be available by 1979 but there will be continued development through 1981.

In-service monitoring and improved inspection techniques will be developed to reduce the risk of major damage due to unforeseen failures. Improved materials, both for rotors and blades, will be of major importance in both larger and cycling machines. EPRI's role will be to catalyse materials development and to appraise new materials by realistic test programs. New materials will become available about 1979 but full acceptance criteria will in general require testing for perhaps an additional two years. An exception is titanium alloy for low pressure blading, which is already undergoing testing, and subject to satisfactory review, could quickly become become available if economically justified.

Turbine bearing failures are most common at low speeds and special lubrication requirements at start-up and run-down will be addressed early in the subprogram, with the object of providing both future and retrofit options by 1979.

The use of a range of materials with widely different properties, and very large mechanical and electromagnetic forces, in generators, pose severe mechanical problems. On line monitoring systems will be investigated, and specific material problems addressed. There exists presently the prospect of improved end ring materials; better conductor materials and joints will be studied.

Specifically this subprogram will seek to achieve the following objectives during the five year R & D period.

- Complete on-line condition monitoring and safeguards for turbine/generation system by 1980.
- Improved materials specifications and definition of materials properties for design evaluation by 1980.
- Guidelines for cycling operation and control to minimize the risk of mechanical damage while insuring economic and flexible operation by 1981.

2. Steam Supply System

In the steam supply subprogram there are three major problem areas - fireside fouling and corrosion, steamside oxide exfoliation, and pressure tube failures. The first two contribute to the third, but do not account for it entirely. Ongoing projects in these areas have already shown that oxide exfoliation is strongly related to heating and cooling cycles. Water treatment and chemical control are also important. There is a background of excellent work related to nuclear plants on which the fossil plant program can draw, but fossil plants have their own particular problems which the subprogram will address as necessary.

Improved materials, and proper selection of materials are clearly important items in reliability, and there is ongoing work in the resistance of boiler tube steels to both steam and coal ash environments. There are also prospects of being able to detect and locate tube leaks at an early stage using acoustic techniques which are presently being studied. Improved inspection techniques and quality assurance will be developed to reduce forced outages.

An existing project on boiler fouling is aimed at a better understanding of the contributions of specific coal minerals; this is relevant to work in other programs on coal cleaning and blending. Other aspects of fouling to be addressed will include operating conditions and combustion.

The need for new units with cycling capability is leading to boilers with greater operating flexibility and ability to control steam conditions over a wide load range. The impact of developments, such as variable pressure and bypass control of steam temperature, will be evaluated in terms of overall unit performance.

By 1980 it should be possible to provide the industry with guidelines for operation which will alleviate both steam side and gas side problems, and which will incorporate experience gained in studies of plant performance under cycling conditions. The specific objectives being focused upon are as follows:

- Provision of techniques for on-line leak detection by 1979.

- Guidelines for control of major steam side corrosion problems by 1980.
- Development of operating guidelines and specifications to permit use of a wide range of fuels by 1981.
- Improved specifications and quality assurance for pressurized components by 1981.

3. Ancillary Systems

The ancillary systems subprogram will include fans, pumps, valves, feed heaters, pulverizers, fuel handling equipment, condensers etc. This is a very diverse area, with attention presently focussed on feed pumps and condensers. Feed pump failure studies have already exposed generic weaknesses in certain designs, which have been corrected by the vendors, or independently in several cases. Performance surveys will be initiated on other specific items in the first year of the subprogram. At the same time overall plant reliability studies will help in the development of component design criteria against which current designs will be assessed, and specification standards developed. EPRI will encourage product development by assisting with utility tests and will ensure objective reporting of results. The subprogram will be aimed at the following specific objectives.

- Testing capability for critical components.
- Ancillary system guidelines for improved operation and maintenance by 1979.
- Provision for specification standards to ensure high quality and direct comparability between different suppliers by 1980.

E. Fluidized Combustion And Coal Cleaning

Program Description

Program Objectives: The basic objective of the Fluidized Combustion and Coal Cleaning Program is to develop technologies that will permit the electric utilities to use coal directly at lower capital and operating costs than techniques presently available. The four subprograms that make up this program include, Fluidized Bed Combustion, Solid Waste Utilization, Coal Cleaning and Direct Use of Fossil Fuels. The projects undertaken in the subprograms are intended to:

- Develop direct combustion of coal in a fluidized-bed boiler and investigate combustion of fossil fuel by other methods not currently practiced by the utility industry.
- Develop improved physical and chemical methods for removing ash and sulfur from coal prior to firing in pulverized coal fired boilers.
- Insure that there are no technical impediments to the utilization of the energy resource available in municipal and other solid wastes.

The technical feasibility of fluidized-bed boilers and advanced coal cleaning techniques will be demonstrated, and the economic advantages firmly established, before 1985. The major technical unknowns that inhibit supplementary firing of solid waste with coal will be resolved before 1980.

Coordination of Program Activities with Others: Effective use of the research funds are enhanced by close coordination with other EPRI programs, government agencies, and industrial organizations, both in the U.S. and abroad. At EPRI close liaison is maintained with the Energy Systems, Environment and Conservation Division Fuel Supply Program to insure that the impact of coal cleaning technology advances are considered in establishing the resource base. The Clean Liquid and Solid Fuels Program of the FF & AS Division support coordinated research in magnetic separation of liberated mineral matter from coal derived liquids.

With federal agencies several coordinating tools are used. For example, projects are coordinated so that a) EPRI funds research on limestone requirements for fluidized bed boilers while ERDA funds major projects on uses for spent limestone, b) EPRI supports research on atmospheric pressure combustors while ERDA conducts major research on pressurized combustors, c) Metal specimens exposed in an EPRI test furnace are evaluated by an ERDA contractor. Co-funding is another coordination tool. It is used for major projects, and for small projects, where technology transfer is enhanced by co-management. An example of co-management of a small project for enhanced technology transfer is the solid waste/ boiler corrosion study to be carried out with Wisconsin Electric Power. Cooperative efforts with federal agencies also enables EPRI and utility co-sponsors to carry out large demonstration projects. EPA and EPRI will jointly sponsor work to evaluate an innovative physical 10,000 TPD coal preparation plant, being built by General Public Utilities and New York State Electric and Gas at Homer City, PA. Plans are being formulated for building a jointly sponsored EPRI/ERDA fluidized-bed boiler demonstration plant at a utility site yet to be selected.

Technology Overview: Technologies being investigated in this program range from the use of drill core data for coal preparation plant optimization to the complex requirements of boiler design. The research bases required for successful development of equipment and techniques useful to the utility industry are, therefore, numerous and diverse. The technology of each subprogram is described below.

Importance of the Program

1. Economic Benefit Overview

Coal cleaning may eliminate (or reduce the cost of) scrubbers needed for most new coal-fired power plants. Fluidized-bed boilers are capable of burning high ash and high sulfur fuels; the range of fuels capable of being used extends to the rejects of a coal cleaning plant. Table 1 presents an economic assessment of fluidized combustion and coal cleaning technologies.

Table 1

Fluidized-Combustion and Coal Cleaning Technologies Costs

	Capital Cost $/KW	Heat Rate Btu/kWh	Busbar Power Cost Mills/kWh
Fluidized Bed Boiler (1)			
. Conventional plant with stack gas scrubber	771	10,090	37.0
. AFBC-once-through lime-stone	632	9,530	31.7
	Capital Cost $/kW	**Operating Costs Mills/kWh**	
Coal Cleaning (2)			
. Scrubber and sludge disposal	64-119	4-6	
. Coal Cleaning (3) plus (reduced) scrubber and sludge disposal	55-86	3-5	

(1) 1975 Dollars, ECAS study Contract No. NAS3-19406, April 8, 1976. $1.00/10^6 Btu coal, $5.00/ton limestone

(2) Report on Sulfur Oxide Control Technology, CTAB, U.S. Dept. of Commerce, September 1975.

(3) Includes $16-23/kW for high level cleaning plant that may be borne by coal producer

2. Other Important Factors

Peaking Power: A fluidized-bed air heater concept will be evaluated by first quarter 1977. This system could be used to repower existing combustion gas turbines, substituting coal for some premium fuels. Compressed air storage can also be integrated with this new combustor concept to provide large peaking plants.

Oil-Fired Boilers: Coal/oil slurries, being studied by EPRI, will potentially allow using coal in power stations where coal storage and preparation equipment can no longer be used. It is also possible that the Federal Energy Agency would consider the use of a coal/oil slurry as complying with their reconversion orders.

Capital Availability: Coal cleaning plants may be constructed by coal companies or, in the case of chemical coal cleaning, by new economic entities, thus not requiring utility capital.

Fuel Costs: A fluidized-bed boiler can burn fuels too high in ash to be fired in a pulverized-coal boiler. This was demonstrated recently when a 4,000 Btu/lb anthracite culm was burned in a test unit. Also, six percent sulfur petroleum coke was burned with SO_2 emissions well below EPA standards; no supplemental fuel was required.

Extent of Market for Technology: Fluidized boilers are a direct replacement for pulverized coal boilers with a scrubber. During the period 1985 to 2000 approximately two hundred 1000 MW coal fired power plants will be needed. If both technically and economically feasible, fluidized bed units could supply part of that need. If all 200,000 MW were installed as FBC units the utility industry could potentially save $20 billion dollars through the year 2000.

In 1975 coal cleaning was used for only 40 percent of U.S. steam coal, most of it for gross removal of mineral matter. The coal cleaning subprogram has as its goal development of processes that will reduce sulfur and ash to levels that will meet EPA's new source performance standards. If this is achieved, at a cost below $100/kW and with combustible loss not greater than 20 percent, most U.S. coal, for steam raising in new boilers, would be so processed. Based on the modest differences shown in Table 1, for state-of-the-art coal cleaning, capital cost saving to the utilities due to reduced scrubbing needs for 200,000 MW, would be $2 billion.

The decision to burn solid waste in utility boilers has been made, for the most part, for non-economic reasons. Municipal solid waste and other available wastes could constitute from 2 to 6 percent of the electric utility industry's energy needs. However, the economic utilization of solid waste depends on favorable local conditions. The "market" for this technology cannot be estimated at this time.

Technology Commercialization: Solid waste utilization is feasible now. EPRI's efforts are devoted to answering certain unknowns that inhibit the use of this resource by utilities. Fluidized-bed combustion will be demonstrated in 1982. While physical coal cleaning technology is now commercial, advances are anticipated by 1979. If current research efforts are successful, one-thousand ton per hour chemical coal cleaning plants could be available before 1985.

Subprogram Structure

1. Fluidized Bed Combustion

Although the main thrust of the subprogram involves demonstrating the most widely known design concept, there is a matrix of concepts and unit sizes that will be studied. The range of these options is shown in Table 2.

Table 2

Variations in FBC Technology

Furnace pressure:	Atmospheric	Supercharged
Size :	Central station	Air heater design
Bed design :	Fluidized bed	Circulating or fast bed
Sorbent :	Natural	Synthetic
Sorbent cycle :	Once through	Regeneration
Fuel :	Coal	Coal cleaning residues

The objective of the fluidized bed combustion subprogram is to develop the technology and demonstrate the process as rapidly as practical.

Most FBC research to date has been carried out in small scale equipment. Small and large fluidized beds behave so differently that extrapolation to commercial scale would be unreliable. Practical design data and correlations, therefore, must be obtained to permit scale-up to larger units. Once these uncertainties are resolved, complete FBC power generating systems will have to be demonstrated. Acceptance by the utility industry will require successful operation of demonstration plants large enough to define capital and operating and maintenance costs.

The principal technical problems to be resolved before demonstration of the process are:

1. Obtaining reliable heat transfer data for scale-up of combustors. Efforts are underway to have this information available by 1978.

2. Determining corrosion and erosion data for the proper selection of tube materials. We anticipate having this information by 1978.

3. Studies directed at determining the efficiency and quality of various sorbents are now in progress and should be complete in 1977.

4. Designs for coal feeding system and controls. This work is planned in conjunction with the demonstration plant design and development to be completed in 1982.

Fluidized bed combustion has been developed primarily with government funds in this country. A 30 MW pilot plant at Rivesville, West Virginia, is scheduled to go on-stream in 1976. EPRI's objective is to build and successfully operate a 200 MW AFBC demonstration unit by 1982. This will be achieved by co-funding with the federal government and a host utility.

