White Paper
Prepared by the Northeast States for Coordinated Air Use Management

June 5, 2006

# High Electric Demand Day and Air Quality in the Northeast

## I. Context of Air Quality Problem

On hot summer days, high electricity demand can dramatically increase ozone-forming air pollution from electric generation that is currently not incorporated into air quality models used for planning purposes. The emission peaks on the hottest days most conducive to ozone formation create an obstacle to continued progress in attaining and maintaining air quality improvements in the Ozone Transport Region.

The seasonal nature of the NOx Budget Program in the Ozone Transport Region is not effectively addressing the short-term daily and hourly spikes in ozone-forming NOx emissions on days of high electric demand and high ozone formation. Peak electricity demand on the hottest days is growing two to three times faster than baseload demand, and the electric power plants that are used to meet increasing peak demand can be among the dirtiest power plants in the region. Furthermore, electric system operators must also maintain a set amount of generation resources (called “operating reserve”) that are on standby and available above and beyond peak electricity demand in case a large electric generator or transmission line goes down when demand is greatest. The increased use of existing relatively dirty resources to meet increasing peak demand and the operating reserve above the growing peak demand adds to the challenge of limiting ozone-forming emissions from electricity generation on hot summer days.

With higher electricity demand also come higher electricity prices. Generation sources responding to peak day demand can garner significant economic rewards, while in some states the costs of traditional emission controls on these sources may be passed through to ratepayers, further adding to upward pressure on peak day prices. Therefore, addressing air quality concerns on peak demand days requires consideration and integration of energy and economic factors in conjunction with air quality and public health concerns. This brings the opportunity for a more expansive definition of available resources on peak days that includes not only supply (generation) but also demand (energy efficiency and conservation).

### *A. Ozone*

Ground-level ozone is a persistent public health problem in the Northeast. Breathing ozone in the air damages lung tissue and may cause permanent lung damage. It reduces lung function, making it harder to breathe and causing shortness of breath. It aggravates existing asthmatic conditions, thus potentially triggering asthma attacks that send children and others with asthma to hospital emergency rooms. Ozone places at particular risk those with preexisting respiratory illnesses, such as emphysema and bronchitis, and it may reduce the body’s ability to fight off bacterial infections in the respiratory system.

Ground-level ozone also affects otherwise healthy children and adults who are very active, either at work or at play, during times of high ozone levels.[1]

The highest concentrations of ground level ozone, or “smog,” in the Northeast are most often seen on the hottest days of the ozone season.  When tracking trends in high ozone levels and hot summer days, it is clear that the Northeast states have made significant progress in improving the region’s air quality over the past 30 years.  The trend in Connecticut, for example, shows a large decrease in the number of 8-hour ozone exceedance days relative to the number of hot days (≥ 90º F) since 1975 (Figure 1).

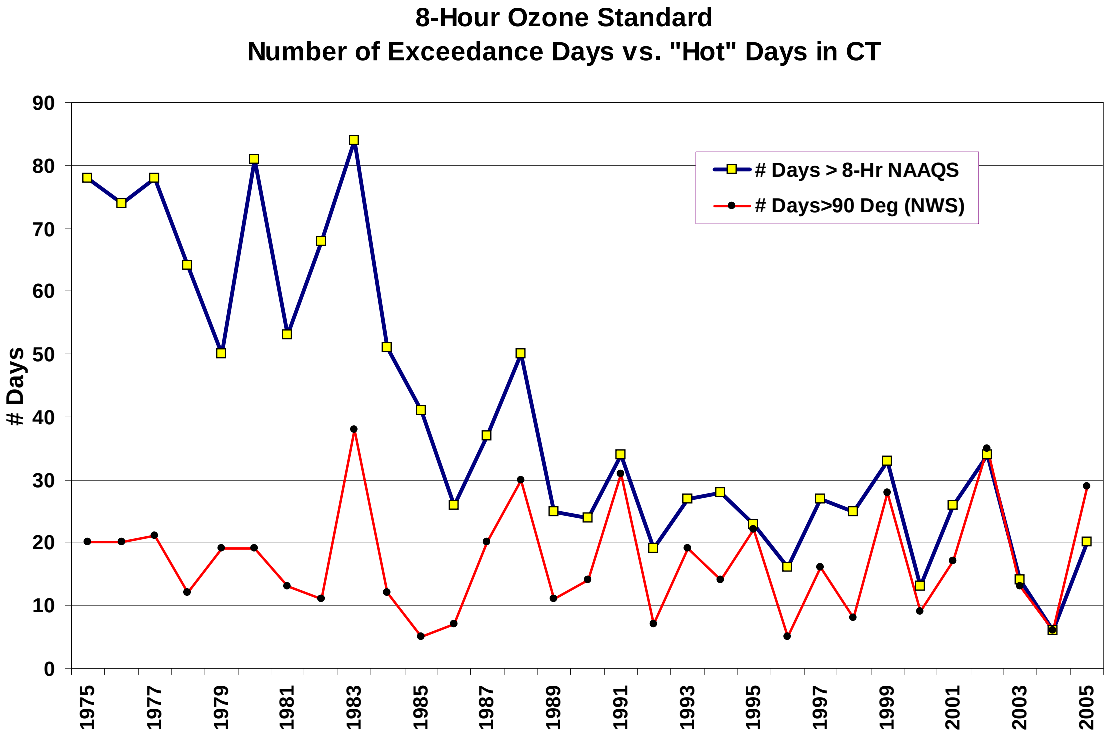

*Figure 1.*  Trend in annual number of 8-hour ozone exceedance days relative to number of days ≥ 90º F or higher in Connecticut from 1975 to 2005.  Temperatures are at Bradley International Airport near Hartford.  The figure shows a decreasing trend in exceedance days that levels off in more recent years (Figure from Connecticut Department of Environmental Protection).

Because upwind regions to the south and west of Connecticut strongly influence ozone levels in Connecticut, its ozone trend is a reflection of measures taken not only in Connecticut, but in other parts of the Ozone Transport Region and other upwind states as well.

The decreasing trend in ozone is due to measures that the states and federal government have taken to reduce the emissions of the chemical precursors of ozone – nitrogen oxides (NOx) and volatile organic compounds (VOCs).

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[1] U.S. EPA, *Ozone and your Health*, EPA-452/F-99-003, September 1999 (available at http://www.airnow.gov/index.cfm?action=static.brochure).

Despite this success, more recent years suggest the decreasing ozone trend has flattened and is no longer decreasing at a sufficient rate to meet timely attainment. While new control measures are on the books and on the way, modeling of future ozone concentrations indicate that people living in large portions of the Ozone Transport Region, both inside and outside the Northeast Corridor, will remain exposed to ozone concentrations above the current health-based 8-hour ozone national ambient air quality standard (NAAQS) of 0.08 ppm after 2009. A larger part of the region will be just below the 8-hour NAAQS, highlighting a potential challenge in maintaining the 8-hour ozone NAAQS during possible successive hot summers (Figure 2).

