

**Environmental Assessment**

**Allen Fossil Plant Units 1, 2 and 3  
Selective Catalytic Reduction Systems  
For Nitrogen Oxide Control**

**Tennessee Valley Authority**

**March 2001**

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## Acronyms and Symbols

ACGIH	American Conference of Governmental Industrial Hygienists
ADT	Average Daily Traffic
AIHA	American Industrial Hygiene Association
ALF	Allen Fossil Plant
ANSI	American National Standard Institute
APH	Air Pre-Heaters
AVS	Acid Volatile Sulfides
BMP	Best Management Practice
CaO	Calcium Oxide
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CCB	Coal Combustion By-products
CERCLA	Comprehensive Environmental Responsibility, Compensation and Liability Act
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CMC	Criteria Maximum Concentration
CO <sub>2</sub>	Carbon Dioxide
CWA	Clean Water Act
DO	Dissolved Oxygen
DOE	Department of Energy
EA	Environmental Assessment
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FWV	Free Water Volume
ICBO	International Conference of Building Officials
LOI	Loss on Ignition
MCH	Midwest Coal Handling
MCL	Maximum Contaminant Levels
MSDS	Material Safety Data Sheet
N	Nitrogen
NAAQS	National Ambient Air Quality Standards
NEHRP	National Earthquake Hazard Reduction Program
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NMSZ	New Madrid Seismic Zone
NNL	National Natural Landmark
NO	Nitric Oxide
NO <sub>2</sub>	Nitrogen Dioxide
NO <sub>x</sub>	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
OSHA	Occupational Safety and Health Administration
OTAG	Ozone Transport Assessment Group
Pb	Lead
PCB	Polychlorinated Biphenyl
PM-10	Particulate Matter—aerodynamic diameter of 10 microns or less
PM-2.5	Particulate Matter—aerodynamic diameter of 2.5 microns or less

## Acronyms and Symbols

RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Plan
RQ	Reportable Quantity
SCR	Selective Catalytic Reduction
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SNCR	Selective Non-catalytic Reduction
TDEC	Tennessee Department of Environment and Conservation
TDF	Tire Derived Fuel
TDS	Total Dissolved Solids
TWRA	Tennessee Wildlife Resources Agency
UBC	Uniform Building Code
USACOE	U. S. Army Corps of Engineers
USGS	U. S. Geological Survey
VOC	Volatile Organic Compound
WET	Whole Effluent Toxicity
Zn	Zinc

## Units of Measure

°C	degree Celsius
°F	degree Fahrenheit
cfs	cubic feet per second
cms	cubic meters per second
d	day
ha	hectares
hr	hour
Hz	Hertz (frequency in cycles per second)
kg	kilogram
km	kilometer
L	liter
lbm or lb	pound mass
m	meter
m <sup>3</sup>	cubic meters
mg/L	milligram per liter
mmBtu	millions of British thermal units
mmsl	meters above mean sea level
mph	miles per hour
MW	megawatt
MWh	megawatt-hour
pH	standard units of acidity
ppb	parts per billion
ppm	parts per million
s	second
yr	year

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# CHAPTER 1: PURPOSE, NEED, AND BACKGROUND FOR THE PROPOSED ACTION

## **Purpose of the Proposed Action**

The purpose of this action is to reduce nitrogen oxides (NO<sub>x</sub>) emissions (up to 90%) by installing selective catalytic reduction (SCR) systems on Units 1,2 and 3 at TVA's coal-fired Allen Fossil Plant (ALF) to meet State Implementation Plan (SIP) limits under section 110 of the Clean Air Act (CAA).

## **Need for the Proposed Action**

TVA must meet Title I CAA requirements for ozone for which NO<sub>x</sub> is a precursor.

## **Background**

The following discussion of NO<sub>x</sub> air pollution and control technologies was primarily taken from *Pollution Engineering Online*, 1998.

### Air Pollution from Nitrogen Oxides

NO<sub>x</sub> emissions are a major factor in causing national environmental problems, including acid rain and high ground-level ozone concentrations. As recently as 1996, more than 50 million Americans were living in areas with unhealthy ozone levels. NO<sub>x</sub> also plays a role in elevated fine particulate levels, a pollutant, the effects of which the U.S. Environmental Protection Agency (EPA) recently addressed by revising the National Ambient Air Quality Standards (NAAQS) to regulate concentrations of particulate matter—aerodynamic diameter of 2.5 microns or less (PM-2.5).