Research on several major process options listed in Table 2 is scheduled during this planning period:

- The supercharged or pressurized furnace design will be evaluated by EPRI in conjunction with an air heater concept. In this instance pressure and temperatures are relatively low, therefore, hot gas cleanup is not a problem. However, for the large, central station, pressurized systems an effective hot gas cleanup system must be developed. Major support for pressurized systems, and the ancillary equipment requirements, is now being provided by ERDA.

- An alternative to once-through utilization of limestone is regeneration. An assessment of the feasibility of this approach should be complete in 1979.

- The design concept which appears to offer inherent solutions to some of the problems listed earlier is the fast or circulating bed boiler. In this concept combustion and heat transfer are decoupled and energy transferred through circulation of solids. The technical feasibility of this approach is to be established by 1980.

2. <u>Coal Preparation</u>

The major research objectives of this subprogram involves developing techniques to produce clean coal (coal that when burned would result in less than 1.2 pounds $SO_2/10^6$ Btu) for new boilers, to reduce loss of fuel value and improve dewatering and drying technology.

EPRI seeks to stimulate the development of coal cleaning technology in order to provide the utilities with coal which can be used directly for power generation within the environmental restraints. Development of advanced preparation technology will also enhance the economic potential of gasification and liquefaction of coal.

This subprogram has two major elements:

1. Physical coal cleaning, which is now a mature technology, may be improved by a) utilization of unexploited differences between coal and mineral matter which will allow more effective separation, b) development of improved process control, c) development of better dewatering and drying equipment. A cooperative program with EPA on the evaluation of an advanced coal washing plant will start in 1977 and be completed in 1980. Four different techniques for utilizing magnetic separation are to be examined in 1977. The most advanced is to be demonstrated in 1979 if projected milestones are achieved.

2. Chemical coal cleaning is a technology in the early stages of development. Effective processes and designs are now being studied. Chemical cleaning plants will involve pressure vessels and could be three to five times as costly as physical cleaning plants. The incentive for their development is the greater reduction in organic, as well as inorganic, sulfur and the decoupling of pollution control from power generation. This development effort involves bench, pilot research and finally demonstration plant. Economic and environmental impact studies will be carried out when sufficient experimental and design data are developed. While only one process is now receiving EPRI support, others are being developed in private laboratories. Assessment of the feasibility of the technique EPRI is now supporting should be available in 1977; a 200 TPD demonstration plant is planned for operation in 1979.

3. <u>Solid Waste Utilization</u>

Municipal and commercial solid waste contain energy that can be utilized for electric power generation by direct combustion or conversion to a fuel gas or liquid.

Most of the techniques for the recovery of energy in solid waste (direct firing, various processes for pyrolysis to gaseous and liquid fuels) have been, or are being, demonstrated at substantial scale. EPA has been the largest sponsoring agency. EPRI does not anticipate any funding of the development of solid waste processing systems but will concentrate its funds on critical tests and evaluation.

Federal agencies, particularly EPA's Office of Solid Waste Management, EPA's Control Systems Laboratory, and the Department of Housing and Urban Development, have been actively financing the development of processes for the recovery of energy and materials from solid waste and research in associated fields.

This heavy government involvement has been a result of the need for the development of better disposal systems and the reduction of adverse environmental effects of present disposal practices.

As a source of energy, municipal solid waste can only contribute a very small fraction to the total electric power generation. EPRI's efforts are therefore best utilized in behalf of its member utilities by filling the gaps in the available information and dissemination of this information. EPRI will also carry out research and development projects where critically needed. For example, a project to quantify tube corrosion when solid waste is used as a supplementary fuel in a pulverized coal boiler is planned for 1976 with completion in 1978.

4. Direct Use of Fossil Fuels

A modest level of effort, $100,000/yr, is budgeted for exploratory research and studies of innovative techniques for utilizing fossil fuels in existing utility boilers. For example, stabilized coal/oil slurries are not economically competitive today because of the high cost of available stabilizers. Basic research on the surface chemistry of coal may yield low cost stabilizers and work in the area planned. The prospects for producing a 0.5% sulfur char/oil slurry will also be evaluated in 1977. These two projects will supplement a major program being initiated by ERDA.

PROGRAM NO. 14 FLUIDIZED COMBUSTION AND COAL CLEANING DATE October 8, 1976

SUBPROGRAMS	FUNDING ($000) 1977	1978	1979	1980	1981	TOTAL 1977-81
Fluidized-Bed Combustion						
Analysis and Technology Development	$ 800	$ 700	$ 1,000	$ 1,200	$ 2,200	$ 5,900
Experimental Development	1,400	1,500	1,500	300	300	5,000
Process Development	1,900	2,000	2,000	2,000	1,500	9,400
Equipment Development	100	500	500	1,000	1,500	3,600
Demonstration	200	1,000	7,000	7,000	4,000	19,200
Subtotal	$ 4,400	$ 5,700	$12,000	$11,500	$ 9,500	$43,100
Solid Waste Utilization	$ 100	$ 100	$ 100	$ 100	$ 200	$ 600
Coal Cleaning						
Analysis and Technology Development	100	100	100	100	100	500
Experimental/Process Development	1,100	1,000	1,000	2,000	2,000	7,100
Equipment Development	-	300	500	1,000	2,000	3,800
Demonstration	-	4,000	4,000	4,000	6,000	18,000
Subtotal	$ 1,200	$ 5,400	$ 5,600	$ 7,100	$10,100	$29,400
Direct Use of Fossil Fuels	$ 100	$ 100	$ 100	$ 100	$ 200	$ 600
TOTAL	$ 5,800	$11,300	$17,800	$18,800	$20,000	$73,700

SUBPROGRAMS AND/OR PROJECT GROUPS	KEY EVENTS 1977	1978	1979	1980	1981	BEYOND 1981
Fluidized-Bed Combustion						
Analysis and Technology Development	▲ 1	▲ 2		▲ 3		▲ 4,5
Experimental Development		▲ 6,7		▲ 8	▲ 9	
Process Development			▲ 10	▲ 11	▲ 12	
Equipment Development						▲ 13
Demonstration			▲ 14			▲ 15
Solid Waste Utilization	▲ 16	▲ 17	▲ 18	▲ 18	▲ 18	
Coal Cleaning						
Analysis and Technology Development	▲ 19	▲ 19	▲ 19	▲ 19	▲ 19	
Experimental/Process Development	▲ 20		▲ 21			▲ 22
Equipment Development						▲ 23
Demonstration		▲ 24	▲ 25	▲ 26	▲ 27	
Direct Use of Fossil Fuels	▲ 28	▲ 28	▲ 28	▲ 28	▲ 28	

KEY EVENT NO.	KEY EVENT DESCRIPTION
	Fluidized-Bed Combustion
1.	Complete design study of utility scale FBC unit. Major design problems identified.
2.	Selection of construction materials established through corrosion/erosion tests.
3.	Fast or circulating bed boiler conceptual design studies completed and related development problems identified. Decision to proceed with development.
4.	By-product lime uses and regeneration technology established. Manuals published.
5.	Pressurized FBC (air heater design) and its application to utilities established.
6.	Complete design data studies (heat transfer, sorbent performance, hydrodynamics) for 200-MWe demonstration plant.
7.	Fast bed parameters and circulation techniques established.
8.	Regeneration studies completed.
9.	Fundamental studies of FBC systems completed.
10.	Complete FBC development test program at Alliance, Ohio. Decision to proceed with demonstration.
11.	Circulating bed development project completed. Technical feasibility established.
12.	Sorbent regeneration test facility program completed. Decision to integrate with FBC demonstration plant.
13.	Major FBC equipment developed. Application to demonstration plant initiated.
14.	Complete design of FBC demonstration plant. Order long lead time components.
15.	FBC demonstration unit operational (1982).
	Solid Waste Utilization
16.	State-of-the-art study completed.
17.	Boiler tube corrosion tests completed.
18.	Utility support projects (air pollution implications, institutional issues, etc.).
	Coal Cleaning
19.	Update state-of-the-art study on coal preparation as necessary.
20.	Complete development projects for chemical coal cleaning (pyrite sulfur removal) process, and for advanced (magnetic) physical coal cleaning process. Decision to proceed to design of demonstration units.
21.	Complete development projects for chemical coal cleaning (pyrite + organic sulfur removal). Decision to proceed to design of demonstration unit.
22.	Development of new physical coal-cleaning technologies.
23.	Major equipment developed and demonstrated.
24.	Final design of advanced (magnetic) physical and chemical (pyrite sulfur removal) cleaning demonstration plants.
25.	Begin operation of 200 TPD advanced physical and chemical coal cleaning demonstration plants. Complete evaluation of Homer City, Pa. prep. plant.
26.	Final design of chemical (pyrite + organic sulfur removal) coal cleaning demonstration plant.
27.	Begin operation of chemical coal cleaning demonstration plant. Support of additional demonstration projects.
	Direct Use of Fossil Fuels
28.	State-of-the-art and conceptual design studies funded as necessary for coal/oil slurries, char/oil slurries, and effects on boiler plant performance of coal blending.

APPENDIX A

UTILITIES REPRESENTED AT

EC&C REGIONAL MEETINGS

EPRI

(E X A M P L E)

Dear EPRI Member Utility:

The Environmental Control and Combustion Program (EC&C) which is part of the Fossil Fuel and Advanced Systems Division of the Institute is planning a series of ten regional one day seminars intended to (1) acquaint sponsoring companies with the scope of the existing EC&C program and (2) provide the EC&C technical staff with a clear prospective on the environmental control problems, and priorities, facing the industry at a regional and local basis. The results will be important in planning the content and priorities within the EPRI EC&C Program. The meeting will be organized on the same geographical basis as the Federal EPA regions to insure uniformity of discussion. Therefore, each meeting will be limited only to utilities within that specific geographical region.

We cordially invite your company to participate in the Regional seminar. We suggest that, if possible, a representative from both your Power Production and Engineering/Research and Development departments attend and participate in the discussions. Please contact Mr. Kurt Yeager, Program Manager, Environmental Control & Combustion, (415-493-4800, Extension 609), with the names of the representatives attending from your company.

Specific seminar topics on which the views of your company are needed include:

1. Existing local and federal environmental control requirements which require positive action on the part of your company.

2. Future environmental requirements which you foresee emerging in the next decade.

3. The impact of these existing and future requirements on the operation of your company.

4. Your recommendations on the technical projects and priorities which the EPRI EC&C Program should consider to be most supportive of your meeting these environmental requirements.

Headquarters: 3412 Hillview Avenue, Post Office Box 10412, Palo Alto, CA 94303 (415) 493-4800

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The EC&C program is intended to provide technical and engineering research and development support to the electric utility industry in effectively responding to air, water and solid waste control requirements. Our first objective is to determine, on a continuing basis, the state-of-the-art, and associated costs, of various environmental control technologies. Second, on the basis of these evaluations we week to support development of a range of environmental control and combustion technologies necessary to meet environmental requirements with minimal impact on industrial productivity and costs.

The EC&C program encompasses evaluation and development of sulfur oxide, nitrogen oxide, particulate and water quality control technology. It also includes combustion and instrumentation support subprograms designed, respectively, to insure the compatibility of new fuel and combustion technologies with utility hardware and operating procedures and to provide the capability to measure the performance and emissions associated with both existing and new energy systems.

To provide you with background information on our present research and development program we have enclosed:

1. An explanation of the interface between the EPRI EC&C and Environmental Assessment Programs ("Responsibility for Environmental R&D in Regard to Fossil Fuels").

2. The 1975-1979 draft Research and Development Program for the Fossil Fuel and Advanced Systems Division.

3. The Environmental Control and Combustion Program review, dated July 2, 1975.

4. Lists of ongoing contracts for both the EC&C and Environmental Assessment Programs.

5. Draft of the 1975-1976 R&D Expenditures for the EC&C program.

Mr. Kurt Yeager may be contacted directly relative to any questions on the enclosed material or the December 2nd meeting.

Thank you in advance for your interest in the EPRI program and for making representatives from your Company available for this seminar. The results of which we feel will be valuable to all concerned.

Very truly yours,

R. E. Balzhiser,
Division Director
Fossil Fuel and Advanced Systems

REB/vbe
Encl.

