Final

FILE

BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF :	)	
	)	
PROPOSED NEW 35 ILL. ADM. CODE, SUBPART W, THE NOx TRADING PROGRAM FOR ELECTRICAL GENERATING UNITS, AND AMENDMENTS TO 35 ILL. ADM. CODE 211 AND 217	))))	R01-9 (Rulemaking-Air)

CAM

NOTICE

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SEE ATTACHED SERVICE LIST

PLEASE TAKE NOTICE that I have today filed with the Office of the Clerk of the Pollution Control Board the TESTIMONY OF CHRISTOPHER ROMAINE of the Illinois Environmental Protection Agency, a copy of which is herewith served upon you.

ILLINOIS ENVIRONMENTAL
PROTECTION AGENCY

By: [signature]
Laurel Kroack
Acting Associate Counsel
Division of Legal Counsel
Bureau of Air

DATED: August 18, 2000

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BEFORE THE ILLINOIS POLLUTION CONTROL BOARD

RECEIVED
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AUG 2 1 2000
STATE OF ILLINOIS
Pollution Control Board

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	)	
PROPOSED NEW 35 ILL.ADM.CODE 217,	)	R01-9
SUBPART W, THE NOx TRADING	)	(Rulemaking – Air)
PROGRM FOR ELECTRICAL GENERATING	)	
UNITS, AND AMENDMENTS TO 35 ILL.	)	
ADM.CODE 211 AND 217.	)	

TESTIMONY OF CHRISTOPHER ROMAINE

Qualifications

My name is Christopher Romaine. I am here today for the Illinois Environmental Protection Agency (Illinois EPA), where I am the Manager of the Utility Unit in the Permit Section in the Bureau of Air.

I have a Bachelor of Science degree in engineering from Brown University and have completed coursework towards a Masters Degree in Environmental Engineering from Southern Illinois University. I am a Registered Professional Engineer in the State of Illinois.

I joined the Illinois EPA in June 1976, at a junior level in the Permit Section in the Division of Air Pollution Control. I became Manager of the Utility Unit in 1999, after about a year and a half as the Acting Manager. I also previously served as Manager of the New Source Review Unit in the Permit Section. In addition to my duties related to permitting, I have assisted in developing a number of regulatory programs for stationary sources. These programs include Reasonable Available Control Technology (RACT) for certain types of volatile organic material units, the Clean Air Act Permit Program (CAAPP), and the Emission Reduction Market System (ERMS).

As Manager of the Utility Unit, I oversee a staff of engineers who review air pollution control permit applications for electric power facilities. This includes the review of construction permit applications submitted for proposed new power plants. My tenure in the Utility Unit has coincided with the influx of proposals for new natural gas fired power plants in Illinois, which has accompanied economic deregulation of the generation of electricity in the State.

The purpose of my testimony is to provide the Board with information on these new natural gas fired power plants, and to answer questions concerning these plants, permitting and NOx control technologies.

New Natural Gas Fired Power Plants

In the two-year span since mid-1998, in conjunction with the economic deregulation of electric power generation, over fifty new natural gas fired power plants that have been proposed in Illinois. Most of these new plants are specifically designed as peaker plants and are intended to operate for a limited number of hours, primarily in summer months. There were previously only a small number of existing peaker power plants in Illinois, which have operated on a limited basis to meet peak power demand and provide emergency power. These new natural gas fired plants also include plants being developed for year round operation, which would function as base load or cyclic plants depending upon the availability of power from existing plants. These new plants are being proposed throughout the state, not only in "downstate" rural areas where new power plants were historically located, but also in the greater Chicago metropolitan area. Most of the new plants are being developed by companies that are new to Illinois, rather than companies like Illinois Power or Commonwealth Edison. At the same time, there are certainly projects that are proposed by Illinois' historic utilities and many of these are at or adjacent to existing coal-fired power plants. These new facilities will operate with existing power plants to meet the demand for electric power.