NO<sub>x</sub> includes nitric oxide (NO) and nitrogen dioxide (NO<sub>2</sub>), and is produced in motor vehicle and industrial combustion processes. These by-products form in three ways: when nitrogen in the fuel combines with oxygen in the combustion air (fuel NO<sub>x</sub>), when fuel hydrocarbons break down and recombine with atmospheric nitrogen (prompt NO<sub>x</sub>) and when the intense heat of combustion causes atmospheric nitrogen to combine with atmospheric oxygen (thermal NO<sub>x</sub>). NO is a colorless gas that is converted in the atmosphere to yellowish-brown NO<sub>2</sub>. NO<sub>2</sub> can cause adverse human health effects, including bronchitis, pneumonia, lung irritation and increased susceptibility to viral infection. Animal studies indicate that intermittent, low-level NO<sub>2</sub> exposures also can induce kidney, liver, spleen, red blood cell and immune system alterations.

NO<sub>x</sub> emissions lead to the formation of ground-level ozone (photochemical smog), which has a strong negative impact on human health and the environment. Ozone impairs lung function and aggravates heart disease and respiratory diseases such as asthma and bronchitis. Ozone also impairs visibility and causes crop and forest damage.

NO<sub>x</sub> reacts with oxygen and other components of air to form nitrates, which can coalesce into fine particles. Studies of collected PM-2.5 suggest that nitrates make up more than 10 percent of the mass of fine particulate in the western two-thirds of the country.

NO<sub>x</sub> also contributes to the formation of acid rain. Acid rain has been shown to destroy fish and other forms of fresh- and coastal-water life, and to damage buildings and materials, forests and agricultural crops. In the eastern United States, NO<sub>x</sub> emissions are responsible for about one-third of rainfall's acidity over the full year and one-half during the winter.

In 1994, national emissions of NO<sub>x</sub> were 23.6 million tons. Electric utility and industrial fuel combustion contributed 9.7 million tons of NO<sub>x</sub>, with an almost equal amount coming from mobile sources. Because so many Americans are exposed to smog, EPA regards ozone as a pervasive air pollutant. Analysis by the Ozone Transport Assessment Group (OTAG) shows significant NO<sub>x</sub> reductions are necessary to solve the ozone non-attainment problem that affects many areas of the United States.

The control of NO<sub>x</sub> came under intense government scrutiny with the passage of the Clean Air Act Amendments (CAAA) of 1990. Titles I and IV of the CAAA are directly applicable to the reduction of NO<sub>x</sub>. Title I deals with the reductions in emissions of air pollutants to attain ambient air quality standards. Ambient ozone levels are the driving force for the installation of NO<sub>x</sub> controls under this title. Title I of the CAAA also regulates the emissions of NO<sub>x</sub> from municipal solid waste incinerators, both new and existing. Title IV is intended to reduce acid rain deposition. It primarily affects utility coal-fired boilers and cogeneration boilers with a 25-MW capacity or greater. Title IV of the CAAA requires a 2-million-ton reduction in coal-fired utility plant NO<sub>x</sub> emissions by the year 2000.

In addition to the requirements for NO<sub>x</sub> reduction derived from the CAAA, state, regional and local guidelines also set limits for emissions of NO<sub>x</sub> from existing sources.

### NO<sub>x</sub> Control Technologies

Numerous technologies are used to control NO<sub>x</sub>. These can be divided into two main categories: NO<sub>x</sub> prevention and NO<sub>x</sub> removal. Common prevention alternatives include low-NO<sub>x</sub> burners and furnace modifications. Selective non-catalytic reduction (SNCR) and SCR are typical post-combustion removal methodologies.

#### *Prevention Alternatives*

In many cases, pollution prevention through the use of low-NO<sub>x</sub> burners, overfire air or low-NO<sub>x</sub> combustors is the most effective control approach. Low-NO<sub>x</sub> burners can reduce NO<sub>x</sub> emissions 20 percent to 60 percent compared to older generation burners. This NO<sub>x</sub> control alternative generally has low to moderate capital equipment costs and low maintenance costs.

Furnace modifications such as overfire air, staged combustion and gas reburning can prevent the formation of NO<sub>x</sub>. These modifications can include additional overfire air ports, which divert approximately 20 percent of the total combustion air to a secondary burning zone above the wind box, thus creating a fireball at or near stoichiometric air conditions. This extends the duration of the primary combustion zone so a greater portion of the devolatilization will take place before entering the fireball, thus reducing thermal NO<sub>x</sub> production.

With gas reburning, natural gas is injected near the primary combustion zone to reduce the availability of oxygen. A significant portion of the NO<sub>x</sub> precursors decompose and form other harmless nitrogen species. Overfire air is injected high enough in the furnace to allow sufficient residence time for the reburning reactions to reduce NO<sub>x</sub> and its precursors and to complete combustion.