A G E N D A

	ITEM	RESPONSIBLE PARTY	TIME
1.	WELCOME		9:00 a.m.
2.	OPENING REMARKS	EPRI	9:10 a.m.
3.	REVIEW OF EC&C PROGRAM	EPRI	9:20 a.m.
	COFFEE BREAK		10:10 a.m.
4.	QUESTIONS & ANSWERS ON EC&C PROGRAM	All Utility Participants & EPRI Staff	10:20 a.m.
5.	DISCUSSION OF EXISTING ENVIRONMENTAL CONTROL REQUIREMENTS & IMPACT ON UTILITIES	Utility Participants	11:00 a.m.
	LUNCH		12:30 p.m.
6.	FUTURE ENVIRONMENTAL CONTROL REQUIREMENTS & IMPACT ON UTILITIES	Utility Participants	1:30 p.m.
7.	RECOMMENDATIONS TO EPRI ON TECHNICAL PROJECTS & PRIORITIES	Utility Participants	2:15 p.m.
	COFFEE BREAK		3:15 p

8.	SEMINAR SUMMARY	Mr. Jerry Lanzolatta	3:25 p.m.
9.	SUGGESTIONS FOR FUTURE SEMINARS	Utility Participants	3:50 p.m.
10.	CLOSE		4:15 p.m.

EPRI REGIONAL SEMINARS

SEPTEMBER 1975 - February 1976

Utilities Represented

Region I - Westboro, Massachusetts October 14, 1975

- Boston Edison Company
- Central Maine Power Company
- Eastern Utility Association
- Fitchburg Gas and Electric
- Montaup Electric Company
- NEGEA
- New England Power Company
- Northeast Utilities
- United Illuminating Co.

Region II - Schenectady, N.Y. November 18, 1975

- Central Hudson
- Consolidated Edison
- Long Island Lighting Co.
- Niagara Mohawk Power Co.
- New York Power Pool
- Orange and Rockland Utilities
- Public Service Electric and Gas
- Rochester Gas and Electric

Region III - Washington, D.C. October 16, 1975

- Baltimore Gas and Electric
- Duquesne Light
- Pennsylvania Electric Co.
- Philadelphia Electric Co.
- Potomac Electric Power Co.
- Virginia Electric and Power Co.

Region IV - Atlanta, Georgia November 25, 1975

- Florida Power Corporation
- Georgia Power Company
- Kentucky Utilities Co.
- Mississippi Power and Light Co.
- Tampa Electric Co.
- Tennessee Valley Authority

Region V - Chicago, Illinois November 24, 1975

- Commonwealth Edison
- Central Illinois Light Co.
- Central Illinois Public Service
- Cincinnatti Gas and Electricity
- Columbus and Southern Ohio Electric Co.
- Consumers Power Co.
- Dayton Power and Light Co.
- Illinois Power Co.
- Indianapolis Power and Light Co.
- Ohio Edison Co.
- Wisconsin Public Service Corp.

Region VI - Dallas, Texas September 25, 1975

Arkansas Power and Light Co.
Dallas Power and Light Co.
Houston Lighting and Power Co.
Louisiana Power and Light Co.
Texas Power and Light Co.
Texas Utilities Generating Co.
Oklahoma Gas and Electric Co.
Salt River Project

Region VII - Kansas City November 7, 1975

Central Kansas Power
Iowa Power and Light
Kansas Power and Light
Kansas City Power and Light Co.
Missouri Public Service Co.
Missouri Utilities Co.
St. Joseph Light and Power Co.

Region VIII - Denver, Colorado November 6, 1975

Public Service of Colorado
Cheyenne Light, Fuel and Power Co.
Montana Power Co.
Tri-State Generating and Transmission Co.

Region IX - Palo Alto, California September 22, 1975

Southern California Edison Co.
San Diego Gas and Electric Co.
Sierra Pacific Power Co.
Pacific Gas and Electric Co.
Nevada Power Co.
Los Angeles Department of Water and Power
Salt River Project

Region X - Portland, Oregon February 10, 1976

Pacific Power and Light Co.
Portland General Electric Co.
Puget Sound Power and Light Co.
Utah Power and Light Co.
Washington Water Power

APPENDIX B

EC&C REGIONAL MEETING MINUTES

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION IX SEMINAR

September 22, 1975, Palo Alto, California

Attendance:

EPRI Staff

Kurt Yeager
Don Teixeira
Bob Carr
Owen Tassicker
Jerry Lanzolatta (consultant)

Utility Representatives

Dale Jones, So. Calif. Edison
Marion Horna, San Diego G&E
Bob Proctor, Sierra Pacific
Mike Sullivan, Sierra Pacific
Bill Barr, Pacific G&E
Andy Ariey, Pacific G&E
Stu Dalton, Pacific G&E
Wally Allen, Pacific G&E
Charlie Vaughn, Nevada Power
Hans Sonderling, L.A. Dept. of Water & Power
Dick Durning, Salt River Project

Utility Comments and Recommendations

1. One company is installing a new coal-fired plant (325 MW) with Wheelabrator-Frye fabric filters as the only particulate removal device. This may provide some relevant cost data, and later on, some relevant operating history, and performance data.

2. Plume opacity and fall-out problems (including smoke produced during startup) deserves a high priority. Synthetic liquid fuels will have a different ash/trace element characteristic than existing fuels and could cause opacity problems. It was noted that the fabric filter at one station produces an invisible plume on a coal-fired boiler with an 18% ash coal.

3. Is EPRI encouraging the proliferation of environmental regulations by developing environmental control technology? In response it was stated that without knowing the cost, reliability and performance aspects of new control equipment, a cost-effectiveness response to regulatory agencies prior to the promulgation and enforcement of a standard cannot effectively be made. This historically has forced the utility industry to only report rather than anticipate and effectively help direct the environmental regulatory process. The result has been a serious industry deficiency in dealing with regulators.

4. Why is stack gas cleaning being considered when development of coal gasification/liquefaction will resolve the environmental control problem? In response it was stated that the technical success of the coal processing projects is yet uncertain and are commercially distant. Scrubbers are available today at a lower cost than current gasification and liquefaction technology and are becoming increasingly mandated by federal and local regulatory requirements.

5. Utilities are being forced to depart from traditional methods of environmental control and process improvement where the vendors were relied on to provide a reliable cost-effective solution. Vendor guarantees are worth less and less these days. Utilities must be in a much better position to specify new process technology and request vendors to do the fabrication and installation.

6. California has a maze of different and sometimes conflicting emissions regulations. Some are based on lb./hour limitations, rather than lb./10^6 Btu. California may be the first state in the nation to have sulfate and nitrate standards and associated more stringent emission standards. The o.04 ppm 24 hour standard for SO_2 is some 3-1/2 times as stringent as the primary national standard. Additional concerns are fine particulate, opacity, radiation, vaporous compounds such as mercury and selenium from coal.

7. New California statutes require that power plant siting criteria and site selection plans be reported to the California State Energy Commission. This commission will then re-adjust all utility expansion plans as the state sees fit. This commission is also trying to take over the jurisdiction of the California Coastal Commission regarding coastal power plant siting.

8. Nuclear site planning in 13 Western states involves interface with the Western Interstate Nuclear Board.

9. Gas turbine power plant facilities are the last resort when all other site plans fail. However, most utilities did not favor construction of simple cycle (peaking) turbines unless the system was designed for future retrofit of combined

cycle (intermediate load) equipment and reliable source of fuel. Maintenance costs and reliability problems with gas turbines, especially the larger machines, are a subject of concern.

10. Natural gas as a utility fuel is on the way out, but nobody knows how much time will pass before all natural gas allocations are gone. This will utlimately mean more widespread problems on oil ignition and boiler warmup without smoking.

11. There was general concern expressed with NO_x control for gas turbines. Particular emphasis was placed on development of an alternative to water injection, both on the basis of cost and regional water availability.

12. Does EPRI have any idea if the emissions regulations for existing units are going to get tougher? Partial answer is an EPRI-sponsored report on ambient air quality and emissions standards to be issued in the spring of 1976. EPA is apparently dropping the tough stance for automotive NO_x control and the emphasis will shift towards power plant NO_x control.

13. Most NO_x controls, except low excess air firing, reduce boiler efficiency. For example, flue gas recirculation fans reduce boiler efficiency and change the excess oxygen levels for stable combustion. Units with steam atomized burners use considerable makeup water (increased demineralizer requirements) and have had 0.5 to 1.5% decrease in overall boiler efficiency. One utility is faced with NO_x regulations of 125 ppm on gas and 225 ppm on oil and have been unable to comply with the regulations. At one station the amount of gas recirculation to the burners that would be required to reduce the NO_x is not possible as it would

overpressure the furnace and overheat the reheat. Removing surface to allow the furnace pressure to go down and gas recirculation to go up would defeat the purpose of eventually changing to oil as a main fuel. Other units are not fully in compliance due to instrumentation problems.

14. Gas turbine repowering on existing boilers can result in a 33% increased capacity at a given site. Availability of distillate fuels is one of the more serious concerns. From a regulation viewpoint, it is not clear whether repowering an existing boiler as a combined cycle retrofit will constitute a "new source" (with new source emission standards) or be part of an "existing source" (with existing emission standards).

15. One unit operating on natural gas at 60% load (300 MW) has exhibited NO_x emissions of less than 30 ppm. This boiler was designed for maximum NO_x control, with flue gas recirculation, overfire air ports, corner firing, etc., and thus has exceptional NO_x control characteristics.

16. POM, or polynuclear organic matter, is an unburned hydrocarbon which is present in stack gas as an uncondensed vapor. The role of trace elements or particulates on particle agglomeration and POM condensation is not known. Battelle has performed work for EPA on POM measurement, which resulted in higher levels than EPA Method 5 measurements. POM Method 5 results are questionable. EPRI is measuring POM and particulate emissions at Four Corners (coal-firing) under a variety of stoichiometric firing conditions.

17. Availability of 0.5% sulfur liquid fuels is poor. Blending facilities to achieve low nitrogen and sulfur levels is probably going to be required for several utilities. Poor

fuel quality results in pump lubricity and erosion problems. EPRI should consider the technical and operating issues associated with fuel blending.

18. Utility representatives recommended that synthetic fuels from coal would be more rapidly utilized if they were liquids. These liquids look as though they may have associated soot and/or smoke problems, and fabric filters may be required on retrofit situations if opacity regulations are to be met. A key consideration on synthetic liquid fuels is fuel nitrogen which may run about 1% by weight and can contribute significantly to NO_x formation.

19. EPA-funded plume dispersion studies by GEOMET wer used by one state to deny a utility request to change the emission regulations to be equivalent to EPA new source standards. The GEOMET study at one station predicted ambient ground level concentrations which were 20 times higher than the highest values measured during the last five years.

20. EPRI should study the problems of converting existing natural gas boilers to oil, since many companies will be in this situation in the near future.

21. One company has a 20-year contract for methanol from Houston Natural Gas. It is suspected that natural gas receives a higher price than methanol, even counting a 55% conversion efficiency, due to the government-controlled price structure for natural gas.

22. EPRI should investigate oil additives and separate vendor claims from reality in this area. Cold-end corrosion control and increased superheat temperatures are possible, but the effects of trace elements in the fuel and other variables are not well understood. Do oil additives have any effect on emissions?

23. New coal-fired power plants have Ringelmann zero requirements in many situations. This is a big problem when wet scrubbers for SO_2 control are also required. A truly "invisible plume" cannot be achieved by any particulate control device other than fabric filters, which are not yet proven on a large scale.

24. One utility has gone to sodium base scrubbing which can reduce SO_2 emissions to virtually any limit by increasing sodium carbonate concentration. They have a problem on byproduce disposal and feel that sludge leachate and sludge disposal studies are of prime importance.

25. One utility has been trying to get their state to raise the SO_2 emission standards to NSPS levels but EPA has been using the Deep Valley Dispersion Model to argue against this relaxation. The statewide standard is 0.21 pounds/MBtu and the county standard is 0.15 pounds/MBtu.

26. An EPA-funded study for TRW to investigate SO_2 monitoring instruments in a utility environment has been very disappointing. No reports or data were made available and the utility has removed their monitors.

27. Ambient air quality monitoring programs with units at high level load are the only way to refute some of the poor predictions made by plume dispersion models. These programs can be very costly.

28. Plume dispersion atmospheric chemistry and biological impact studies are extremely important in order to identify the BENEFITS, if any, of the "mad dash to put in scrubbers."