Gas Turbines

The new power plants in Illinois use gas turbines to produce electricity. Gas turbines are also known as combustion turbines and are more commonly referred to as jet engines. Gas turbines are called "gas" turbines because the working fluid is a hot gas, not because they burn natural gas. Indeed, some of the new power plants being developed in Illinois are being built with the capability to burn oil as a secondary fuel, which would allow these plants to continue to function if there were an interruption in their natural gas supply, as would most likely occur in winter months when natural gas is used for space heating.

A gas turbine is a rotary internal combustion engine with three major parts: an air compressor, burner(s), and a power turbine. In the air compressor, a series of bladed rotors compresses the incoming air from the atmosphere. A portion of this compressed air is then diverted through the combustors or burners, where fuel is burned, raising the temperature of the compressed air. This very hot gas is mixed with the rest of the compressed air and passes through the power turbine. In the power turbine, the force of the hot compressed gas as it expands pushes another series of blades, rotating a shaft. Much of the mechanical energy produced by the power turbine is consumed to drive the air compressor. The remainder is available to do useful work. In the case of a gas turbine power plant, the power turbine turns an electric generator to make electricity.

Peaker plants are generally developed with only basic or simple cycle gas turbines, as described above. This is because simple cycle turbines have relatively low capital cost compared to the power that they can produce. At the same time, their operating costs are relatively high, in large part due to the use of natural gas or oil as a fuel. Thus the economics of simple cycle turbines fit their use for peaking power production.

Gas turbines are also used to generate electricity in hybrid systems known as combined cycle turbines, which are generally designed to operate year round to supply electric power. The difference between simple cycle turbines used for peaking and combined cycle turbines is that in a combined cycle turbine, the hot exhaust gases discharged from the turbine do not go directly to the atmosphere. Instead, the hot exhaust gases from the turbine, which are typically at about 1000 °F, are ducted through a waste heat boiler and are used to generate steam. This steam is then used to drive a steam turbine generator, as in more traditional steam power plants. The recovery of the heat energy in the exhaust of a gas turbine in this manner increases the energy efficiency of a combined cycle plant by about 50 percent compared to a simple cycle turbine. (The thermal efficiency of modern simple cycle power plants is about the same as that of a coal fired power plant, that is, between 30 and 35 percent.) The additional output from the plant makes the natural gas fired combined cycle plant more cost-competitive with coal-fueled plants for electric power generation.

When considering the actual gas turbine, there are two basic types of turbines, so called heavy-duty or frame turbines and aero-derivative turbines. Frame turbines are specifically designed for land-based utility or industrial applications. Aero-derivative turbines, while adapted for land-based applications, are derived from aircraft engines and generally have counterpart models of engines that are used on jet aircraft. Depending on the manufacturer and engine model, the extent of these adaptations varies. Aero-derivative turbines generally operate at higher air compression levels than frame turbines and are not available in as large sizes. The thermal efficiency of the aero-derivative engines generally appears higher than the frame units, but aero-derivative are also reported to have a higher capital cost per unit of electrical output.

There are a handful of manufacturers of each type of turbine. The major manufacturers of frame turbines are General Electric (GE), Westinghouse, Siemens Westinghouse, and Asea Brown Boveri (ABB). Major producers of aircraft engines include Pratt & Whitney, Rolls Royce and again GE (formerly Stewart & Stevenson). In addition, a number of firms make smaller industrial turbines that are not used in utility applications. The new power plants being developed in Illinois include projects with turbines from each of the major manufacturers of turbines

Each manufacturer makes a number of different models of gas turbines in a range of sizes. Gas turbines are rated by their power output, i.e., the amount of electricity in Megawatts (MW) that they can nominally produce. The new peaking plants being developed in Illinois have turbines that range in size from a nominal output of about 20 MW to 190 MW. Except for two small plants, the new peaker power plants being developed in Illinois have two or more turbines, which are usually the same model. The amount of power produced by a plant can be managed by turning gas turbines on or off, so that each gas turbine normally operates in its upper load range, which is where gas turbines are most efficient. The new combined cycle power have units that range in size from a nominal output of about 168 to 310 MW, except for a cogeneration project at a manufacturing site, which has 14 MW turbines. The combined cycle plants usually have two or four units, although one plant has proposed to install ten combined cycle turbines.