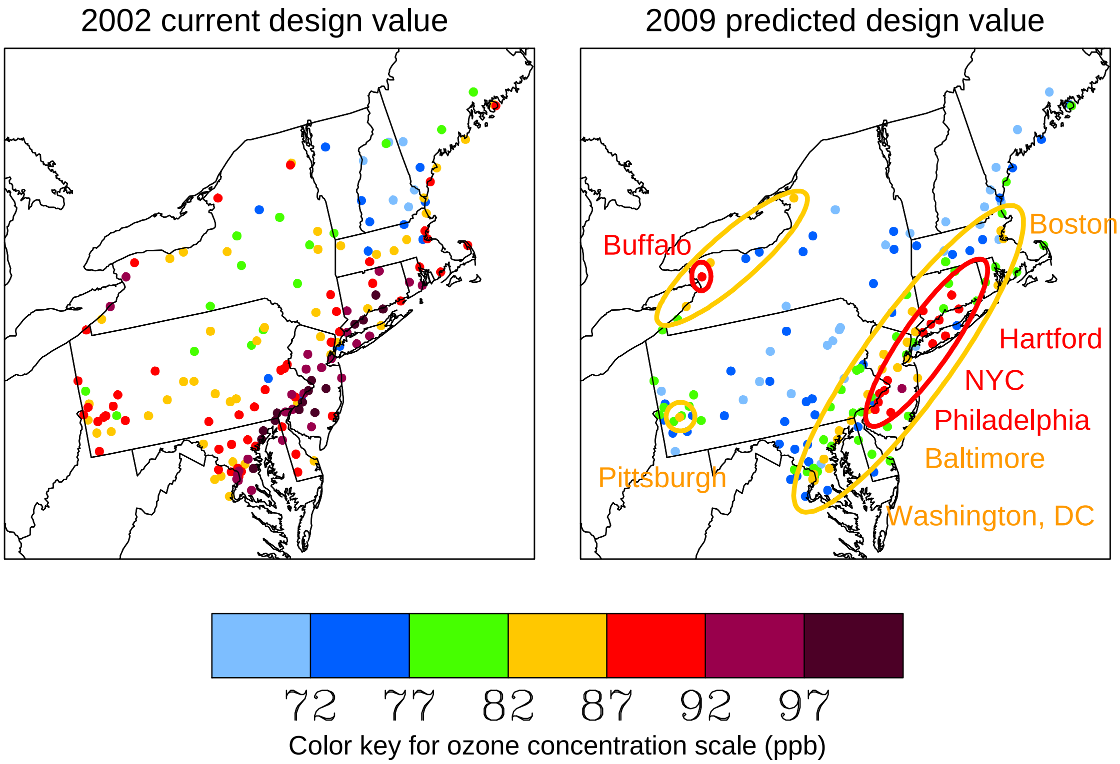

*Figure 2.* The map on the left presents color-shaded 8-hour ozone concentrations representative of design values in 2002 at individual ozone monitors (represented by circles) in the Ozone Transport Region. The map on the right presents the modeled ozone design values in 2009. Red shading indicates monitors with ozone levels above 87 ppb, which is above the 8-hour ozone NAAQS of 85 ppb (0.08 ppm). Orange shading represent monitors with modeled ozone levels from 82 to 87 ppb, which ranges from just below to above the 8-hour ozone NAAQS of 85 ppb. While the difference between the left and right maps indicates continued progress in reducing peak ozone concentrations, the elliptical regions in the right side map highlight the areas of continued nonattainment and near nonattainment. These areas contain the major east coast population centers. Note that the 2009 predicted design value map includes the benefits of control measures which have been adopted and take affect after 2002 (adapted from OTC modeling).

In light of the flattening trends in ozone and the modeled 2009 ozone levels, demonstrating attainment of the 8-hour ozone NAAQS in State Implementation Plans (SIPs) and maintaining the standard once attained will continue to be major challenges in the Ozone Transport Region. Addressing emissions from the electric generation sector on high electric demand days will be a key component in meeting these challenges. Figure 3 illustrates the relationship of EGU NOx emissions, high electric demand, and high ozone days for the New Jersey/downstate New York/southern New England region. NOx emissions from power plants (or electric generating units – EGU) on high electric demand days increase significantly over their ozone season average, which typically are also days of high ozone. This large increase occurs within the confines of the NOx Budget Program in the Ozone Transport Region, suggesting that the seasonal budget does not adequately limit NOx emissions on high electric demand days – the days that are also often the most conducive to ozone formation in the region.

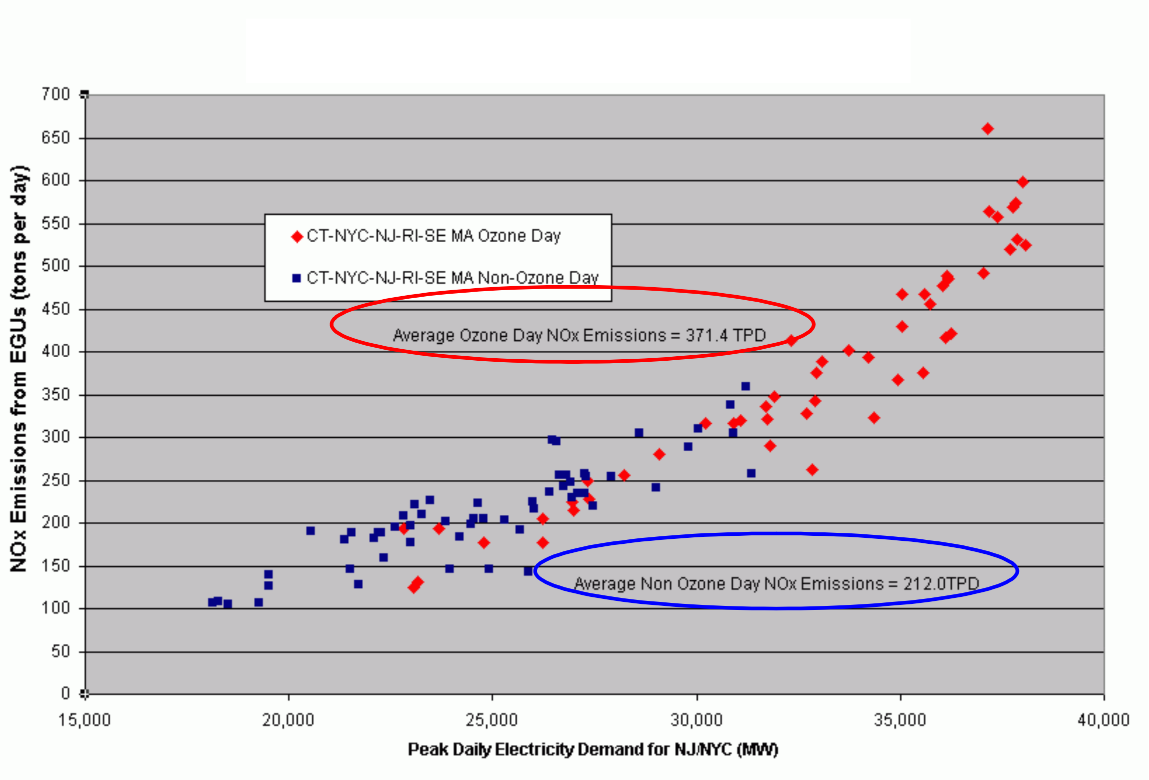

*Figure 3.* Plot of peak daily electricity demand versus daily NOx emissions from EGUs. Blue squares indicate days of relatively low ozone having daily average EGU NOx emissions of 212.0 tons per day. Red diamonds indicate days of high ozone, and have daily average EGU NOx emissions of 371.4 tons per day. The figure indicates virtually all the days of highest EGU daily NOx emissions correspond to days of high ozone.

### B. *Other air quality goals and challenges*

States have additional air quality goals and challenges beyond ozone. Meeting the current fine particulate matter NAAQS (PM2.5) as well as EPA's proposed more stringent PM2.5 standard in the future is a key objective. Demonstrating reasonable progress through regional measures to improve visibility in national parks and wilderness areas will be a long term task under the federal regional haze rule.

## II. Analysis of High Electric Demand Day

### A. *Electric generation on peak summer days*

As a general matter, an EGU can be considered as falling within one of three types of generation depending on its operation characteristics. "Baseload" units operate to provide the minimum electricity demand, or "load," of a system, thus run almost continuously and produce electricity at an essentially constant rate. "Load following units" typically run at lower levels during the night, and then increase generation during the day to follow the electricity demand. "Peaking" units typically operate less than 10 percent of the time, and are usually turned on only at times of peak demand, for example on the hottest hours of summer days when air conditioning demand is high. They may only run a few hours or days during the course of a year, and may not operate at all during cooler summers. There are regulatory definitions of peaking units that typically define them as EGUs having a capacity factor not exceeding 10 percent averaged over three consecutive years or ozone seasons, with the capacity factor not exceeding 20 percent during any one of those years or ozone seasons (e.g., 40 CFR 72.2 (defining by year); 40 CFR 75.74(c)11 (defining by ozone season)).

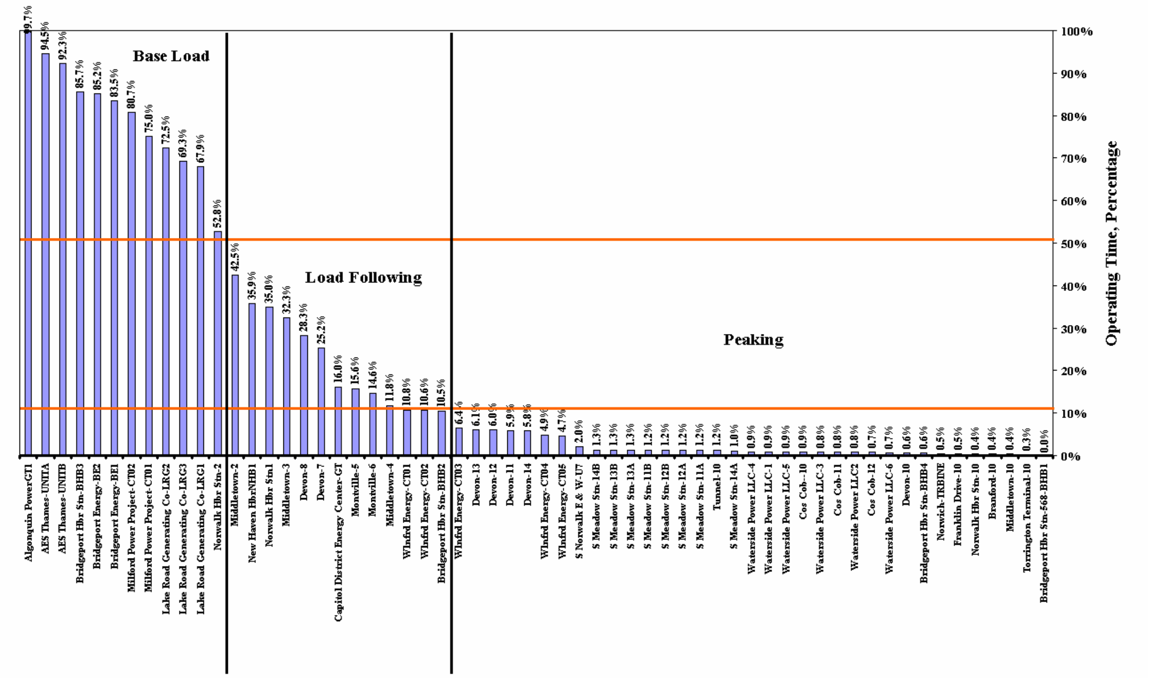

*Figure 4.* Example of baseload, load following, and peaking units in Connecticut based on average operating time percentage during the 2002-2005 ozone seasons.