29. The PDS methods for NO_x measurement by wet chemistry is not only slow, but isn't really very accurate (+10 ppm). In addition, the performance of continuous stack SO_2 monitor is often poor. A comparative evaluation of the performance and reliability of state-of-the-art commercial systems as a function of operating environment in the utility context should be done.

30. EPRI should consider studying the use of agricultural waste water for power plant cooling cycle applications. Sewage effluent may also be considered in this context, specifically with regard to nuclear plants. Agricultural waste water is generally as saline as sea water.

31. The question of water use was heavily emphasized: water reuse, dry cooling, obtaining water, methods of water treatment and disposal. The state is water short and the use of fresh water for cooling is discouraged by the water use planners while at the same time the Coastal Commission is encouraging that power plants be built inland, thereby requiring fresh water. The problem of residual chlorine discharge, however, was not considered a major problem in this region. Concern was expressed that some of the older inland stations would be required to go to zero discharge under the NPDES system. The resulting cost is unreasonable since their life expectancy is short.

32. One important siting criteria is the rate at which the ground water will re-charge the water table when deep wells for power plant makeup purposes pump the water out at a high rate. EPRI should consider the need to reliably estimate the re-charge rate?

33. Research is needed for the quantitative assessment of the chemical and physical behavior of pollutants after they emerge from the stack and their effects on people and other living organisms.

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION VI SEMINAR

September 25, 1975, Dallas, Texas

Names	Company	Position
Jerry Lanzolatta 9342 South Citrus Lane Sun Lakes, AZ 85224	Consultant for EPRI	
John O. Rich 1816 N. 38th Street Phoenix, AZ	Salt River Project	Asst. General Manager
Kurt E. Yeager Palo Alto, CA	EPRI	Program Manager, Env. Control & Combustion
J. R. Pollard P. O. Box 321 Oklahoma City, OK 73101	Oklahoma Gas & Elec.	Supervisor, Env. Control Air - Water
Jerry Govett P. O. Box 321 Oklahoma City, OK 73101	Oklahoma Gas & Elec.	Results Engineer
Bryan W. Ferguson P. O. Box 6331 Dallas, TX 74222	Texas Power & Light	Chemical Engineer
Brian Ballard P. O. Box 6331 Dallas, TX 75222	Texas Power & Light	Chemical Engineer
W. R. Deatherage P. O. Box 6331 Dallas, TX 75222	Texas Power & Light	Manager of Mechanical Engineering
Fred Manhart 142 Delaronde New Orleans, LA 70174	Louisiana Power & Light	Associate Engineer
W. F. McGuire P. O. Box 1700 Houston, TX 77001	Houston Lighting & Power	Principal Engineer Environmental Protection Dept.
R. W. Cox 1506 Commerce St. Dallas, TX 75201	Dallas Power & Light	Manager, Research & Environmental Services

Names	Company	Position
R. K. Payne 1506 Commerce St. Dallas, TX 75201	Dallas Power & Light	Manager of Production
James H. Woodward 9th & Louisiana Little Rock, AR 72203	Arkansas Power & Light	Director, Power Production
Max H. Tanner, Jr. 1506 Commerce St. Dallas, TX 75201	Dallas Power & Light	Manager of System Operation
John D. Janak 2001 Bryan St. Dallas, TX 75201	Texas Utilities	Manager of Power

Utility Comments and Recommendations

1. With coal and lignite the fuel of the future in much of the Southwest, efforts to improve electrostatic precipitator performance and reliability becomes increasingly important. Factors such as measuring ash depth in hoppers has not been handled well by vendors with a resulting negative impact on ESP performance. In addition, fine particulate emissions are becoming of increasing concern in the region because of existing local standards as well as the relationship to opacity.

2. EPRI should consider a program for developing power plant emission factors. It would also be valuable to relate opacity to the quantity and composition of particulate emissions.

3. It was suggested that a complete environmental impact statement on the use of SO_2 scrubber systems be made in the interests of objectively understanding the relative costs and benefits.

4. Considerable interest was expressed that EPRI become more involved in programs related to flyash and sludge disposal and water discharge abatement. Concern was particularly expressed on regulations for toxic substances which effectively require zero discharge. For example, both the federal and state water discharge regulations have a catch all clause (there shall be no discharge of toxic materials) exposing the utilities to many unknowns.

5. 316B regulations were of general concern. It was suggested that EPRI develop the necessary information base and guidelines to aid the utilities in the design of intake structures,

etc., to avoid entrainment and entrapment. This might logically consider initially collecting and evaluating the results of the extensive efforts which individual utilities have already performed on this problem. Existing intake structures should not require plant shutdowns or the expensive construction of retrofitting generating stations with cooling towers. Modifying the intake structures would be a reasonable alternative.

6. The need was expressed for more knowledge on ground water monitoring techniques and development of simplified approaches satisfactory to both utilities and regulators.

7. A mention was made concerning the latest FPC Power Survey where emphasis by federal agencies on environmental concerns are related to the synergistic effects of discharges on social issues. Is EPRI broadening its research into areas of social studies, i.e., unemployment, public transportation, public health, etc.?

8. Concern was expressed over more stringent local NO_x controls because of the ultimate regulatory objective of controlling oxidant levels by the curtailment of NO_x emissions from power plants.

9. It was recommended that further research and development on gas turbine performance be given a low priority because of their poor reliability, low availability of conventional gas turbine fuels, high maintenance, and high fuel cost. Technological developments should be tied to the availability of synthetic fuels as a reliable fuel source.

10. There is a need for the verification of the many diffusion models used in ambient air quality determination.

11. An evaluation of fuel additives is necessary for both boilers and turbines to determine their real impact on emissions as a function of fuel and combustion conditions as well as their side effects on performance and reliability.

12. Concern was expressed that as standards become more stringent, the cost of power to the customers increases without associated benefit. For example, one utility has a 30 min. ambient standard rather than a 3 hour standard. This requires nearly double the level of emission control.

13. In one area, the ambient reservoir and stream temperatures often exceed the permissible discharge temperatures from power plants.

14. Alternative biocides to prevent condenser fouling must be developed to eliminate the free residual chlorine from condenser discharge. Amertap is unsatisfactory.

15. In one area each water discharge must be treated separately. This results in adding solids to the ultimate discharge in order to control pH. Emphasis should be placed on the economics of trace element removal (Fe and Cu). For example, requirements to remove (Fe and Cu) from generating plant discharge will force significant increases in costs of treating plant discharges.

16. Many utilities believe that the 4 minute per hour smoke emission limitation will be exceeded during startup, soot blowing, extreme load changes and equipment malfunction.

17. EPA is using outdated emission factors with no identifiable relationship between actual data and reported data. Emphasis should be placed on developing improved analytical techniques as input to ASTM and EPA with use of the techniques to achieve improved emission factors.

18. One utility has three boilers burning lignite, and plans to add large lignite fired units for the next ten years. A particulate emission level of 0.3 lbs/million Btu will be required.

19. The region generally requires stringent fuel quality in terms of sulfur irrespective of ambient air quality requirements. Plants after 1969 typically require 0.7% sulfur content fuel oil.

20. Cooling towers may be necessary to meet the permissible cooling water discharge temperature in some areas. In addition to the requirements of Section 316A, there is also concern that intake structures may need to be modified according to the requirements of Section 316B.

21. Concern was expressed that an enormous amount of money will have to be spent to modify older units to meet the regulations which will soon be retired.

22. The historic fuel base is generally gas with very limited oil, lignite, coal, and nuclear.

23. The future growth of the region will be primarily western coal and lignite with limited nuclear because of the high initial cost and the fuel reprocessing problems. The sulfur content of fossil fuel will be between 0.4% and 0.7%.

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION I SEMINAR

October 14, 1975, Westboro, Massachusetts

Attendance:

EPRI Staff

D. P. Teixeira (Project Manager)
R. C. Carr (Project Manager)
Kurt Yeager (Manager, EC&C Program)
G. Jerry Lanzolatta (Consultant)

Fossil Fuel Task Force Representative

John L. C. Bachofer, Jr., General Public Utilities

Utility Representatives

Charles W. Dolloff, Boston Edison Co. (Environmental Coordinator)
C. P. Quigley, Boston Edison Co. (Mechanical Engineer, Engineering and Construction)
Mehehdra B. Patel, Boston Edison Co. (Mechanical Engineer, Engineering and Construction)
Val Thompson, Central Maine Power Co.
Don France, Eastern Utility Association
David Foote, Fitchburg Gas & Electric
Ed Hyland, Fitchburg Gas & Electric
Paul Sunderland, Montaup Electric Co.
Tom McCabe, NEGEA
Phil Morrow, NEGEA
E. Kaplan, New England Power
J. F. Kaslow, New England Power (Vice President)
Edward Keith, New England Power
Sushil K. Batra, NEPSCO (Manager, Energy Research)
John Crawford, NEPSCO
John Menzie, NEPSCO
Nino M. Molino, NEPSCO (Mechanical Engineer)
Edward R. Stoler, New England Power Planning (Chief, Environmental Affairs)
Daniel Hedden, Northeast Utilities
Bob Meyer, Northeast Utilities
H. B. Whitcomb, Northeast Utilities (Supt. Results)
Dick Grossi, United Illuminating Co.

Utility Comments and Recommendations

1. The use of intermittent control is of considerable interest, however, a number of practical as well as regulatory problems need further attention. These include:

   - The storage and rapid switching between high and low sulfur fuels.
   - Furnace slagging could result from different coal ash fusion temperatures. This is a particular problem with changing between Eastern and Western coals.

   Related to this issue, regulatory agencies in the region will be evaluating the use of 2.2% sulfur fuel oil at a utility plant with tall stacks where a minimum effect on ambient air quality is expected.

2. The possible curtailment of NO_x emissions from power plants to control oxidant level is of concern. For example, the cost of water or steam injection on new turbines in 1972 was about $8/kW. Generally in the region O_2 and CO are monitored only when NO_x is monitored.

3. Many questions were asked on additives and suggestions made that EPRI place more emphasis on their performance, cost, and side effects as a function of fuel and combustor variables. For example, one company used an additive for a short period of time while burning a low sulfur coal. On one unit it reduced plume visibility and an increase in load of 20% was possible. The same additive was unsatisfactory on two other units at the same station.

4. Electrostatic precipitator efficiency has become a major problem as a result of both fuel quality and stringent local emission regulations. Additional research is needed to insure more reliable operation for existing units as well as design specifications which the industry can confidently use in purchasing new precipitators.

5. Guidelines should be developed on the comparative performance of opacity instrumentation and its relationship to actual stack grain loading and particulate size distribution. Regulatory agencies are directing the use of specific instrumentation based apparently on unsubstantiated vendor claims. Little or no data exists from which the industry can respond to these directions. This is becoming more of a problem as fuel sulfur levels in the region are relaxed. Regulators assume that particulate emissions increase as fuel sulfur content increases. This, of course, is not necessarily true.

6. Problems exist in achieving 0.1 ppm total residual chlorine. Tests are in progress to determine the effectiveness of ozone, anti-fouling paints, dechlorination, etc., for maintaining acceptable condenser cleanliness. Completion of the tests, being performed by Marine Research, Inc., is expected in the spring of 1976.

7. Additional areas related to chemical water quality control which should be addressed by the EPRI program include:

   - Sludge and ash disposal
   - Separation of ash from sluice water
   - Achievement of trace metal discharge limits, particularly when lower quality oil is being consumed (Vanadium, Aluminum, Nickel)

- Disposal of air heater and fireside wash, etc.
- Development of instrumentation for continuous water quality measurement
- Zero discharge

8. The 316A & 316B water quality regulations are of great concern. Many of the utilities have experienced both thermal problems and fish entrapment (Menhaden). Several companies are performing periodic fish entrapment studies. The general feeling is that EPRI should provide a focal point for communicating and evaluating the considerable utility industry effort in this area and providing guidelines to the industry for effectively dealing with this problem. This needs to be done quickly to be most useful. Several examples of experience in this area were reported:

   - One company received a 95°F dispensation for a period of time and noticed no adverse effects.
   - Another company did not receive once-through cooling approval and installed spray pond cooling equipment. To date the performance is questionable, with salt drift a significant problem. This has caused insulator flash-over as well as vegetation and paint degradation. Plans are to convert to fresh water.
   - Rate of change of thermal shock varies from station to station depending on permissible outlet temperature and permissible ΔT.
   - One company installed a fish sill to prevent bottom swimming fish from entering the intake and a submerged diffuser to eliminate their thermal problems with Menhaden.