In summary, while gas turbine are similar in concept, the new power plants proposed in Illinois vary greatly due to the nature of the plant and the type and number of turbines and the associated systems that have been selected by the developer.

Emissions

Gas turbines emit nitrogen oxides (NOx). As in other types of high-temperature combustion units, NOx is formed thermally by combination of oxygen and nitrogen in the air at the temperatures and conditions experienced in the burners of the gas turbine. NOx can also be formed from the combination of nitrogen contained in a fuel with oxygen when the fuel is burned. This is not significant for burning natural gas, which contains negligible amounts of nitrogen. Factors affecting NOx formation from a gas turbine include ambient conditions, burner design, and firing rate.

Due to the particular features of different gas turbines and continuing developments in burner design, the preferred source of information on the expected emissions of a particular model of turbine is the manufacturer of the turbine. Manufacturers routinely provide detailed data sheets providing the maximum expected emissions of a particular model of turbine, along with other performance data, under different conditions of gas turbine load and operating conditions and ambient temperature. Once gas turbines are installed, actual emission rates can be determined by measuring the amount of pollutants in the exhaust of the turbine as it passes through the stack.

The NOx emissions of gas turbines are routinely expressed in terms of the concentration of NOx in the turbine exhaust, normalized to 15 percent oxygen to account for variations in the amount of combustion air used in different models of turbines. For the modern turbines at the new power plants being proposed in Illinois, the maximum NOx emission rates provided by the manufacturers' of the turbines range from 9 to 30 ppm when firing natural gas, without add-on control. This is roughly equivalent to NOx emissions in the range of 0.036 to 0.12 pound per million Btu heat input, depending upon the design and performance of a particular model turbine.[1]

The amount of NOx emitted from these new turbines becomes significant because of the large amount of fuel being burned. For example, even a relatively small 44 MW gas turbine consumes about 400,000 cubic feet of natural gas per hour at full load (400 million Btu fuel heat input). In addition, the operation of peaker plants is concentrated on hot summer days, coinciding with the same weather conditions that are conducive to exceedances of the ozone air quality standard.

Gas turbines also emit carbon monoxide (CO) and, at much lower concentrations, volatile organic material (VOM), as a result of incomplete combustion of fuel. Factors affecting CO and VOM formation from a gas turbine again include burner design, and firing rate, which directly influence the time, temperature and turbulence of the combustion conditions experienced in the burners and the efficiency of combustion. In the absence of other measures, emissions of NOx and CO/VOM are generally considered to be related inversely. That is, everything else being equal, increasing flame temperatures and turbulence in a burner, which improves combustion efficiency and lowers emissions of CO/VOM, results in conditions that are more conducive to formation of NOx. Likewise, lowering peak flame temperatures and turbulence, which reduce NOx formation, tends to lower combustion efficiency and increase emissions of CO/VOM. Thus one constraint in combustion modifications to reduce NOx formation is being able to maintain or even improve combustion efficiency.

Existing Regulations

Modern gas turbines are able to readily comply with the applicable NOx emission standards that have been adopted for them, that is, the federal New Source Performance Standard for Stationary Gas Turbines, 40 CFR 60, Subpart GG. This standard, which was developed in the late 1970s, limits the NOx emissions of utility turbines to 75 ppm NOx, with an adjustment for thermal efficiency. Accordingly, this testimony focuses on the applicability of the federal rules for Prevention of Significant Deterioration of Air Quality, (PSD), 40 CFR 52.21, on the

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[1] There are also a few projects that involve <u>used</u> turbines moved from another location. The reported NOx emissions of these turbines range from about 40 to 175 ppm. This is equivalent to NOx emissions ranging from 0.16 to 0.7 pound NOx per million Btu heat input.

development of the new natural gas fired power plants.

The Illinois EPA administers the PSD permit program for sources in Illinois under a delegation agreement with USEPA. PSD can have an effect on a proposed power plant because a plant that qualifies as major for a pollutant under PSD is subject to additional requirements for that pollutant under the PSD rules. In particular, a major plant must be operated to comply with control requirement for the pollutant that represent Best Available Control Technology (BACT), as determined and approved on a case-by-case basis during issuance of a construction permit for the project. A Construction Permit that contains such approval is commonly referred to as a PSD permit. Otherwise, with respect to the PSD rules, a "non-major" project need only manage and control its future emissions so as to comply with the terms of its permit, so does not that it constitute a major source.