Figure 4 is an example of how units can be grouped according to their average operating time. Based on the operational characteristics of the three types of generation, it can be seen that the units that help increase daily electricity generation during periods of peak electricity demand during the ozone season are the load following and peaking units. This is also illustrated in Figure 5, which is a profile of hourly EGU NOx emissions broken down by the three generation types over the course of one week in Connecticut with high electricity demand, hot weather, and high ozone levels. During the week of August 11-17, 2002, peak generation in the state was largely provided by load following units, with a smaller portion provided by peaking units. It should be noted that the drop-off in hourly base load emissions starting on Tuesday, August 13, was largely due to the shut down of Bridgeport Harbor Unit #3 (net capacity about 375 MW), which remained out of service for the remainder of the week. This outage likely resulted in a slightly higher fraction of the peak demand being met with load following units during the outage period.

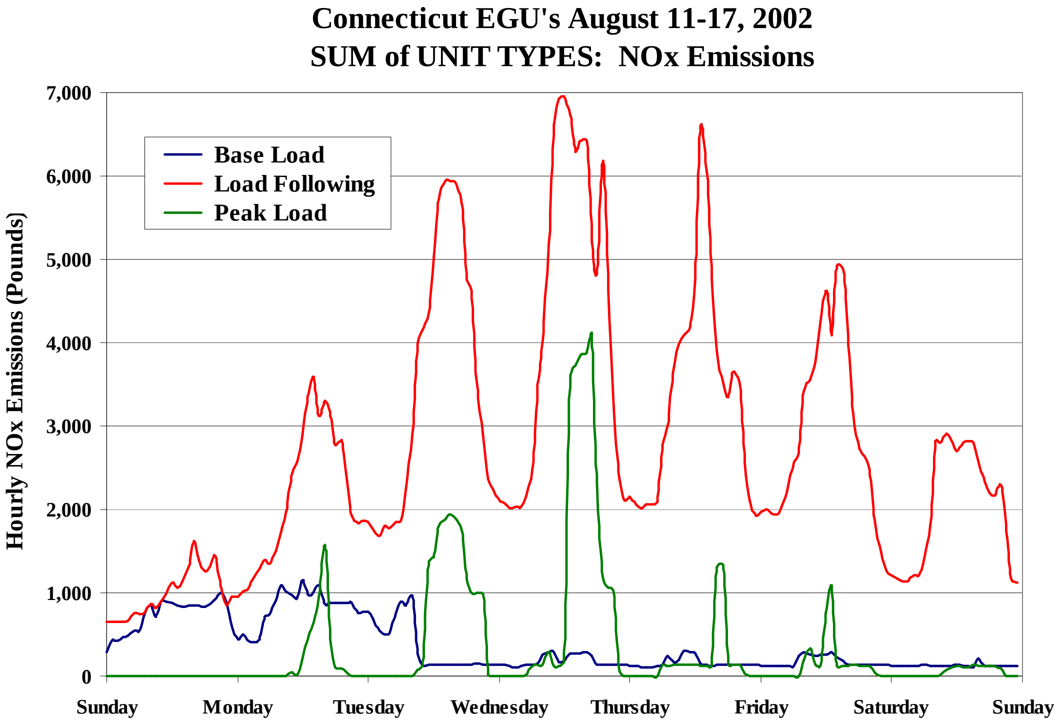

*Figure 5.* Example of hourly emissions profiles over the course of one week in August 2002 in Connecticut showing the increase in hourly emissions of load following and peaking generation units relative to baseload units. This was a week of high electricity demand, hot weather, and high ozone levels.

The types of fuels and units used as load following and peaking can differ across different power pool regions. In New England, NOx emissions attributable to coal remained fairly constant throughout the ozone season of 2005, indicating the prevalent use of coal plants as baseload units. The major increase in NOx emissions with increasing electricity demand on warmer summer days in 2005 came to a large extent from greater utilization of residual oil (Figure 6).

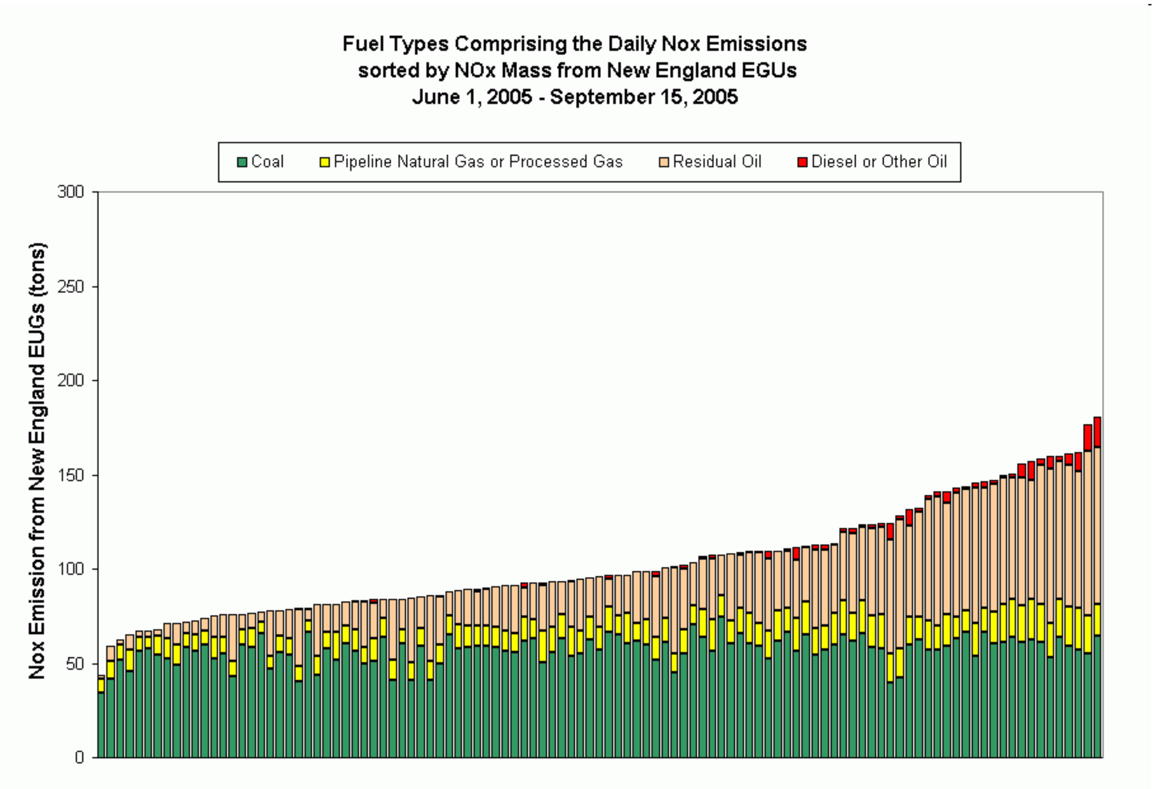

*Figure 6.* Daily NOx emissions by fossil fuel type from New England EGUs during the 2005 ozone season. Note that NOx emissions from coal EGUs stays relatively constant, indicating its use as baseload. The increase in NOx emissions above baseload occurs primarily from residual oil (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

The number of EGUs in operation in New England during the 2005 ozone season, however, did not vary as much as the changes in NOx emissions, indicating that the residual oil EGUs were load following units, i.e., running most of the time, but increasing generation, hence NOx emissions, as electricity demand increased (Figure 7). These oil units tend to have higher NOx emission rates, suggesting they are less controlled for NOx than units utilized more often (i.e., higher capacity factors).