9. Consideration should be given to the problem of noise control. This problem is driven both by the increasing noise potential of new large utility hardware and emerging noise regulations. To date, vendors have not reliably responded to this concern. Problem sources with respect to both in-plant and boundary line noise include:

   - Low frequency noise from combustion turbines (noise level during start-up seems to be adequately controllable by silencers)
   - Mechanical draft and natural level cooling towers
   - The larger draft fans associated with state-of-the-art boilers

10. Several utilities have installed silencers to minimize the noise during boiler start-up.

11. Concern was expressed on idenfiable oil slicks where additional research is needed to distinguish industrial compounds vs. fuel oil compounds.

12. One utility is utilizing shredded municipal waste for power generation. If successful, the state will build a 100% refuse boiler and sell steam as energy to the utility.

13. It was noted that one state legislature is charged with reviewing/revising legislation based on consideration of costs versus benefits. In effect, it must make tradeoff judgments based on some evaluation of the ecnomic impact of the legislation relative to its environmental impact.

14. Regional generating growth has historically been about 7%. Future capacity planning is being based on a 5-6% growth rate.

15. Future expansion of generating capacity in the region will primarily rely on nuclear for base load, oil for cycling and pump storage/combustion turbines for peaking. Coal capacity is discouraged by the transportation costs involved coupled with (1) very stringent ash/sludge disposal regulations which generally require use of a sanitary land fill, (2) difficulties associated with increased waste water volumes, (3) the nuisance problems associated with coal and the impact on public relations. Cost comparisons indicate that utilities in the region can afford to pay \$13-15/bbl for oil before regenerative scrubbers appear competitive. Relaxation of State Implementation Plans to permit use of moderate (1-2%) sulfur oil is encouraging if federal nondegradation requirements under the Clean Air Act do not disrupt this trend. The 24 hour Class II regulation appears to be the controlling parameter on fuel sulfur content in the region.

    Some existing oil-fired capacity, which was originally built for coal firing, can be remodified to again permit burning of coal. This would both provide fallback if the oil supply is cut off and may also be required under federal fuel allocation authority. To get the capacity back may require installation of new pulverizers, ash handling equipment and upgrading of electrostatic precipitators.

16. Environmental restrictions and the cost of compliance is the driving function on retiring old capacity.

17. The price difference between #2 and #6 oil is about 3 cents/ gal. and rising. As a result, considerable attention is being paid to using #6 oil in combustion turbines.

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION III SEMINAR

October 16, 1975, Washington, D.C.

Attendance:

EPRI Representatives

Robert Loftness (Director, Washington Office)
Kurt E. Yeager (Manager, Environmental Control Program)
Jerry Lanzolatta (Consultant)

Utility Representatives

Doug Clark, Baltimore Gas & Electric (Principal Engr. Elec. Production)
Ahmad Rafi, Baltimore Gas & Electric (Senior Engr. Electric Engineering)
Gordon Knight, Duquesne Light (Supt. Tech. Svc.)
David H. Fyock, Penelec (Dir. Res. & Env. Quality)
R. D. Imler, Penelec (Project Engr.)
George Kotnick, Philadelphia Electric (Sup. Engr.)
W. B. Willsey, Philadelphia Electric (Supt. Services)
Jerry Scouville, Pepco (Mgr. Environmental Affairs)
Dick Ungemach, Pepco, (Mgr. Gen. Eng'g.)
Mark Dean Weiss, Pepco (Engineer)
Jim Braswell, Vepco (Dir. Fossil & Hydro Oprs.)
Sam C. Brown, Jr., Vepco (Ex. Mgr. E.S.)
Bob Schultz, Vepco (Dir. Mechanical Design)
John W. Waddill, Vepco (Dir. Mechanical Design)

Utility Comments and Recommendations

1. As a result of environmental considerations becoming "all-important," the emphasis has gone from stressing efficiency to such an extent that central station efficiency has remained at a standstill.

   Equipment vendors have been very convincing to regulatory people and are telling them (and being believed) that pollution control equipment is available and dependable when it really isn't.

   Legislators have said that the purpose of the various pollution control laws is to "force technology" to the point that the requirements of laws on the book could be met. The legislators know that the technology is not at hand when the laws are written.

2. In a discussion on intermittent control strategy (ICS), it was indicated that it is of utmost importance to impress on higher management how much more ecnomical intermittent control and load shifting can be in comparison to installing expensive constant pollution controls. In this connection, it is recommended that development of ICS be of high priority to EPRI.

3. Several utilities have scrubbers and are very much disturbed with their performance and reliability. The vendors promised the regulatory agencies performance levels that cannot be met. Many problems are a result of poor quality control. A cost benefit study on the scrubber issue should be considered by EPRI.

4. The issue of fuel oil additives for the purpose of reducing sulfate emissions is of concern due to emerging

regulatory pressures. Certain fuel oil additive manufacturers are making claims that sulfate emissions can be reduced through the use of their additives. Guidelines on the use of additives in turbines and boilers for controlling all types of emissions would be very valuable. One company has installed an H_2SO_4 injection system for stack conditioning with reasonable acceptance.

5. The present FEA coal conversion program provides a strong demand for upgrading electrostatic precipitators. In this regard, consideration should be given to evaluating agglomerating additives for improving fine particulate collection efficiency.

6. A number of measurement and instrumentation needs were identified by the utility representatives. These included:

    - Develop means to measure entrained water in gas scrubber emissions.
    - Develop a monitor to determine opacity in gas containing entrained water.
    - Evaluate and develop, as necessary, methods to measure acid sulfates and nitrates in the ambient air.
    - Evaluate and standardize laboratory leachate procedures for fly ash and sludge with particular emphasis on trace metals.
    - Develop a faster, simpler procedure for determining oil and grease in water discharges (One company is using an infra-red method).

- Monitoring instrumentation for liquid effluents should be critically considered, particularly the sensitivity and reliability required by EPA permits.
- Research and development should be devoted to developing instrumentation for continuously measuring water quality. Particular emphasis should be placed on monitoring heavy metals from ash settling ponds.

7. One of the major problems that require effective research in the area of flue gas desulfurization is the maintenance of a sludge storage area. One state has required that sludge be stored over a 10 foot layer of fly ash. The reasoning behind this requirement is unknown. The state also is requiring monitoring wells around the disposal sites to check on possible ground water contamination.

8. In the area of water quality control, the following recommendations on priority needs were identified:

   - Additional studies are needed relating to the storage and handling of fly ash and scrubber sludge.
   - More research is needed in the area of cooling tower drift and particulate size distribution.
   - With the advent of 316B regulations, research must be done to stimulate new designs in the area of circulating water intake structure and screen designs.
   - The control of total dissolved solids appears to be a major problem that needs further investigation.
   - Recommendations for treating coal pile run-off and water treatment sludge should be developed.
   - Examine the basis for chlorine limits in regulatory guidelines and give consideration to the nonguideline limits now being imposed by the EPA. Alternative methods for treating circulating water should be

investigated. Pepco has done some work with bromine chloride, but the state has now indicated that all halogens will be restricted. Amertap has not been a successful alternative for condenser cleaning.

- The separation of particulate matter from water relative to dredging spoils appears to be a major problem and needs further investigation.

9. Efforts should be directed to investigating the hot corrosion (sulfidation) problem with gas turbines. This appears to be a common problem with all operators of GE Frame 7000 gas turbines. One company has a GE-7000 gas turbine and report that after 2000 hours they were required to replace the first stage. The unit is fired on No. 2 oil. Additional study needs to be devoted to improving the time between overhauls. Numerous internal corrosion problems have been experienced and this needs further investigation.

10. There is a need to work in the area of low level (Hz) noise. One company has had noise problems from the increased fan capacity associated with scrubber systems.

    Some research should be directed into the actual design of machinery which could minimize the magnitude of noise abatement devices.

11. More information needs to be developed in the area of slagging in coal furnaces. Emphasis is particularly required in the area of coal ash chemistry. Baltimore Gas and Electric has done some work with Babcock and Wilcox in the area of flux treatment for lowering the fusion temperature of low sulfur coals so that such coals can be used in cyclone furnaces.

12. One company has a MagOx scrubber operating at between 38% and 74% availability. This crubber is primarily for removing particulates and operates very little to remove SO_2. The lining in these scrubbers has failed. It appears that a possible cause of failure can be relating to curing the original coating. It appears that the base coat was too thick. A replacement coating of flake glass with a polyester binder seems to be working on the particulate scrubbers. This unit is also experiencing fan problems as a result of poor demister operations.

13. Another company has a MagOx scrubber that has operated between 35% and 70% availability. The major problems have been mechanical by nature. The system operates with a pH of 2 and has gone as low as 1-1/2. These high acid conditions have resulted in major corrosion problems. The scrubber at one plant has had zero availability and the unit is presently operating on fuel oil. The Peabody scrubber at this facility has experienced numerous problems which have been traced to poor quality control. The scrubbers are lined with natural rubger and have experienced major liner problems thorughout the system. The MagOx scrubber SO_2 removal efficiency when operating has been in the range of 90% $\pm$5%. The particulate scrubber has experienced 99.5% particulate collection efficiency. They have not fed any lime to the system and have not experienced any scaling problems.

14. The City of Philadelphia has a NO_x regulation requiring an emission limitation of 0.3/lb per million Btu. It appears that the GE combustor cans are only capable of meeting the NO_x regulation half the time. It was found that the improved combustion cans will not maintain compliance with the NO_x regulations during cold, dry days. The city has agreed to accept these modified combustor cans as the best available technology for their useful life.

15. Some efforts to determine the potential for increased utilization of anthracite coal should be made. Existing cost trade-offs in the face of today's economics may be entirely out of date.

16. The Washington office of EPA through the Steam Team indicated that dilution control for Ph would be permitted.

17. One company has cancelled a limestone scrubber for their station and has reverted to a coal cleaning operation. The coal cleaning plant with a capacity of 1.3 million tons per year will produce two grades of coal. One stream will produce a low sulfur coal 0.8% or less. The second stream will produce a moderate sulfur coal 2.2%.

    The specific gravity of the water-magnetite solution is such that when it circulates at high velocity in the cyclone vessel, the coal, which is lighter, rises to the top and is drained off there. The heavier sulfur coal and other impurities are drained off from the bottom of the vessel. The low sulfur product will meet new source performance standards and will be used on the new additions. The raw coal will have a sulfur content averaging 2.7%. This will be typical of a metallurgical coal preparation plant. The Btu loss is estimated to be between 5 and 7%.

18. Considerable efforts in the region have been directed to the use of municipal waste. These include the following:

    - One company has been evaluating the use of low pressure saturated steam from a municipal refuse fired boiler. This steam would be used to supplement station auxiliary steam requirements. Generally, stations use auxiliary steam from a reducing station. This refuse derived steam could be supplied through an isolated system which would relieve the utility from utilizing its own auxiliary steam. Such isolated systems under consideration involve soot blowing, oil heating, air heating, and building heating.

- Another company is considering the burning of shredded refuse. This work is in conjunction with the 1-95 group in Northern Virginia.
- One company has been working with Teledyne National in connection with solid waste utilization. The study involves firing oil and shredded waste. Present experience has been on firing waste material with coal.

19. Future capacity will be nuclear and coal for base load with pumped storage and combustion turbines for peaking.

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION VIII SEMINAR

November 6, 1975, Denver, Colorado

Attendance:

EPRI Representatives

Jerry Lanzolatta, Consultant
Larry Nannen, Project Manager
Kurt Yeager, EC&C Program Manager

Utility Representatives

George Green, Public Service of Colorado, Director Environ. Eng. & Planning
Bill Brines, Public Service of Colorado, Sr. Envir. Engineer
George Brown, Public Service of Colorado, Production
Steve Goering, Public Service of Colorado, Engineer
Ron Donovon, Cheyenne Light Fuel & Power, Supt.
Tom Smith, Montana Power Co., Ass't. Environmentalist
Dan MacLeod, Tri-State G&T, Primary Production Engineer
R. F. Rish, Tri-State G&T, Planning Manager

Utility Comments and Recommendations

1. The opacity problem associated with coal-fired power plants was presented as an area in which the utility industry of the region required considerably more information. Of particular interest is the ability to predict opacity based on boiler/collector design and operating conditions plus outlet grain loading, particulate composition and size distribution. A second area requiring attention is the incompatibility between results obtained by in-stack optical instrumentation and outside observers. As a result, there is a trend on the part of regulatory agencies toward reliance on in-stack instrumentation based on unsubstantiated vendor claims. It has also been noted by one utility that it is impossible to accurately measure opacity in a scrubber system with existing instrumentation. Therefore, it is incumbent to increase our efforts in substantiating the visual opacity against the recorded opacity.