The major drawbacks of each of these technologies include their inability to meet required emission standards or future limits. And in some cases, as for cyclone burners (such as at ALF) or wet bottom boilers, these technologies may not be applicable. Further, when applicable, low-NO<sub>x</sub> burners also may increase the loss on ignition (LOI) content of the fly ash, increase furnace and water tube corrosion, lower boiler efficiency and increase particulate emissions.

#### *Post-combustion Removal*

SNCR is a post-combustion chemical process for the removal of NO<sub>x</sub> from combustion gases. A nitrogenous compound, typically ammonia or urea, is injected directly into the hot flue gases. At suitably high temperatures (1600°F to 2100°F), the nitrogenous compound decomposes and chemically reduces the NO<sub>x</sub> to form molecular nitrogen and water. The temperature of the hot flue gases is the primary driving force for the reaction, and a catalyst is not needed. The efficiency of the chemical reaction depends on factors that include flue gas temperature, residence time at temperature, amount and type of nitrogenous reagent injected (ammonia or urea), mixing effectiveness and uncontrolled NO<sub>x</sub> levels. Twenty percent to 40 percent reductions of uncontrolled NO<sub>x</sub> levels are common. The two primary reagents used for the SNCR process are anhydrous ammonia and urea. Approximately 280 SNCR systems have been installed worldwide for a wide variety of industries. In the United States, commercial installations and demonstrations have included most boiler configurations and fuel types, as well as other major NO<sub>x</sub>-emitting process units such as cement kilns. However, there is no experience on large (greater than 160 MW) boilers in electric utility service. In addition, SNCR operation results in large amounts of ammonia slip (the emission of unreacted ammonia).

SCR uses a catalyst to promote the chemical reaction between NO<sub>x</sub> and a nitrogenous compound, generally ammonia, to produce molecular nitrogen and water. First patented in 1959, SCR is used to significantly reduce NO<sub>x</sub> emissions from more than 250 sources in the United States. However, only a few of these sources are coal-fired boilers. There are more than 500 sources worldwide using SCR technology. In the United States, SCR has been applied on utility and industrial boilers, gas turbines, process heaters, internal combustion engines, chemical plants and steel mills. Reduction levels of better than 90 percent are achievable with SCR, given the proper fuel, combustor and operating parameters.

In the SCR process, the catalyst allows the chemical reaction between NO<sub>x</sub> and ammonia to occur at significantly lower temperatures (350°F to 1100°F) and with greater reagent utilization than does the SNCR process. An ammonia/air or an ammonia/steam mixture is injected into the combustion gas stream containing the NO<sub>x</sub>. The gases are thoroughly mixed in a turbulent region, and then pass through the catalyst where the NO<sub>x</sub> is reduced. The catalyst promotes the reaction but is not consumed by it. The catalyst's effectiveness lessens with time as its surface becomes

contaminated with dust or trace elements from the flue gas. Several different catalysts are available for use at different gas temperatures. Base metal catalysts may contain titanium, vanadium, molybdenum or tungsten. Operating temperature ranges for base metal catalysts are between 450°F and 800°F. For higher temperatures, 675°F to 1100°F, zeolite catalysts have been used. For lower temperatures, 350°F to 550°F, catalysts containing precious metals such as platinum and palladium are preferred.

Tightened NO<sub>x</sub> removal requirements have resulted in more SCR installations in the United States. Capital and operating costs have dropped rapidly over the past decade as a result of technological innovation, increased manufacturing expertise and competition among suppliers. Longer-than-expected catalyst lives have contributed to the reduced operating costs.

There is a concern about the use of SCR with high-sulfur fuels because sticky ammonium bisulfate can be deposited on the catalyst, air heater and other downstream surfaces. This compound is formed through the reaction of ammonia with sulfur trioxide (SO<sub>3</sub>), which in turn is formed by the oxidation of the sulfur during the combustion process and then through the oxidation of sulfur dioxide (SO<sub>2</sub>) by the SCR catalyst. By minimizing ammonia slip and suppressing the oxidation of SO<sub>2</sub>, the amount of ammonium bisulfate may be kept to a level that does not affect boiler operation.

Ammonia slip, the emission of unreacted ammonia, is caused by the incomplete reaction of injected ammonia with NO<sub>x</sub> present in the flue gas. A system designed to achieve good distribution and mixing of the injected ammonia with the flue gas, as well as proper catalyst sizing and selection, will ensure ammonia slip is controlled to levels low enough that effects on plant operation, ash properties and health will be insignificant. The drawbacks of SCR technology include the difficulty of storing and transporting ammonia, the high capital cost of the catalyst, the difficulty of thoroughly mixing the injected ammonia in a turbulent zone prior to the catalyst, maintenance of the required reaction temperatures and disposal of spent catalysts.