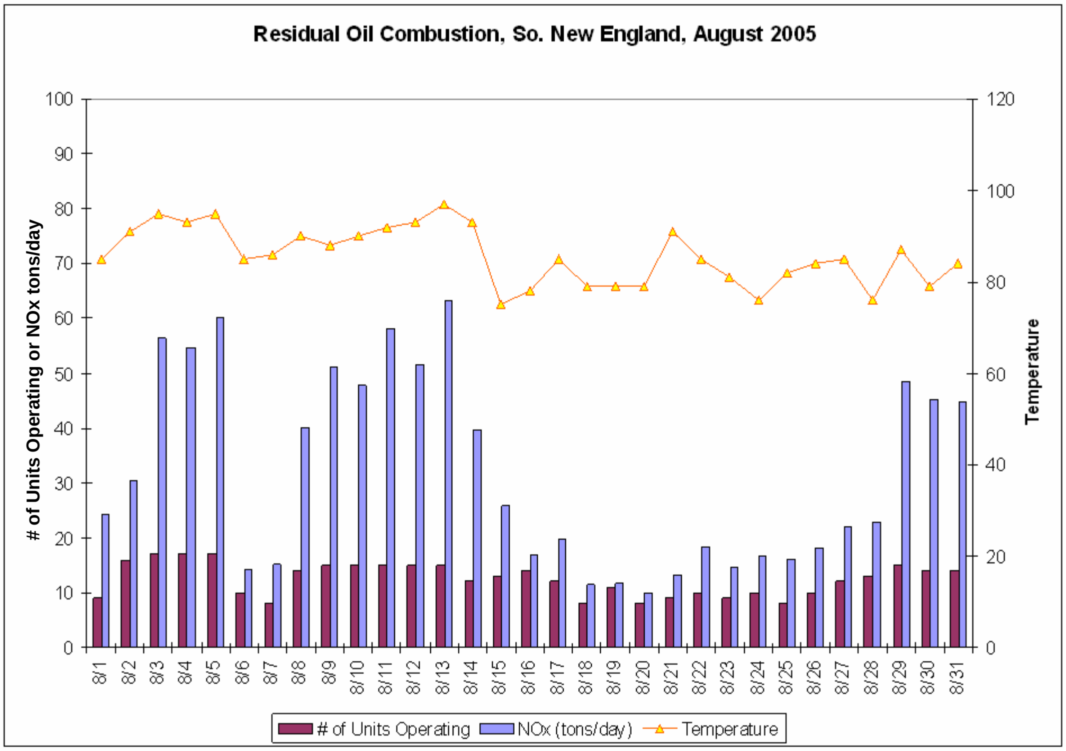

*Figure 7*. Daily NOx emissions and number of residual oil-burning EGUs operating during August 2005 in southern New England. The bar chart indicates that the number of residual oil-burning EGUs operating did not vary much during this period, but NOx emissions increased and decreased significantly with temperature-driven generation demand (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

In contrast to the New England region, the increase in EGU NOx emissions in the New Jersey/downstate New York region during warmer days of the 2005 ozone season was about evenly split between increased utilization of natural gas and diesel oil. NOx emissions from residual oil also increased, but not to the same degree as in the New England region. NOx emissions from coal remained fairly stable, once again indicating its use as baseload generation (Figure 8).

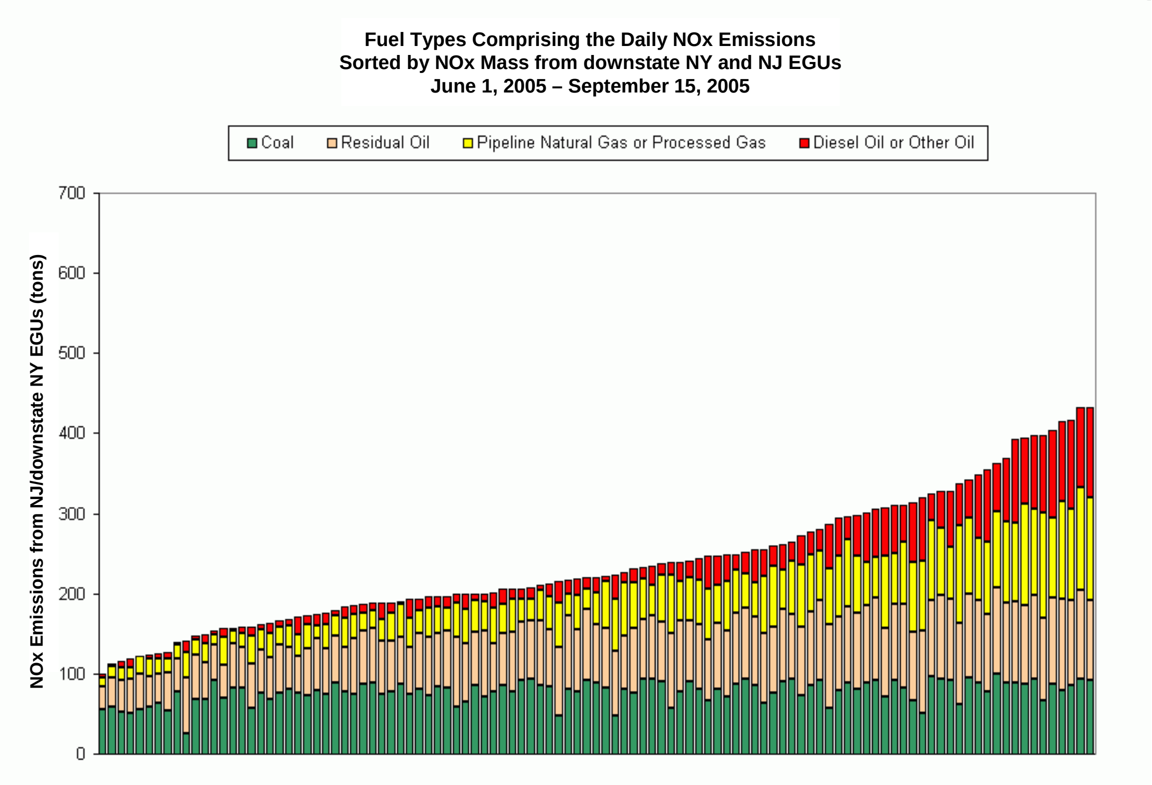

*Figure 8.* Daily NOx emissions by fossil fuel type from New Jersey/downstate New York EGUs during the 2005 ozone season. NOx emissions from coal and residual oil EGUs stayed relatively constant, indicating their use mainly as baseload. The largest increase in NOx emissions occurred primarily from diesel oil and natural gas, as compared to residual oil in New England (see Figure 10) (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

Unlike residual oil EGU utilization in southern New England, the number of diesel and other oil-fired combustion turbines in operation in the New York portion of the New York City multi-county nonattainment area varied significantly on a day-to-day basis during the 2005 ozone season, along with NOx emissions. This suggests that the increase in NOx emissions on peak summer days in this region comes to a significant degree from peaking units, primarily combustion units in this case, brought on line just to meet hourly peak electricity demand (Figure 9).

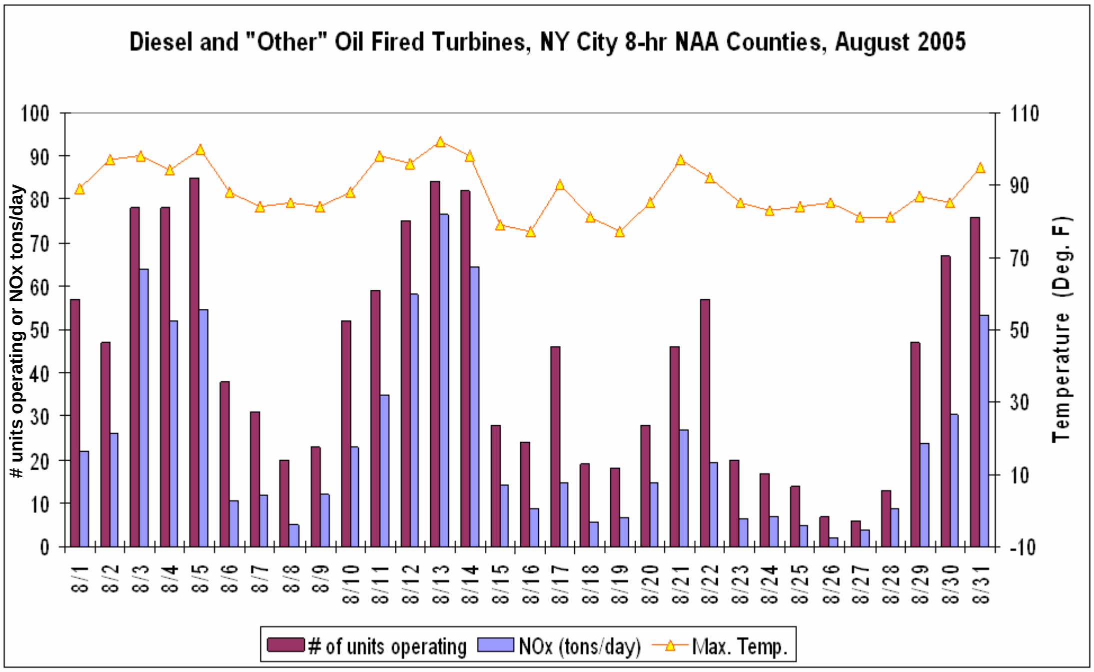

*Figure 9.* Daily NOx emissions and number of diesel and other oil-fired combustion turbines operating during August 2005 in the New York portion of the New York City 8-hour ozone nonattainment area. The bar chart indicates that the number of turbines operating varied greatly during this period, in contrast to southern New England (see Figure 7). NOx emissions also increased and decreased significantly with the operating units and temperature-driven generation demand. This suggests that the NOx increase in this particular region comes in part from diesel gas and other oil-fired turbines (see Figure 8) operating as peaking units to meet increased demand (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

## III. The Air Quality Impact of Peak Day Electricity Generation

### *A. Daily and hourly NOx emissions*

As discussed in Section II, electric generation, and its associated NOx emissions, is not constant throughout the day, weeks, and months in the Ozone Transport Region. Generally, we see more demand for electricity in the summer, and possibly winter, than in the spring and fall. Daily electrical demand is usually associated with the temperature, the warmer the day the more electrical demand. And hourly electrical demand is very temperature dependent with hourly demand constantly increasing and decreasing.