2. The issue of scrubber use for SO_2 and/or particulate removal presented several viewpoints and a variety of problems requiring technical attention.

   The problem areas identified include:

   - Disposal of scrubber sludges containing alkaline ashes that exhibit certain amounts of self-fixation.
   - Definition of the technological limits (and costs) in operating scrubbers in a closed loop configuration.
   - Development of scaling inhibitors, effective demisters, and improved understanding of the effects of trace elements on hardware.
   - Measurement of entrained water in scrubber effluents.

- Typical scrubber availability has been on the order of 65%. One company reported an availability of 35%. The continuous maintenance requirements must be reduced to achieve any marked improvement in availability.

As a result of these problems, one major company in the region has completely given up on scrubbers for particulate removal. Difficulties have proven to be much less with electrostatic precipitators.

3. An improved design basis for electrostatic precipitators is needed to provide adequate specifications to vendors and to evaluate the responding bids for performance versus cost. Because coal quality, in terms of precipitators performance, is and will continue to be decreasing, the need for reliable retrofit technology to improve performance becomes more critical.

4. In the Rocky Mountain states, water supply is becoming a problem affecting the siting of new plants. The poor initial quality of makeup water for use in boilers requires either expensive water purification technology or hardware designed to resist water quality effects. Related water use and disposal needs include:

   - Control of $CaSO_4$ scaling in the wet sluicing of alkaline fly ash.
   - Guidelines for the use of alternative dewatering techniques other than vacuum filters.
   - Practical alternatives which are responsive to severe regulatory restrictions on the use of scaling inhibitors. It was indicated that the primary problem was with once-through condensors. Cooling towers are less of a problem.

- Improved brine concentration technology for use under emerging power plant water quality restrictions.
- Understanding and ability to control the effects of trace element concentration across scrubbers.
- Reliable guidelines and specifications for minimizing the cost of waste treatment.
- Improved design bases and application guidelines for the use of dry cooling towers.
- Zero discharge regulation.

5. Considerable interest was expressed for the continued use of combustion turbines for peaking capacity. Both G.E. and Westinghouse are advocating nuclear for base load and turbines for peaking. G.E. has established a separate engineering unit in Schenectady for environmental control. This renewed R&D interest seems to be based on their currently favorable market position. Other related comments were:

   - Turbine fuel supply is a growing problem but is offset in capacity planning by the reduced environmental and lead time considerations relative to alternative generation modes.
   - Water injection is not a satisfactory answer for NO_x control in this region because of the unacceptable water use rate (250 gal./min. versus 60 gal./min. for evaporative cooling) and water quality improvement costs.

6. The Denver Regional Council of governments has concluded that methanol from either coal or garbage is too expensive for practical application at this time, and that the use of any syngas fuel plus ammonia production in off-peak periods is not economical or a viable alternative for fuel from

garbage or rubbish disposal. The only alternative is to burn rubbage and garbage directly in boilers as a substitute for coal.

7. Politically driven problems are a particular concern to utilities in the region. For example, railroads and environmental interests in one state have combined to effectively halt the development of slurry pipelines by blocking the required right of eminent domain. A general regional problem affecting utility operation is the anti-growth issue and the use of Rocky Mountain natural resources by the rest of the nation.

8. It was recommended that EPRI focus utility industry attention on determining the degree to which current control technology has been successful in meeting current national and local environmental standards and at what real cost.

9. One utility expressed interest in the dry removal of SO_2 (Nacholite).

10. The future capacity growth of the region will primarily be coal and limited nuclear for base load with pumped storage and combustion turbines for peaking.

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION VII SEMINAR

November 7, 1975, Kansas City

Attendance:

EPRI Staff

Kurt Yeager, Program Manager, (415) 493-4800
Larry Nannen, Project Manager, (415) 493,4800
Jerry Lanzolatta, Consultant (602) 963-4779

Utility Representatives

Herb Schmidt, Production Supt., Central Kansas Power, (913) 625-3437
Ed L. Birdsall, Asst. V.P., Iowa Power & Light, (515) 281-2900
Ed. F. Buckley, Envir. Eng., Iowa Power & Light (515) 281-2220
J. D. Wallace, Kansas Power & Light, (913) 233-1351
Wayne R. Johnson, Manager Production, Kansas City Power & Light Co., (816) 471-0060
J. S. Allen, V.P. Future Planning, Missouri Public Service, (816) 353-5023
Earl Dryer, Senior V.P., Missouri Public Service Co., (816) 353-5002
R. W. Call, Missouri Utilities Co., (314) 335-9461
C. Wilson, V.P. Electric Production, Missouri Utilities Co., (314) 335-9461
R. B. Mayer, St. Joseph Light & Power, (816) 233-8233

Utility Comments & Recommendations

1. Considerable concern was expressed about equipment reliability and availability. Fuel deterioration has created slagging problems resulting in shut down. Efforts are particularly needed in equipment reliability as a function of fuel chemistry. The effort should include variation in configuration to cope with coal differences.

2. The need was expressed for a cost/benefit study of pressurized furnaces versus balance draft furnaces. The effort should relate I.D. fan cost savings versus increased maintenance costs, unit outages and particulate handling problems.

3. One utility must reduce load each night to clean the SO_2 scrubber modules. This SO_2 scrubber system requires 51 men specifically for scrubber maintenance. This represents 25% of the total plant staff. Additional problem areas have included:

   - materials of construction and component lifetime
   - slurry valves
   - isolation damper leakage
   - pH meter performance and reliability
   - Increased I.D. fan capacity (pressure drop increases from 25" to 60" with addition of the SO_2 scrubber
   - Expansion Joint material
   - Disposal of scrubber sludges
   - Measurement of entrained water in scrubber effluents

An environmental impact study on the use of SO_2 scrubbers should be made to evaluate the relative costs and benefits.

The utility commented that although the scrubber system was supplied by a vendor, it has been up to the utility to shoulder the responsibility of making the system work.

This scrubber facility is currently consuming about 1 ton of limestone per 4 tons of coal. Total annual coal consumption is 2.2 million tons with a sulfur content of about 4%. Limestone costs are currently \$3.60/ton.

4. In one state of this region, the water quality regulations require that the operator responsible for water quality be licensed by the state.

5. Considerable interest was expressed for the development of guidelines for fly ash and sludge disposal and water discharge abatement. Particular emphasis should be placed on immediate identification of least cost technical alternatives. With coal, our predominate fuel research is necessary for the utilization of ash.

6. Considerable concern was expressed relative to ESP performance. Needs included:

   a. An improved comparison of hot side versus cold side precipitators.
   b. Improved particulate measuring instrumentation--both optical and in situ particulate sizing.
   c. Improved fly ash level controls for ash hoppers.
   d. Methods to avoid particulate reentrainment in precipitators.
   e. Capability of removing ash from silo without creating fugitive dust problems.

7. As of July 31, 1975, variances under the Clean Air Act are prohibited. After that date, utilities must negotiate an "order to comply" by a specific date.

8. Some utility plants in the region must also convert to coal firing by 1979 in accordance with F.E.A. requirements and are finding coal availability a serious problem.

9. Improved knowledge of fuel additive performance, cost and impact on reliability is necessary for both emission control and boiler slagging modification.

10. Additional research is needed on scrubbing and particulate removal with Western low sulfur alkaline coals.

11. This region has the lowest average annual load factor (∿45%) primarily because of wide climate variances. As a result, at least 30% of total capacity must be in the peaking category. Peaking fuel availability is a particularly critical problem with natural gas being totally eliminated for utility use in the region as early as 1977.

12. Because there are no suitable alternatives available, combustion turbines will continue to be utilized for peaking generation in the foreseeable future. Therefore, research is recommended to achieve the following objectives:

    a. Improve reliability and availability
    b. Extend operating time between overhaul
    c. Minimize internal corrosion
    d. Develop wider range of peaking fuel capability including consideration of a pulverized coal burner for combustion turbine application

e. Reduce noise levels

f. Improved information based on performance and cost of additives and their impact on turbine reliability.

13. One utility has been operating a 100 MW repowered system in which the combustor turbine exhaust is fed to a steam boiler. Because of natural gas shortages, etc., unit is only being used as a peaking facility. Reliability of the repowered system has been particularly limited by expansion joint failures.

14. Guidelines should be developed on the comparative performance of opacity instrumentation and its relationship to actual grain loading and particulate size distribution.

15. The future capacity will be coal and nuclear for base load with gas turbines for peaking.

MINUTES OF

ENVIRONMENTAL CONTROL & COMBUSTION

EPRI REGION II SEMINAR

November 18, 1975, Schenectady, New York

Attendance:

EPRI Representatives

G. Jerry Lanzolatta, Consultant
Larry Nannen, SO_x Project Manager
Kurt Yeager, EC&C Program Manager

Utility Representatives

Floyd F. Dooris, Central Hudson, Associate Environmental Engineer
Peter C. Freudenthal, Con Edison, Chief Air Quality Engineer
F. W. Lipfert, LILCO, Manager - Air Quality
M. S. Pollock, LILCO, Manager - Electric Production
R. G. Aldrich, NMPC, Research and Development
Kurt Anderson, NYPP/ESEERCO, Manager - Environmental Affairs
Kenneth Juris, NYPP, Administrator - Air Quality Program
William H. Smith, O&R, Senior Power Development Engineer
John M. Telesh, Jr., O&R, Power Development Engineer
Bob Geiger, PSE&G, NY, Adm. Manager - Environmental Affairs
Chandan Sengrepta, PSE&G, Lead Research Engineer
Robert M. Burton, RG&E, Environmental Engineer - Air
M. J. Corson, RG&E, Assistant Chief Engineer

Utility Comments and Recommendations

Water Quality

1. The issue of emerging minimum or zero discharge water quality requirements is forcing utilities in the region to emphasize adaptation of stringent water treatment technology to power plants. Additional development work is recommended to minimize the costs associated with these requirements. The use of current sedimentation technology for water treatment, for example, is often unacceptable because of conflicts between achieving required dissolved solids levels and pH. Specifically, iron and other trace metals have been found to redissolve because of pH changes in the waste basin.

2. Several utilities indicated that water quality requirements were limiting the use of chlorine as a biocide to prevent condenser fouling. Mechanical cleaning alternatives have not been satisfactory and rapid development of alternative, compatible biocides should be emphasized.

3. Sections 316A and B of the Clean Water Act are also a source of considerable concern with respect to their impact on the continued operation of power plants. The forcing function on use of cooling towers is primarily fish impingement problems, not thermal considerations. In this regard, it was recommended that EPRI place emphasis on impingement issues. The time frame for dealing with entrainment restrictions is probably to short for EPRI to be effective. It was further recommended that EPRI initially approach the problem by gathering, interpreting and reporting the extensive work already done by individual utilities. For example, it was reported that one company is performing work with Alden Laboratories on fish kills. The results of this study can be made available for general industry consideration.

4. With respect to cooling towers, specific development needs include:

- Evaluation of drift level
- Development of drift eliminator designs for salt or brackish water
- Improved dry cooling tower efficiency
- Determination of the effects of pathogens entrained in cooling tower plumes
- Investigate the botanical injury from cooling tower drift to trees and vegetation.

One company has conducted laboratory experiments which indicate that saline drift from a natural draft cooling tower might potentially injure some tree species. ESEERCO is conducting follow-up laboratory studies. But field studies to confirm the laboratory results are not available. Plant species indigenous to other parts of the country where salt water cooling towers might be used should be tested.

Air Quality

5. Attention should be paid to developing procedures for avoiding opacity problems during boiler startup and load change.

6. It was recommended that EPRI stimulate development of smokeless turbine combustors with the combustion turbine industry. ESEERCO has supported gas turbine additive studies with one company for near-term control of this problem. The possible relationship of this work to EPRI-supported efforts at Public Service Electric and Gas Company should be considered.

7. In the related area of turbine fuel control and maintenance longevity, Long Island Lighting has found maximum benefits from washing the turbine during shutdown, coupled with operation of both stringent air and fuel cleaning techniques.