The need for PSD approval or a PSD permit for a proposed project is determined by its potential emissions of pollutants. Because enforceable limits must be considered in determining potential emissions, the permitted emissions of a proposed new source effectively become the source's potential emissions. Permitted emissions generally reflect the hours of operation or throughput requested by a source in its application, with emissions in compliance with applicable standards or at such lower rate as also specified in the application. Accordingly, the need for a PSD permit is triggered for a proposed new power plant if the permitted emissions of a pollutant, for example NOx, requested by the applicant equal or exceed the major source threshold of the PSD rules. The applicability threshold for year-round turbines is emissions of 100 tons per year, whereas the threshold for simple cycle turbines is generally 250 tons per year.[2] The applicability of PSD to propose additions of turbines at existing power plants cannot be distinguished based upon the type of turbines, like the new plants. This is because the applicability provisions of PSD for

[2] There are two applicability thresholds for a major new source under the PSD rules. One threshold, set at annual emissions of 100 tons or more, applies to 28 listed categories of sources. The other threshold is set at 250 tons and applies to all other categories of source. Gas turbines are not listed as one of the specific categories of source. However, one of the listed categories is "Fossil fuel-fired steam electric plants of more than 250 million British thermal units per hour heat input." This category has been construed to cover combined cycle turbines, which do use steam to produce electricity. Simple cycle turbines generally do not use steam to produce electricity.

modifications at existing sources that are already major are significantly different than the provisions for new sources. For an existing major source, applicability of PSD is triggered by a modification to the source that would result in a significant increase in emissions. For this purpose, the significant emission thresholds are an annual increase in permitted NOx emissions of 40 ton per year. For the purpose of determining whether there is a significant emission increase of a pollutant, actual emission decreases that are contemporaneous with the proposed increase in emissions may be considered to show that there is not a significant net emission increase. Accordingly, even though PSD may be triggered for an existing source by a much smaller emission increase than for a new source, most of the new turbines proposed at existing power plants are not considered major for NOx because of compensating decreases in NOx emissions that have or will occur from existing units.

Permitting of Gas Turbines

Like other construction permit applications, construction permit applications for peaker plants are reviewed to determine whether the application shows compliance with the applicable air pollution control requirements. If compliance is shown, permits are prepared with detailed conditions that identify applicable rules and requirements and set forth appropriate testing, monitoring and recordkeeping to verify compliance when and if the proposed facility is built.

Modern gas turbines readily comply with the adopted NOx emission standard that applies to them. The principle technical task in processing an application for a peaker plant is to address the federal PSD rules, as it may establish project specific emission standards. As previously explained, based on the data for maximum emissions and operation provided in an application, a proposed plant or project may constitute a major source subject to PSD for one or more pollutants. Alternatively, it may also constitute a non-major source for many or all pollutants, as is the case for most of the new peaker plants proposed in Illinois.

For a proposed minor source, the task in permitting is to develop a permit that contains appropriate conditions to limit the emissions of the relevant pollutant from the source to below major source thresholds, as described by the applicant in its application. This generally requires establishment of (1) short term limits on emissions, usually expressed in pounds/hour (2) long-term limitations on hours of operation or fuel consumption, (3) annual limits on emissions, expressed in tons/year, and (4) provisions for testing, monitoring, and recordkeeping which the Permittee must implement to verify compliance applicable limitations.

For a proposed major source, conditions delineating permitted emissions must also be developed as described above for a minor source. However, the limits for a major source provide for permitted emissions in excess of major thresholds and are based on the emissions described in the application, which were addressed by the BACT determination, impact analyses, and other requirements for a major project.

In either case, permit analysts rely on the information in the application, including the emission data provided by the manufacturer of the gas turbine. If a permit is issued for the project, significant representations made in the application are made conditions so as to govern restricting the operation of the project. Emission testing to date has shown that turbine manufacturers are able to reliably predict maximum emission levels of new turbines as needed for purposes of permitting.