Figure 10 provides an illustration of the daily variability in EGU NOx emissions in the New Jersey/downstate New York area. Average daily emissions during the 2002 ozone season were 286.5 tons/day, but NOx from electric generation more than doubled on peak days, reaching over 600 tons/day.

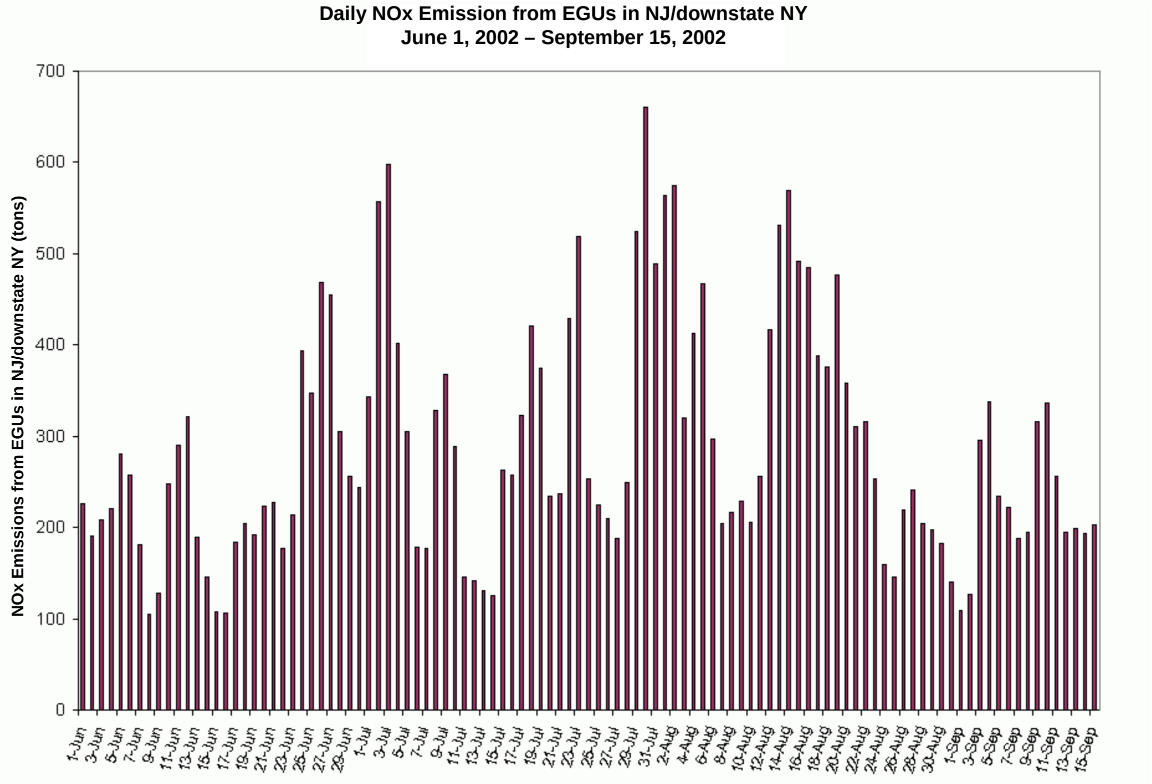

*Figure 10.* Day-to-day variability in NOx emissions from electric generating units in New Jersey/downstate New York between June 1, 2002 and September 15, 2002. Average daily NOx emissions were 286.5 tons per day (TPD) (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

As with the New Jersey/downstate New York region, there were also significant peak emission days in New England. NOx emissions from EGUs in New England averaged 134.6 tons/day from June 1, 2002 to September 15, 2002, with NOx emissions almost doubling to over 250 tons per day on peak days (Figure 11).

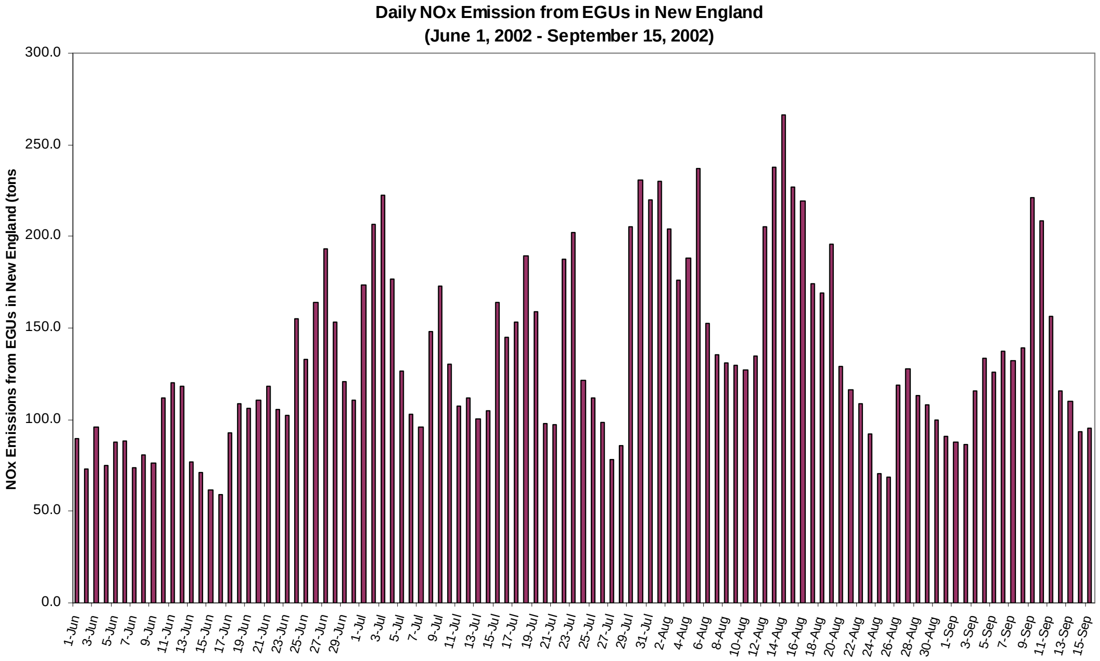

*Figure 11.* Day-to-day variability in NOx emissions from electric generating units in New England between June 1, 2002 and September 15, 2002. Average daily NOx emissions were 134.6 tons per day (TPD) (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

Figure 12 provides a different illustration of temperature and NOx emissions from EGUs. This figure orders the daily EGU NOx emissions in New England during the 2002 ozone season from lowest to highest NOx amounts, with the temperature trend indicated by the line drawn above the bars. This illustrates that the highest EGU NOx emissions tend to coincide with the warmest days in New England. A similar relationship is seen as well with EGU NOx emissions in the New Jersey/downstate New York region.