8. The impact of changing fuel quality and coal conversion under FEA requirements on electrostatic precipitator (ESP) performance is of considerable concern in the region. Opacity violations have caused one plant to derate by about 5% and increase exit gas temperature by 50°F. Acid smut fallout from oil-fired plants is also causing local problems. The change from oil to coal, plus more stringent (99.5%) particulate control regulations, are generally forcing the expensive replacement of ESP installations. Upgrading existing ESPs has not been very effective for existing technology. It was recommended that additional development emphasis should be placed on the following ESP issues:

   - Methods to avoid reentrainment
   - Ways to avoid degradation
   - Evaluation of the comparative performance of hot- versus cold-side ESPs
   - Improved reliability in ash removal systems for ash hoppers
   - Instrumentation to identify and isolate electrode failures.

9. It was reported that the use of European oil burner designs on relatively small boilers, coupled with significant wind box modification, had produced considerable reduction in emissions. Combustion Engineering has proposed to one company that the use of 36 corner fired burners rather than

the normal 16 would substantially control both NO_x and particulate emissions.

10. It was recommended that consideration be given to improving combustion turbine stack design to avoid ground level impingement close to the plant during high velocity winds.

11. It was reported that EEI is consolidating utility experience in the use of oil additives.

12. It was recommended that increased attention be paid by EPRI to the measurement of emissions from all classes of plants including those equipped with scrubbers. Particular emphasis should be placed on defining reliable emission factors, and the variables affecting these factors, for emerging pollutatn issues such as sulfates, nitrates, POM, asbestos, and trace metals.

13. Existing SO_2 and particulate dispersion models are unreliable for use in highly variable terrain. This is particularly discouraging to the use of intermittent control strategies for several plant locations in the region where this control alternative could by far be the most cost effective. The unsatisfactory economics of any other control alternative may thus force premature plant closures in the region. Intermittent control strategies have been developed and are being applied on Long Island, where fuel switching is acceptable (2.8% to 1% - Suffolk Co. and 2.0% to 0.3% - Nassau Co.).

14. It was recommended that a pressing utility requirement needing immediate EPRI attention is the comparative performance of instack gaseous and particulate monitors. Highly variable results have been noted and a diagnosis of

this variability is needed, not only in terms of instrument performance, but also relative to guidelines for installation and operation as well. Again it was recommended that the most appropriate first step may be a gathering, analysis and reporting of industry experience.

15. Concern was expressed over the EPA regulation for stack testing which requires that testing be done high in the stack. It was recommended that EPRI evaluate the technical problems of applying less expensive, time-consuming, and less hazardous breech testing as well as the variables affecting its accuracy.

Noise Control

16. It was recommended that EPRI consider establishing a noise evaluation and control effort. Noise standards already exist in New Jersey and are a general regional concern. EPRI and industry efforts should be directed toward developing dependable noise specifications. Ongoing industry efforts include an ESEERCO supported field evaluation of transformer noise and power plant construction noise. Other areas requiring attention include induced draft fans, cooling towers and pulverizers.

Other

17. In terms of improving EPRI/industry communications as well as the payoff from EPRI efforts, several positive recommendations were presented:

- Increase EPRI credibility and publicity within the technical community through greater participation and publication of results through technical societies.

- Increase direct participation by the utility industry through more project-level working groups. Utilities should have more input to project definition and priorities.
- More emphasis on direct communication of research results through industry seminars and technical service meetings versus distribution of paper reports would improve technical transfer from EPRI as well as user feedback to EPRI.

18. A question was raised relative to the regulatory justification for existing and potential future NO_x standards. The driving function for immediate NO_x control on power plants in the region, particularly in urban areas, was reported as being directed to the control of oxidant levels.

19. Future capacity trends in the region reflect the extremes of both high urban and rural service areas. Combustion turbines typically comprise 25-30% of the capacity of the urban utilities, but considerably less in rural service areas. There is increasing reliance on nuclear and coal in place of oil for base load throughout the region. This new base load capacity will of necessity be located primarily in the rural areas of the region and the closely related New York Power Pool, and will, in general, be jointly owned by the members of the power pool.

MINUTES OF

ENVIRONMENTAL CONTROL AND COMBUSTION

EPRI REGION V SEMINAR

November 24, 1975, Chicago, Illinois

Attendance:

EPRI Representatives

G. Jerry Lanzolatta, Consultant
Kurt Yeager, EC&C Program Manager

Utility Representatives

R. M. Bob Lundberg (Fossil Fuel Task Force representative), Commonwealth Edison, General Staff Engineer
Terrence Kurtz, Central Illinois Light Co., Energy Supply Eng.
Dale W. Magnuson, Central Illinois Light Co., Env. Engr.
James Birkett, Central Ill. Public Service, Coordntr., Env. Protect.
Mike DuBro, Cincinnati Gas & Electricity, Electric Production
E. E. Galloway, Cincinnati Gas & Elect., Principal Env. Engr.
Thomas E. Carroll, Cols & So. Ohio Elec. Co., Env. Department
Robert E. Ruby, Cols & So. Ohio Elec. Co., Generation Department
Joe Agosta, Commonwealth Edison, Res. Engr.
John R. Gilliom, Commonwealth Edison, Prod. Sys. Analysis
H. M. Johaningsmeir, Commonwealth Edison, Mgr. Sta. Mech. Engg.
J. P. McCluskey, Commonwealth Edison, Env. Affairs
Roy A. Wells, Consumers Power Co., Exec. Dir. Env. Activities
Howard R. Palmer, Dayton Power & Light, Mgr. Pwr. Prod. Planning
Larry L. Idleman, Illinois Power Co., Env. Affairs
Phillip L. Licklider, Illinois Power Co., Power Production Dept.
Jack Berlier, Indpls. Power & Light, Mgr. Pwr. Prod. Planning
David M. Gausman, Ohio Edison Co., Production Department
Jim Shook, Ohio Edison Co., Mechanical Engineer
Thomas P. Meinz, Wisconsin Pub. Service Corp., Env. Department
R. A. Solboe, Wisconsin Publ. Service Corp., Supt. Steam Plants

Utility Comments and Recommendations

Water Quality

1. Section 316A and B of the Clean Water Act are of particular concern to the utilities of Region 5 because of the potential for requiring costly cooling towers on new and existing plants. Emphasis should be placed on analyzing the significance of the data collected on the biological impact of cooling water intake structures and determining how to use impingement data after it is collected. In addition, considerably more effort should be given to practical cooling systems and discharge pond design.

2. Region 5 is enforcing a maximum 0.2 ppm total Cl^- residual requirement. This will force the application of new chemical or mechanical biocide treatments. It was recommended that EPRI consider a program with the industry to determine the many unanswered questions relative to the use of biocides. These include:

   - Characterization of fish toxicity. This probably should be done on a regional basis because of the differences in fish populations.
   - Determination of how low a Cl^- concentration can be used before condenser fouling, etc., occurs.
   - Determination of the costs and benefits of alternative biocide methods and agents.

   In this regard, two studies are being conducted under the sponsorship of one company to determine Cl^- toxicity and intake structure impact on the fish population of Lake Michigan. These studies are being performed by Lymnetics, Inc., and the University of Wisconsin at Milwaukee. In addition, one utility is using sodium hypochloride injection in the water box to control Cl^- concentration. This is being injected after the intake screen to maintain only a trace of Cl^- residual at the condenser outlet.

3. Considerable uncertainty exists on the design of offshore discharge of once-through cooling water. Specifically, it is unclear just how well mixing will occur. As a result, a good deal of expensive trial and error effort is generally required after installation to achieve the desired results.

4. One utility will expend $180 million to control water pollution from its fossil generator capacity of 10,000 MW.

5. Because of increasingly stringent regulation on the quality of water discharges, it was recommended that attention be given to the characterization of suspended solids in the ash sluice water, so that least cost control solutions to meeting discharge regulations can be defined.

Air Quality

6. A priority problem within the region is the need for a site-specific design basis for SO_2 scrubber application. The very large high-sulfur, coal-fired generating capacity in this region is forcing the near-term commitment to this type of control technology under existing State Implementation Plans (SIP) and New Source Performance Standards (NSPS) without an adequate design basis on which to reliably proceed. For example, there utilities in Ohio alone are planning a total of 5,000 MW of scrubber capacity to meet NSPS between now and 1983. In order to increase reliability and to reduce the cost, it is planned that some of these sources may combine low-sulfur coal combustion with partial scrubbing.

7. If Supplementary Control Systems (SCS) are not allowed in the pending Illinois SIP, a number of generating plants will be forced to operate at considerably reduced load for several years to meet environmental requirements. Positive control options cannot be economically justified by the affected utilities and sufficient low sulfur coal is not available to fuel the plants.

8. The new Ohio SIP, as defined by EPA, will essentially require SO_2 scrubbers or similar performance, constant control systems on essentially all existing coal-fired generating capacity in the state. These emission requirements are in the range of 1.0% to 0.5% SO_2 on plants currently consuming coal typically in the range of 3% to 4% sulfur content.

9. It was reported that the cyclone boiler operating on Illinois coal can cause opacity violations even if the grain loading requirements are met. For example, the Illinois state standards are 0.2 lb/MBtu on existing sources and 0.1 lb/MBtu on new sources. Meeting both cases can still violate opacity requirements. It was also noted that cyclone boilers operating on Western coal result in high carbon carryover, probably because of the high coal moisture content.

10. It was recommended that EPRI evaluate the in-stack testing vs. the breeching measuring techniques.

11. A comparative evaluation on commercial SO_2 monitoring equipment is necessary.

12. A priority requirement is the development of capabilities to upgrade existing electrostatic precipitators to meet more stringent emission requirements and to operate satisfactorily on off-design coals, particularly Western coals producing high resistivity fly ash.

13. A related issue is ash handling systems, including ash removal from precipitator hoppers and transport to storage and disposal sites. In many cases, the existing ash handling system has not been sized to handle the large quantity of ash produced by the currently available or required coal. Again, the switch to lower grade Western coals, often having both a lower heat content and a higher ash content, in facilities not designed for its use has been responsible for much of this problem. Also, the transition from water to pneumatic ash handling systems for avoiding reliability and water pollution problems has created additional air pollution problems.

14. The need for guidelines on the use of emission control additives in both boilers and combustion turbines was defined by several utilities. These guidelines would identify both the conditions under which the use of various additives should be considered as well as the performance, quantity required, cost and side effects which can be expected.

15. It was noted by several utilities that the nonsignificant deterioration requirements in the Clean Air Act may force the use of SO_2 scrubbers, etc., even with Western coal. In addition, the need for reheat to meet nonsignificant deterioration requirements should be carefully examined and better guidelines developed to avoid unnecessary reheat losses.

16. One company indicated that improvements to electrostatic precipitator design and operating procedures should be developed to reduce the rate of performance degradation with operating time. This utility indicated that even after periodic overhaul, no significant improvement was apparent and the original performance specifications could not be reattained.

17. The need for utility industry guidelines on the noise control characteristics of utility hardware is rapidly emerging because of the promulgation of noise control regulations at the state level. Hardware areas of particular concern include rotating machinery such as fans, turbines, transformers, and steam venting of SH during boiler startup.

18. The increased use of Western low-sulfur subbituminous coal has created a number of operational problems beyond the fouling and corrosion of heat transfer surfaces. These include:

    - Drying and handling this high moisture content fuel
    - Carbon carryover which causes severe induced draft fan wear. As a result, fan life can be as short as three months.
    - Air heater and precipitator fires
    - Steam generator derating because of the lack of mill capacity for this lower heat content fuel. This derating can amount to 5-10%.
    - The need for additives such as SO_3 injection to increase the fly ash conductivity and thus achieve particulate emission requirements with existing electrostatic precipitators.

19. Combustion turbines will continue to be used as peaking capacity although dependence on this form of generation may be reduced if reliable, fast start coal generation capabilities can be developed. As a result, it was recommended that efforts to improve turbine reliability or availability continue to be emphasized, together with the development of practical syntehtic fuel technologies.