SNCR and SCR may be used as a hybrid system. The SNCR process would provide a substantial portion of the NO<sub>x</sub> removal and the SCR process would both control ammonia slip and perform the remaining treatment. A possible advantage of a hybrid SNCR/SCR system would be a reduction in capital cost since the amount of expensive catalyst required would be reduced.

### Allen Fossil Plant

ALF is located in Shelby County, Tennessee about 5 miles southwest of downtown Memphis (Figure 1). The plant site is located on the south side of McKellar Lake near the left bank of the Mississippi River. The plant is accessed by way of a plant road from T. O. Fuller State Park. The plant is located on a 499 acre (202 hectare) reservation. Most nearby lands are industrial site properties. The closest residences are located about three miles away.

The plant was built in the 1950's by Memphis Light, Gas and Water. Construction of the plant began in March of 1956. The original three generating units became



operational between May and October 1959. Generating capacity for each unit is 330 MW (total 990 MW). The plant was leased by TVA in 1965 and purchased by TVA in 1984.

Sixteen gas turbines were added by TVA in 1971 and four additional gas turbines added in 1972. These gas turbines were designed to start quickly and provide almost 621 MW of additional power during periods of peak demand. The gas turbines are located on the plant site southeast of the main powerhouse. The plant generating capacity produces 4,900 billion kilowatts-hours of electricity in a typical year. This is enough electricity to supply electricity to 345,000 homes

Each of the seven burners per unit at Allen is of a cyclone design. In 1994-95 Allen switched from using higher sulfur eastern coal to burning low-sulfur coal from western states. Coal is transported to the plant by barge only. Coal consumption for Allen is approximately 7,200 tons per day (about 2.1 million tons annually based on 80% load factor). The coal combustion process produces SO<sub>x</sub>, NO<sub>x</sub>, and ash particles (called fly ash or particulate). Large concentrations of these pollutants may adversely affect human health, vegetation, and wildlife. In 1972, high-efficiency electrostatic precipitators were installed on all three units to remove fly ash. Use of low-sulfur coal aids in addressing the need for environmentally acceptable emissions of SO<sub>2</sub>. Instruments mounted on the unit stacks monitor the SO<sub>2</sub> and the NO<sub>x</sub> emissions to assure continuing compliance with environmental regulations. All three units have stacks that are 400 feet in height. The result of switching to low-sulfur coal in conjunction with adding overfire air was a reduction in SO<sub>2</sub> emissions from about 3.7-3.8 lb/mm Btu to 0.8 lb/mm Btu, or about a 79 percent decrease in SO<sub>2</sub> emissions compared to earlier levels.

#### Related National Environmental Policy Act (NEPA) Documents

NEPA documents prepared by TVA related to the Allen Fossil Plant are listed below.

- Energy Vision 2020 - Integrated Resource Plan. Environmental Impact Statement. Tennessee Valley Authority. December 1995.
- Allen Gas Turbine Plant Units 1-16. Environmental Statement. Tennessee Valley Authority. October 1971.
- Gas Turbine Peaking Plant Addition, Units 17-20 Thomas H. Allen Steam Plant, Shelby County, Tennessee. Environmental Statement. Tennessee Valley Authority. March 1972.
- Allen Fossil Plant Biogas Fuel Supplement Project. Environmental Assessment. Tennessee Valley Authority. January 2000.

#### Scoping Process

A TVA interdisciplinary team reviewed the potential direct and indirect effects of the proposed use of SCR systems at Allen for NO<sub>x</sub> control. From this review the following environmental issues were identified for review:

- Beneficial effects to air quality from reducing NO<sub>x</sub> emissions

- Contamination of coal combustion by-products with ammonia
- Contamination of chemical pond and ash pond with ammonia
- Wastewater and impacts to surface water quality from ammonia in the chemical pond and ash pond effluent
- Compliance with floodplain Executive Order 11988 for the West Ash Pond extension
- Public and worker safety issues related to the storage and handling of anhydrous ammonia
- Socioeconomic effects of the project related to increased jobs

Issues identified with minor potential for impacts were terrestrial ecology; wetlands, and floodplains; land use; visual aesthetics and noise; archaeological and historic resources; solid and hazardous waste; aquatic ecology; groundwater quality; and transportation. These major and minor issues were the basis for the evaluations in the Environmental Assessment (EA).

#### Public and Agency Involvement

In October 2000 a notice of availability for this EA was published in the Memphis Commercial Appeal serving Shelby County. This notice informed interested persons that copies of the EA were available for review at the main and two branches (Levi and South) of the Memphis/Shelby County Public library. The period for public and agency comments was October 20 to November 23, 2000.

Copies of the draft EA were sent to the Tennessee Department of Environment and Conservation (TDEC) and the U. S. Fish and Wildlife Service (Cookeville, TN Office). Coordination was also completed with the Tennessee State Historic Preservation Officer (SHPO).