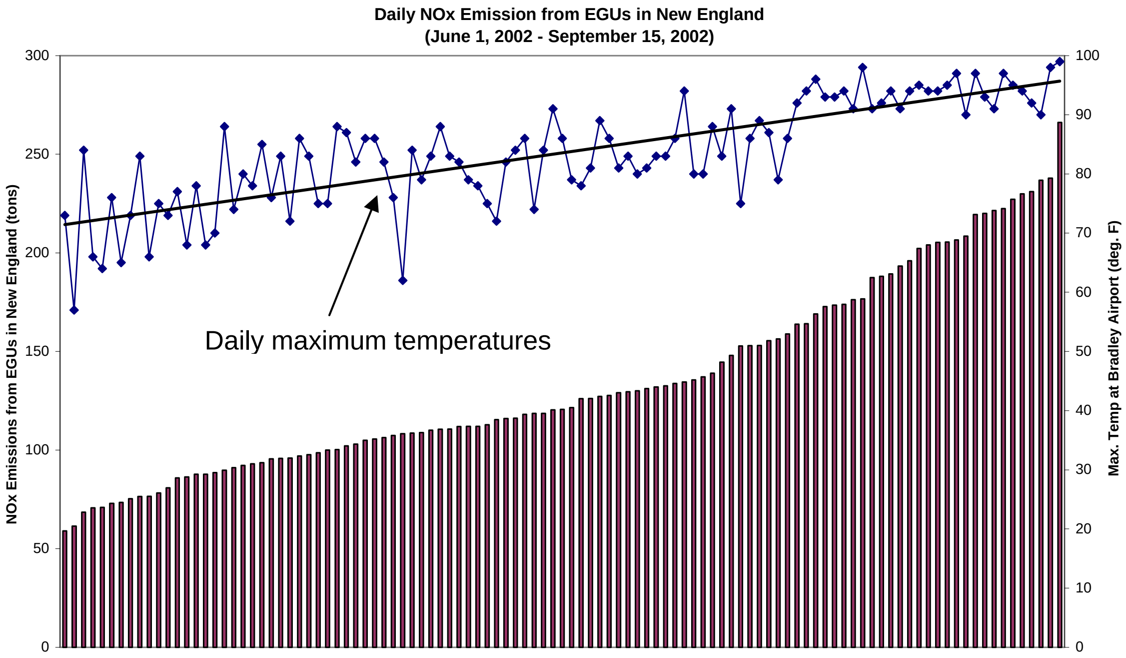

*Figure 12.* Daily EGU NOx emissions during the 2002 New England ozone season (see Figure 11) ordered by increasing NOx amounts. The line above the bars indicates the daily maximum temperature at Bradley International Airport near Hartford, CT that corresponds to each bar directly underneath a temperature point. In general, increasing temperature corresponds to increasing EGU NOx emissions (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

The increased electricity demand on the hottest days results in large part from increased residential air conditioning demand. In Connecticut, for example, increased residential use of air conditioning on peak summer days accounts for 25 percent of total electricity demand. Because peak electricity demand is growing at a rate faster than baseload demand due to increasing residential air conditioning, the potential exists for even greater variability in day-to-day EGU NOx emissions in the future.

### *B. Modeling the air quality impacts of peak day electricity generation*

The variability in NOx emissions from EGUs is significant enough to affect predicted ozone concentrations in ozone modeling. Unfortunately, the ozone models currently do not capture this ‘real world’ variability. Ozone models contain temporal profiles that allocate annual NOx and VOC inventories to particular months, days and hours of a day. These profiles are often referred to as modeling ‘default’ profiles. For NOx point source emissions (e.g., EGUs) the modeling ‘default’ profiles do not accurately represent all types of electric generators, especially those that operate to meet peak electrical demand.

An example of this is the changing operational conditions of older units previously treated as baseload. In some locations there are old oil-fired units originally designed for baseload, but now only operate when called upon as standby power supplies. Their emission rates are based on operating at 90 percent load, but their current operational status involves more start up and shutdown emissions while generating little power in standby mode.

In addition, the increased generation needs due to growth in peak demand as compared to the baseload can lead to smaller, more nimble distributed generation sources located closer to the point of demand. These may not be captured as EGUs in the models, further minimizing the modeled NOx emissions due to increased electricity generation.

Figure 13 illustrates how the regional ozone modeling for the Ozone Transport Region incorporates NOx emissions from the EGUs using state-specific 'default' profiles. The EGU NOx emissions are allocated across the months according to state-specific allocation factors, and then allocated over the days of the week. NOx emissions are also allocated by hour, showing an increase and decrease in emissions over the day. The EGU NOx emissions vary somewhat on a monthly and daily basis during the ozone season, with Saturdays and Sundays somewhat lower than weekdays. This variation, however, is simplified in that each individual day of the week within a particular month has the same EGU NOx emissions. For example, while a Tuesday's EGU NOx emissions may differ from a Wednesday's, each Tuesday in the same month will have the same amount of EGU NOx emissions as every other Tuesday that month.

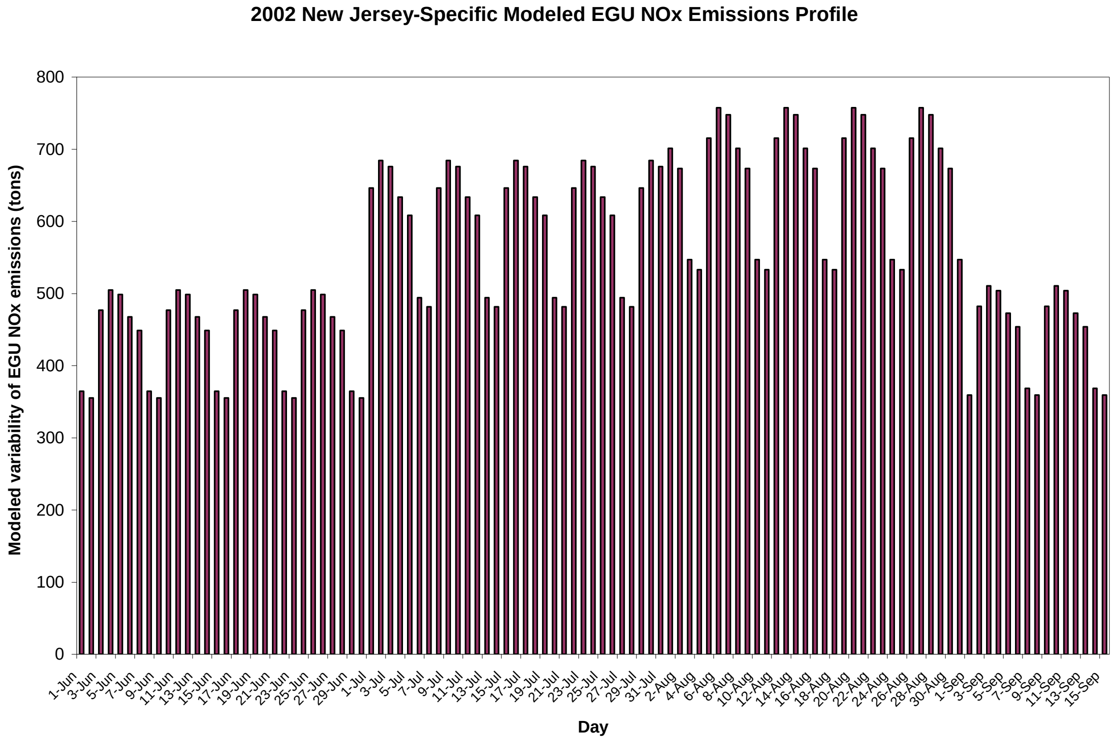

*Figure 13.* Example of a state-specific 'default' profile (New Jersey in this case) for daily EGU NOx emissions that is input into the regional ozone model for the Ozone Transport Region. The New Jersey state-specific NOx tons are from MARAMA[2] and include NOx emissions from more electric generators than included in the U.S. EPA Clean Air Markets database.

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[2] MARAMA (Mid-Atlantic Regional Air Management Association), 2002 MANE-VU Emissions Inventory Version 1 Summaries, http://www.marama.org/visibility/EmissionsInventory/NJ.xls (New Jersey).

As illustrated in Figure 13, ozone modeling in the Ozone Transport Region incorporates EGU NOx emissions that do not vary to the same extent they vary in reality. (To see this, compare Figure 13 with Figure 10.)

The New Jersey Department of Environmental Protection (NJ DEP) has begun an effort to better characterize NOx temporal variations and their impact on regional ozone formation using hourly data found in EPA's Clean Air Market Division's (CAMD) database. In this effort, NJ DEP is using hourly data in the CAMD database to match all EGUs, whether they are considered to be baseload, load following, or peaking units. Five states in the Ozone Transport Region have reviewed these matched files and designated their high electric demand day (HEDD) EGUs. New Jersey, Connecticut, and Maryland looked at units operating on high electric demand days for the 2002-2005 ozone seasons. New Jersey and Maryland designated HEDD EGUs as those whose annual average operating time is about 20 percent or lower. Connecticut designated HEDD EGUs as those whose annual average operating time is about 50 percent or lower. Massachusetts designated their six highest residual oil-fired load following units as HEDD EGUs. New York designated HEDD EGUs as those defined by regulation in 6NYCRR, Part 200, Subpart 227-2. Using the CAMD data, NJ DEP was able to group EGUs in the remaining states in the Ozone Transport Region as "peaking" and "load following" versus "baseload" according to their relative contributions to maximum hourly and annual NOx amounts from all point sources. EGUs that contributed less than 2 percent to NOx on an annual basis, but greater than 1 percent of NOx on a maximum hourly basis, were considered peaking or load following units. The NOx emissions from these peaking and load following EGUs were then controlled to 0.1 lb/mmBtu in the ozone model during the course of a modeled ozone episode. The results of this rough run showed a decrease of greater than 7 ppb in maximum ozone during the course of the modeled episode attributable to these units. This is a significant impact, and indicates an important opportunity for future efforts to reduce ozone forming NOx emissions from EGUs. Note that the NJ DEP is continuing to refine its model run as it receives matched hourly data from the states in the Ozone Transport Region.