Capacity Plans

20. Capacity in the region is heavily oriented toward coal. Future growth plans will continue this emphasis plus increased reliance on nuclear for base load. The nuclear percentage by 1985 will be in the range of 20% to 50% depending on the utility. Combustion turbine capacity is about 10% of total capacity for most utilities in the region. Increased consideration of the use of coal-fired capacity for peaking generation is evident because of the future lack of liquid or gaseous fuel. The development of fast start capabilities for coal-fired units is therefore of fundamental importance. The coal-fired capacity growth plans, particular in the states of Michigan, Wisconsin, and Illinois, indicate considerably increased reliance on Western coal as the preferred option for meeting SO_2 control requirements. This could be considerably affected if emerging nondegradation requirements result in the need for flue gas desulfurization even when low-sulfur coal is used.

MINUTES OF

ENVIRONMENTAL CONTROL AND COMBUSTION

EPRI REGION IV SEMINAR

November 25, 1975, Atlanta, Georgia

Attendance:

EPRI Representatives

G. Jerry Lanzolatta, Consultant
Kurt Yeager, EC&C Program Manager

Utility Representatives

Jack Powell, (Fossil Fuel Task Force representative), TVA, Power Research Staff
F. E. Gartrell, Consulting Engineer (P.P.)
J. E. Dawson, Florida Power Corp., Manager, Eng.
R. S. Albright, Georgia Power Co., Chief Civil & Mechanical Engineer
T. E. Byerley, Georgia Power Co., Mgr. of Env. Affairs
Glen Gosa, Georgia Power Co., Coordinator of Env. Affairs
L. L. Pitts, Georgia Power Co., Vice President Production
David Ratcliffe, Georgia Power Co., Senior Biologist
Joseph B. Beard, Kentucky Utilities Co., Env. Technologist
N. L. Stampley, Mississippi Power & Light, V.P. Production
William J. Johnson, Tampa Electric Co., Sr. Consulting Engineer
Joseph Greco, TVA, Chief, Plant Engr. Branch

Utility Comments and Recommendations

Water Quality

1. By far, the predominant concern of the utilities was in water quality programs. Their major concern was associated with water chemistry. Among the problems enumerated were (a) pH adjustment for very large streams including such things as coal pile runoff. Can this be done on a continuous or a batch-type treatment basis? (b) Discussions were held on common ponding for water treatment. Apparently this is an acceptable scheme in certain states and regions in the United States. Presumably in any totally closed-loop system this, or almost any other method of treatment, would be acceptable. However, if there is any effluent water into the environment, the common treatment approach may not be acceptable. (c) In certain areas, concern was expressed overinternal water side cleaning which results in waste effluents, including cooper, that must be removed. (d) It was recommended that a study be made on the hierarchy of water usage; that is, determine how the water effluents from one part of the overall power generation system can be used as input or makeup water for some other component of the system in order to minimize the total volume of water required. (e) Construction runoff water was identified as a problem in different locations. (f) There seems to be a wide variety of interpretations on 316a and b. Just what do they imply? In conclusion, it was recommended that the EPRI program emphasize the development of guidelines on the performance, cost, reliability and operating requirements of alternative waste water treatment systems.

2. A question was raised about the possiblity of discharging heated water into the interface between fresh water and saline water at coastal sites. Would this be an ideal place for such a discharge?

Air Quality

3. Concern was expressed about the information on allowable emissions that EPA is providing the states for inclusion in their implementation plans. The states of Ohio and West Virginia were specifically mentioned as those in which EPA had used its modeling techniques to determine allowable emissions. It was suggested that EPRI might wish to validate or refute the results of the EPA models.

4. It was pointed out that studies of the effects of coal washing on ash are normally concerned with the amount of total ash reduced by the washing process. However, increasing attention is being given to the effectiveness of washing and other coal cleaning techniques in reducing the content of sulfur and other undesirable constituents. The suggestion was made that EPRI consider investigating the effects of various coal cleaning techniques upon ash characteristics affecting precipitator performance and upon the size distribution and chemical composition (particularly trace elements content) of emitted ash from a power plant.

5. The utility representatives present were eager to see results on comparisons of hot-side versus cold-side precipitators. They were quite concerned that all variables involved in a precipitator system be considered in making any comparative studies. Ash hopper and sluicing system problems should be considered. It was proposed that monitoring of electrostatic precipitators be sectionalized to indicate collection efficiency in any section of the precipitator.

6. A question was raised as to why European design of burners for oil-fired plants works well in terms of minimizing particulate emissions while the U.S. manufacturers of burners have not been so successful. One possibility suggested was that it was just a matter of size. The European designs that have been observed have been only for very small burners compared to the large ones used in U.S. plants. The suggestion was made that EPRI research with the U.S. manufacturers the possibility of designing more efficient large burners.

7. It was suggested that the EC&C program on instrumentation increase consideration of sampling technology for particulates being emitted from scrubbers. The question was also raised as to whether EPRI was developing a technique for correlating opacity measurements from optical monitors with grain loading. One company agreed to organize the information it had accumulated on some efforts to correlate Lear-Siegler readings with grain loading and to provide it to the EPRI staff.

8. Boiler component reliability was an area identified as needing a great deal of investigation and, potentially, studies on this could be of quick and major economic value to utilities. A variety of problems were identified that resulted in forced outages, such as internal corrosion on the heaters of once-through systems not found in subcritical units. Some indication was apparent from company's charts that modern plants are built to barely meet specifications with no reserve margins while older plants were more reliable because of greater margins of safety and lower furnace rating. As a result, their future boiler will have lower furnace ratings and lower pressure (2400 psi). Concern was also expressed that part of the proglem may be traceable

to water treatment procedures and the low pH which is often encountered in the water circulation system. There was criticism of burner designs which were not providing optimum air-coal distribution for maximum burning efficiency. In general, it appeared that there was no concensus on specific deficiencies which resulted in excessive unit outages now being experienced. If EPRI is to respond to this apparent need, it would likely have to initially engage in detailed reliability analysis of outage data collected by EEI and other organizations to identify specific problems meriting research. One likely outcome of such a study would be a report identifying design and operational deficiencies which result in high forced outages without any indication of the need for further R&D.

9. Another problem area identified for inclusion in the combustion area of the EC&C program is design and operating characteristics for boilers which will be used for swinging or peaking loads. It was anticipated by several utilities at this meeting that they would meet future swinging loads with coal-fired plants. While this has not generally been indicated in the seminars of other areas, several of the boiler manufacturers in the country are now supplying boilers for this purpose. I have not heard of their engaging in any special design studies to minimize startup and shutdown cost and to fully evaluate the effect of two-shift operations on such plants.

10. It is also clear that one wishes to minimize capital charges on a "swinger" or "peaker," at the expense of operating costs. Low capital cost water and air pollution control technologies need to be evaluated for inclusion in this type of plant. The question was asked of EPRI if they had valid information on the amount of sulfur which is rejected in the power plant pyrite separators and pulverizers. This problem could have some significance as coal washing may very well

bring eastern coals down to levels which can be utilized to meet air quality standards on existing generating units. The sulfur removal which might be achieved by pulverizer rejection over and above that resulting from prior coal cleaning might be a topping device to enable the utility to meet standards when they are otherwise marginally deficient.

11. The development of design criteria for refuse firing in boilers is of economic and public relations importance, particularly to urban generating facilities in the region.

12. Gas turbines will be utilized for peaking generation in the future, therefore research is desirable in the following areas:

    a. Improve reliability and availability
    b. Extend time between overhaul.
    c. Minimize internal corrosion.
    d. Investigate boundary line noise levels.
    e. Additives performance, cost and side effects.

Regional Capacity Characteristics

13. Current base load capacity is approximately 80% coal with greater emphasis on oil in Florida because of the relative transportation costs. Future growth plans are generally directed toward achieving a greater balance by 1985 between coal and nuclear (about 60%/40%). Oil will be phasing out in several utilities because of the uncertainty in its availability. Peaking capacity will continue to be in the range of 10-15%, divided among combustion turbines, pumped storage and fast start coal fired capacity.

MINUTES OF

ENVIRONMENTAL CONTROL AND COMBUSTION

EPRI REGION X SEMINAR

February 10, 1976, Portland, Oregon

Attendance:

EPRI Representatives

Robert Carr
G. Jerry Lanzolatta, Consultant
Owen J. Tassicker
D. P. Teixeira
Kurt Yeager

Utility Representatives

Thomas M. Ashton, PP&L, Manager Advanced Engineering (Fossil Fuel Task Force Representative)
Carl R. Anderson, Montana Power Co., Mgr. Env. Protection Dept.
Leonard Booth, PGE, Manager Coal Plant Projects
George J. Eicher, PGE, Manager Environmental Services
R. Bruce Snyder, PGE, Meteorologist - Environmental Services
Robert E. Peterson, PP&L, Manager Environmental Services
Peet M. Soot, PP&L, Research Coordinator
W. J. Finnegan, Puget Power, Manager Environmental Affairs
J. Harold Hutchinson, Utah Power & Light, Spec. Project Engineer
Robert D. Anderson, Wash. Water Power, Fish & Wildlife Biologist
Robert W. Anderson, Washington Water Power, Projects Engineer

Utility Comments and Recommendations

Air Quality

1. The fundamental issue facing Western utiliites, as expressed by several utilities in the region, is Best Available Control Technology (BACT). This criterion forms the basis for many state control regulations as well as federal New Source Performance Standards (NSPS) and nondegradation requirements. This is a moving target often subject to interpretation by organizations not qualified to make such judgments. As a result, utilities have cnsiderable difficulty in forecasting with confidence the levels of control which will justify a long-term capital commitment. If such forecasts are made, the technology available to achieve these levels cannot meet acceptable utility standards for reliability and availability.

2. The variability in coal quality has had a major effect on electrostatic precipitator (ESP) sizing and cost. As a result, utilities are beginning to consider both ESPs and bag filters as alternative particulate removal technologies and are seeking bids on both. One company is taking this approach on their new plant.

3. One company reported that they have examined the effect of additives on ESP efficiency. The additives considered included Na, NH_3 and SO_3. Only SO_3 was found to be effective, increasing efficiency in one case from 60% to 95%.

4. A number of problems and needs relative to combustion turbines were identified. These included:

- Development of a reliable peaking fuel source. In this regard it was suggested that methanol might be the most easily achievable synthetic source.
- Better definition of the fine particulate emission factors and composition associated with combustion turbines. In this regard, one company indicated that they had considerable background in determining turbine emissions.
- Development of practical alternatives to water injection for NO_x control, both on the basis of cost and water availability.
- Development of a pulverized coal burner.
- Definition of noise control specifications for lower frequency turbine noise emissions.
- Improved turbine reliability and availability.
- In Oregon, one utility's local regulations prevents the sale of power from combustion turbines to other utilities. This could cause severe problems in meeting local demand.

Water Quality

5. Water quality problems facing utilities in the region include (a) fly ash and scrubber sludge disposal, (b) zero surface water discharge requirements, (c) inadequate evaporation to achieve the necessary cooling tower blowdown concentration, (d) development of acceptable biocides which are compatible with Cl^- discharge requirements, and (e) achieving an overall plant water balance to minimize both discharge and water usage.

Instrumentation and Measurement

6. It was recommended that the EPRI program place increased emphasis on defining analytical guidelines for determining

the elemental composition and chemical state of particulate emissions. Specific emphasis should be placed on the difficult problem of submicron particulate characterization. These small particles may have a composition considerably different from the average based on the total fly ash fraction. These differences will, in turn, affect the atmospheric chemistry as well as the health and environmental implications of these particles.

7. A need was expressed for a real time sulfur and heating value measurement technique to determine how well the coal being burned relates to the sulfur emission regulation. This could save considerable fuel cost by permitting higher average sulfur content coals to be burned without risking an emission violation.

8. A related need is for better guidelines on the fate of coal sulfur to determine how much is removed in the pulverizer, the furnace, and the particulate removal system. If this cannot be accurately predicted. Then in border-line sulfur control situations, expensive blending facilities may have to be used to insure that standards are met.

9. Accurate guidelines should be developed for relating the performance of opacity instrumentation to actual stack grain loading and particulate size distribution. These should consider not only instrument performance but also the installation and operating variables which affect this performance in the utility context.

Other

10. Development of design criteria for refuse burning in boilers is needed to evaluate its complexity.

11. It was suggested that EPRI develop and maintain at least a bibliography of utility related R&D which could be accessed by individual companies to guide their specific technical information needs.

12. The variability in coal quality and its effect on boiler as well as particulate removal performance requires that a much better understanding of ash chemistry and the combustion variables affecting this chemistry be developed.

13. Future growth will be coal with limited nuclear for base load, with pump storage and combustion turbines for peaking.