While many peaker projects request permitted emission levels just below the PSD applicability threshold of 250 tons per year, it is not apparent that developers are unrealistically constraining the operation of projects. It is quite probable that the operation of some plants is being overstated, so as to maximize their capability to provide peak power. In addition, independently owned peaker plants do enter into advance contracts to provide power upon demand. Accordingly, the requested levels of operation may be related to the ability to establish contractual obligations, even though a plant's anticipated levels of actual operation are much lower. In any event, the developers of peaker projects have generally demonstrated an interest in maximizing the permitted hours of operation of plants and their ability to supply power. For certain plants, this makes it necessary for the developer to select new models of gas turbines that have low NOx emission rates, if the proposed plant is to be permitted as a non-major source.

For a major project requiring a PSD permit, the BACT demonstration submitted as part of the permit application must also be considered. As already indicated, most peaker plants are being developed as non-major sources. To date, only three BACT determinations for NOx that have been made for simple cycle peaking plants in Illinois. All involved GE frame turbines burning only gaseous fuel. The BACT demonstrations in these applications evaluated the use of add-on control devices for NOx and demonstrated that add-on control devices should not be required. Dry low-NOx burners achieving 15 ppm NOx, hourly average, have been determined to constitute BACT. The later two determinations also include BACT limits set at 12 ppm NOx monthly and 9 ppm NOx on an annual average. This is equivalent to NOx emission rates that are in the range of 0.036 to 0.06 pound per million Btu heat input.

Some simple cycle turbines that are not part of a major project have been permitted with similar emission limits. That is, permitted hourly emission limits have been set for the turbines based on use of dry low-NOx burner achieving 15 ppm NOx, hourly average. However, this resulted from the applicants' selection of turbines and burners capable of achieving this emission rate. Other non-major simple cycle turbines have also been permitted with higher emission rates. Notably, projects using GE aero-derivative turbines routinely have been permitted with NOx emission limits reflecting 25 ppm NOx, as achieved with water injection. This is equivalent to an emission rate of about 0.1 pound NOx per million Btu heat input. However, except for one project with used turbines, NOx emission rates for firing natural gas generally do not exceed about 0.015 pound per million Btu.

For the new combined cycle plants being developed in Illinois, BACT determinations made to date have required use of add-on control with SCR to limit turbine unit emissions to no more than 4.5 ppm, and recently, 3.5 ppm NOx. This is equivalent to an NOx emission rate that is less than 0.015 pound per million Btu heat input.

The only significant combined cycle turbines that have been non-major, so as to not be subject to BACT, replace coal-fired boilers at an existing coal-fired power plant. The turbines have been permitted at a NOx emission rate that reflects 25 ppm. (0.1 pound NOx per million Btu.) This does not require use of add-on NOx control on these turbines but instead can be achieved with burners designed with appropriate combustion modifications.

Conclusion

As shown by the large number of new power plants that have been proposed in Illinois in the two-year span since mid-1998, in conjunction with the economic deregulation of electric power generation, the nature and character of Illinois' electric power plants is not static. The permitted NOx emission rates, which are required to be achieved by these new generating units, vary over a wide range. The proposed budget rule must address the NOx emissions from all significant electrical generating units in Illinois.

STATE OF ILLINOIS)
) SS
COUNTY OF SANGAMON)

PROOF OF SERVICE

I, the undersigned, on oath state that I have served the attached TESTIMONY OF CHRISTOPHER ROMAINE upon the person to whom it is directed, by sending a copy by facsimile to the (312) 814-3669 and by placing it with a courier for overnight delivery to the following:

TO: Dorothy Gunn, Clerk
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Hearing Officer
Illinois Pollution Control Board
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SEE ATTACHED SERVICE LIST

from Springfield, Illinois on August 18, 2000.

Cynthia Sims

SUBSCRIBED AND SWORN TO BEFORE ME

This 18th day of August, 2000

Steph C Ewart
Notary Public

"OFFICIAL SEAL"
STEPHEN C. EWART
Notary Public, State of Illinois
My Commission Expires 11/16/02

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