## IV. Identifying NOx Reduction Strategies and Challenges for Peak Ozone Days

### *A. Overview*

The units now used to meet peak electricity demand on the Northeast's hottest days often do not have stringent emission controls because they operate relatively infrequently (typically less than 10 percent of the year). While their use is infrequent, it is often concentrated on the warmest days of the ozone season, the worst days to be adding additional NOx emissions.

Analysis of the units in operation during peak demand times in New England and the New Jersey/downstate New York region indicate that a relative few units may contribute the most to the increase in daily NOx emissions. This indicates that a handful of load following and peaking units could be the prime targets for NOx reduction strategies on the worst ozone days in at least parts of the Ozone Transport Region. Care would need to be taken, however, that unit-specific measures do not lead to shifting generation to other dirty EGUs currently operating at lower capacity in the region, or that "leakage" occurs where dirtier generation shifts outside and upwind of the Ozone Transport Region.

Based on the above discussion, it appears that the ozone season NOx Budget Program in the Ozone Transport Region, while being met, does not provide sufficient constraints to achieve necessary NOx reductions on peak ozone summer days. Electric generators are able to meet their seasonal budget allocations through NOx emission controls on high utilization units without having to implement significant controls on other units.

Because peak ozone formation and peak electricity demand often occur at the same time in the Ozone Transport Region, additional efforts to reduce NOx emissions from electric generators on peak demand days must be cognizant of electric system needs. By the same token, electricity generation choices on peak demand days during the summer should be cognizant of public health and air quality needs. Therefore, in considering options to reduce NOx emissions from electric generators on peak demand days, planners should consider strategies that go beyond traditional smokestack controls and include consideration of other less traditional options. These can include output-based NOx allocations, surrendering of or limiting allowances on hot summer days, energy efficiency and conservation measures, and other approaches.

### *B. Technology-based NOx control measures*

Peaking units operating 500 hours or less during the year often do not have NOx controls because of their limited use and relatively low seasonal NOx emissions, even though they can have high hourly NOx emission rates and contribute significantly to total daily EGU NOx emissions on the peak days they operate. Their NOx emissions can have far more impact on ozone levels than their overall seasonal emissions would suggest because the few days that they do operate typically are the hottest days most conducive to ozone formation.

Traditional technology-based control measures for EGUs will depend on the type of EGU under consideration. As the previous discussion points out, the types of fuels and units (peaking or load following) contributing the most to peak daily NOx emissions in different power pools can differ. In New Jersey, for example, high-emitting combustion turbines ("high emitting" means having a NOx emission rate greater than 0.15 lb/mmBtu) are important NOx emitters on hot summer days. In southern New England, it can be load following units burning residual oil.

The differences in which fossil fuel units power producers rely on during peak demand days in New England and the New Jersey/downstate New York areas suggest the need for different control technology options, which may apply as well across the greater Ozone Transport Region. Note that there is a need for additional analysis of trends in fuel use and EGU utilization on a daily basis during peak demand days in other parts of the Ozone Transport Region.

In the case of combustion turbines, the generating capacity varies with size, ranging from about 1 MW up to several hundred MW in generation capacity. Aeroderivative turbines are at the lower end in terms of size, with the largest aeroderivative turbines approaching 40 to 50 MW in size with simple cycle efficiencies approaching 45 percent. Aeroderivative turbines are adapted from aircraft designs, and can be thought of as airplane engines without the airplane. Larger simple cycle gas turbines used exclusively for stationary power generation can have generation capacities of several hundred megawatts and operate at thermal efficiencies approaching 40 percent. These are generally cheaper, more rugged, and can operate longer between overhauls than aeroderivative turbines. Turbine combustors operate at very high temperatures, so turbines without emissions controls can produce high levels of NOx.[3]

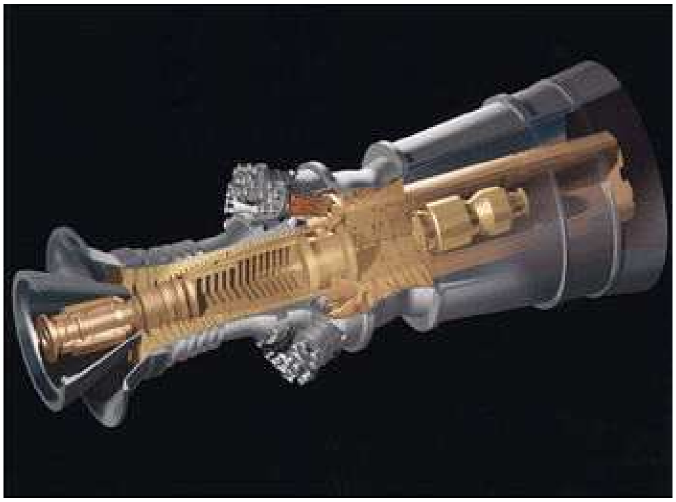

*Figure 14.* Illustrative view of simple cycle combustion turbine used to generate electricity.

A snapshot of one August day during 2002 indicated that high emitting combustion turbines in New Jersey contributed over 50 percent of the state's total EGU NOx emissions beginning around 3 p.m. in the afternoon, then decreased to only 15 percent by 8 p.m. that evening. Most of these sources operating as peaking units in New Jersey do not have any NOx controls.

Consistent with the specific example of New Jersey, the total NOx emissions from EGU combustion turbines across the Ozone Transport Region increased significantly on high ozone days in 2005 relative to their seasonal average. During the days of July 26-27, August 4, and August 12, 2005, which all saw regional exceedances of the 8-hour ozone standard in the Northeast, the aggregated average NOx emissions rate from combustion turbines across the region increased over their seasonal average, indicating increased electricity generation from dirtier combustion turbines during these polluted days (Table 1).

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[3] Gas Turbines, Energy Solutions Center, at http://www.energysolutionscenter.org/distgen/AppGuide/Chapters/Chap4/4-3_Gas_Turbines.htm (accessed April 24, 2006).

### Daily NOx Emissions in 2005 from Combustion Turbines* in OTR States

| Date | Number of Units Operating | Total NOx Emissions (tons) | Total Heat Input (mmBtu's) | Average Emissions Rate (lbs/mmBtu) |
|---|---|---|---|---|
| May 1 – Sept. 30 | 477 | **Total:** 7,363.3<br>**Daily ave:** 48.1 | **Total:** 94,718,950<br>**Daily ave:** 619,078 | 0.155 |
| Tuesday, July 26 | 372 | 220.6 | 1,979,451 | 0.223 |
| Wednesday, July 27 | 418 | 260.2 | 2,155,401 | 0.241 |
| Wednesday, August 4 | 365 | 181.9 | 1,756,262 | 0.207 |
| Friday, August 12 | 354 | 185.0 | 1,736,021 | 0.213 |

*Summarizes data from 477 combustion turbines in OTR states reporting hourly emissions to EPA in 2005 under the NOx Budget Program or Acid Rain Program.

*Table 1.* Table of aggregated daily average NOx emissions and emissions rates from combustion turbines in the Ozone Transport Region states. The seasonal average NOx rate from these sources is 0.155 lbs/mmBtu. The average NOx emissions rate increased to above 0.20 lbs/mmBtu on the four indicated days in 2005, which were all high ozone days in the Northeast. By comparison, the seasonal average NOx emissions rate from all EGUs in the Ozone Transport Region states during the 2005 ozone season was 0.164 lbs/mmBtu (average of 1,104 units) (data from U.S. EPA Clean Air Markets – Data and Maps (http://cfpub.epa.gov/gdm)).

The major share of NOx emissions from high emitting combustion turbines during the hottest part of the day coupled with the lack of existing NOx controls create a significant opportunity for NOx reductions at opportune times relative to ozone episodes in the Northeast. Control options include water injection and replacement of existing aeroderivative turbines with newer Dry-Lo NOx-based simple cycle turbines.

Initial analysis estimates the cost of retrofitting water injection technology on combustion turbines reduces NOx by about 55 percent at a cost of about $75/MWh, or about $37,000/MW for peak turbines operating less than 500 hours per year. By comparison, the market price of peak electricity in New Jersey is over $700/MWh. Similarly, a recent New York Times article stated that in 2003, New York City received from the local power authority $40 for each kilowatt of demand the city removed from the electricity grid during times of peak electricity demand ($40/kW is equivalent to $40,000/MW).[4]

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[4] Anthony DePalma, NY Times, "Relieving the Power Grid, Dirtying the Air," April 8, 2006. This article also reported that New York City was disconnecting facilities from the grid when requested during peak demand days by turning on their emergency backup diesel generators, which are typically higher polluting, thus contributing to greater air pollution on peak summer days.

Therefore, the costs of this technology in relation to the current market price at peak demand make this a potentially attractive short term option.

Over the long term, complete replacement of existing aeroderivative turbines to newer Dry-Lo NOx-based simple cycle turbines hold the promise of reducing NOx emissions by over 90 percent. This could be done at a cost of $500,000 to $800,000 per MW, and represents complete replacement of the turbine, rather than an add-on control.

### *C. NOx allowance options*

It is apparent that the seasonal NOx Budget Program in the Ozone Transport Region does not create sufficient incentives through allowance banking and trading to reduce NOx emissions effectively on hot summer days when ozone is often at its highest. Furthermore, while the NOx Budget Program originally included units as low as 15 MW, the Clean Air Interstate Rule (CAIR) includes only units down to 25 MW. Therefore, the units between 15-25 MW will no longer be part of the NOx Budget Program when CAIR replaces it after 2008. This represents a further erosion of the NOx Budget Program's ability to reduce NOx emissions from smaller, potentially dirtier EGUs on high electric demand days. Below are possible options that could improve the effectiveness of the trading programs in achieving NOx reductions from EGUs on hot summer days.

#### 1. Increased allowance retirement rate

Options within the existing budget program could include requiring more NOx allowances relative to tons emitted for peaking units. Connecticut, for example, has implemented a retirement requirement of seven discrete emission reduction credits or allowances per ton of NOx emitted from peaking EGUs that cannot meet their allowable 24-hour NOx emission rate and are in Connecticut's NOx trading program. This, however, may not provide sufficient incentive to reduce emissions on peak summer days, so that a higher retirement ratio could be needed.

#### 2. Reallocation of allowances

There are also options to encourage greater utilization of the cleanest units during peak hot summer days. With higher natural gas prices, some of the cleanest gas turbines in the Northeast do not operate as much during peak demand days, while other dirtier, lower fuel cost plants (e.g., residual oil and diesel) ramp up generation to meet demand. To address this, the allocation of allowances could be distributed according to electric generation output, rather than the traditional fuel heat input method.[5] This would provide an incentive to run cleaner plants more during peak demand periods. A relatively greater share of allowances could also be given to newer plants, presuming these are likely the cleanest in the EGU fleet.

#### 3. Limiting access to allowances if performance standard exceeded

Another strategy would be not allowing units to acquire allowances to accommodate increased NOx emissions on hot summer days if their emissions rates exceeded a unit-

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[5] Operators of some cleaner power plants may also have permit conditions restricting the number of hours the units may be operated. This may have to be addressed separately as it wouldn't necessarily be resolved through an output-based reallocation of allowances.

specific allowable performance standard. This could be done by establishing hourly emission performance standards for every unit in operation on hot summer days without requiring any specific control technology. However, as with the increased allowance retirement rate option above, this strategy may not create a sufficient price incentive to reduce emissions.

### *D. Other considerations for air quality and electric system planning*

There are additional considerations existing at the interface of air quality and electric system planning needs that arise because different planning authorities have different goals (i.e., improving air quality versus ensuring electric system reliability). The independent system operators (ISOs) who are responsible for managing the regional electric power systems are engaged in long-term planning processes to secure resources and increase grid stability for the period after 2008. These planning processes intersect with those being convened now by air quality regulators for ozone and PM2.5 SIPs. In response to the Federal Energy Regulatory Commission (FERC), the region's ISOs are evaluating their existing resource and operating reserve requirements. Demand growth, especially driven by peak electricity demand growth, has resulted in the ISOs recommending that additional resources be developed to meet peak demand and to increase the amount of operating reserve (i.e., the amount of capability held in reserve above and beyond peak demand). These last two components feed off each other, akin to a “positive feedback loop” pushing development of new electric system resources.

The evolving electric system may exacerbate existing and potential regional air quality impacts. First, peak demand in general is increasing at a rate more rapid than overall base demand. Second, FERC has recently increased the required operating reserves that the ISOs will need to maintain and plan for in the future. The combined effect significantly increases the amount of resources that will be required by the ISO to be available to provide these operating reserves in the future. In real terms, if in 2005 an ISO is required to maintain a 15 percent operating reserve (e.g., capability to replace a large unit out of service or loss of transmission line), the capacity needed might be on the order of 1,500 MW that must be available to provide service within 10-30 minutes of being called. With peak load growth and FERC-driven increases in operating reserve requirements, the amount of resources needed to provide service within 10-30 minutes after 2005 could increase to 2,000 MW or more, and these increased resources must be included in ISO planning.

A real world example of the pressure to increase operating reserves is the construction of a new 345 kilovolt transmission line into southwestern Connecticut. System reliability planning requires the availability of operating reserves within 10-30 minutes to quickly replace the new line if it is lost, but the existing contingency measures are not sufficient to make up the entire load available with the new line. Therefore, the new transmission line will require a significant increase in the number of “quick start” electric system resources needed as a contingency measure if the new line fails during operation.

Several additional factors are also in play; the definition is broad of a resource, capacity, load, and units being available to provide service within 10-30 minutes. While ISO and even some air quality regulators have often interpreted these terms to relate to actual generating units, this narrow view may simply result in continued short-term solutions that rely on inefficient fossil-fueled generation. Energy efficiency, conservation, demand response, and distributed resources can and should be accommodated and integrated into long-term capacity and resource planning.

As an example, ISO-NE, the ISO for New England, has commenced planning to initiate an auction for long-term resources beginning in 2008. Air regulators need to participate in these planning processes and to assure that not only do these ISO decisions not produce further harm, but to recognize that this is the moment to assure that the ISO decisions actually improve air quality. Simultaneously, air regulators are undertaking processes to plan for the attainment and maintenance of the ozone and PM2.5 standards. Measures to reduce the air emissions from EGU and smaller units are part of the air planning processes, which also extend out several years. Decisions made or not considered by air regulators could affect energy markets and result in higher costs, which will be borne by someone. ISOs and public utility commissions (PUCs) therefore need to be engaged in the air planning processes.

At first glance, the PUC and ISO worlds appear to be at least as complicated, or even more so, than those of the air regulators. Understanding PUC and ISO processes, decision making, pressure points, and other key milestones is critically important to assure that air quality concerns are both heard and factored into relevant decisions. Participating at the start also helps to mitigate the potential for state environmental agencies arriving in the middle when specific generating facilities are being permitted.

Energy efficiency and demand side measures can be less expensive than existing generation and can reduce federally mandated congestion charges that would otherwise go towards building new generation. A process that values all resources by including energy efficiency and demand side measures (preferably valuing them higher than the supply side) will facilitate solutions that avoid continued reliance on building more transmission lines or building more generators. This in turn will reduce the need to operate inefficient fossil-fueled generation on peak days and help to achieve our air quality objectives.

Other factors also contribute to the need for integrating air quality and electricity planning processes. Several Northeast and Mid-Atlantic states have launched the Regional Greenhouse Gas Initiative (RGGI). While carbon constraints are not within the OTC’s purview, RGGI provides a vehicle to help the overall region, including non-RGGI participating states, achieve co-benefits to air quality, public health and energy security, all of which fit squarely within OTC’s charge. The RGGI provision to require states to auction at least 25 percent of their carbon allowances for public benefit purposes can create increased investments in energy efficiency, renewable energy, and improved technology.

To address air quality and electric system planning needs, the market signals sent by electricity rate structures could be adjusted to provide incentives for operating the cleanest plants more on peak demand days. Higher values could be set for electricity generated by cleaner units, while lower values placed on electricity from dirtier EGUs. The overall total payments for electricity could be kept the same, but payments within this amount could be redistributed so that higher individual payments would go to the cleaner units, while lower payments would go to the dirtier ones. Consumers, therefore, would not see a difference in their bills.

## V. Summary

While there has been significant success in reducing the number of ozone exceedances in the OTR over the past two decades, current trends indicate stagnation in the rate of progress. In addition, ozone modeling predicts that many of the most heavily populated regions of the OTR will not attain the 8-hour ozone NAAQS by 2009, and many more areas will be just under the NAAQS, raising concerns about maintaining it.

The NOx Budget Program has contributed to the improving air quality in the OTR, but it is increasingly evident that the daily variability in NOx emissions from electric generation is not fully addressed through the program. Peak NOx emissions from electric generation on the hottest days in the Northeast can be more than double the seasonal average, and these often occur on the days that are most conducive for ozone formation. The types of units contributing the most to the increase in NOx emissions typically do not operate much over the course of the season, and tend to be dirtier than generation needed to meet baseload demand.

The NOx emission estimates used in ozone modeling do not capture the full range of variability in NOx emissions from electric generation. Therefore, the models may not adequately assess the ozone impacts of electric generation during periods of peak demand.

Strategies available to reduce NOx emissions from electric generation on the hottest days include traditional control technologies and adjustments within the NOx Budget Program. Reducing electricity demand is also an important area for achieving reductions. Energy efficiency and conservation should be included among the resources for consideration as part of the “capacity” potential as there are multiple opportunities yet to be exploited. Identifying and implementing these go beyond the traditional regulatory arena of state environmental agencies, and will involve the PUCs, ISOs, and other stakeholders.