Evaluating Northeast Electric Generating Unit NOx Emissions Based on Electric Demand

David L. Mackintosh
U.S. Environmental Protection Agency
5 Post Office Square OEP05-02, Boston, MA 02109
mackintosh.david@epa.gov

ABSTRACT

Ground-level ozone in the Northeast has long been associated with warm sunny days when high electricity demand increases nitrogen oxide (NOx) emissions from electric generating units (EGUs) and sunlight promotes ozone formation. Each major EGU typically has a temporal NOx emission limit (i.e. pounds per hour and/or tons per year) and a heat input NOx limit (i.e. pounds per million BTU). However, the total daily NOx emissions from all EGUs is highly dependent on electric demand and the resultant combination of which units operate, the fuel utilization at these units, and the emission control performance on the given day. This study combines Northeast EGU NOx emissions data from the Environmental Protection Agency (EPA) Clean Air Markets Division (CAMD) data base and electric demand reported by the regional electric grids (ISO New England, ISO New York, and PJM Interconnection) to analyze EGU performance on a NOx emissions per megawatt basis.

INTRODUCTION

The Clean Air Act requires EPA to set national ambient air quality standards (NAAQS) for ground level ozone to protect public health with an adequate margin of safety and for the protection of public welfare. Ozone is an oxidant that can irritate the air ways causing coughing, a burning sensation, wheezing and shortness of breath and it can aggravate pulmonary and cardiovascular diseases. Many urban and suburban areas throughout the United States have high levels of ground level ozone due in part to winds carrying emissions miles away from their original sources (Finding of Significant Contribution, Oct 1998). This study focuses on areas contributing to the multistate area of New York-N. New Jersey-Long Island, NY-NJ-CT and has been designated by EPA as being in nonattainment status for ozone.

Ozone is a secondary air pollutant created by the chemical reaction between gaseous emissions of nitrous oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Some of the major sources of NOx and VOCs emissions are industrial facilities, electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents.

In the United States, NOx emissions from EGUs are at their highest on hot and humid summer days as more electricity is used by households and businesses to power air conditioners. During these high electric demand days (HEDDs) the peak electric demand can be two to three times greater than the base electric load.

This analysis examines the relationship between daily peak electric demand and daily NOx mass emissions of EGUs contributing to the NY-NJ-CT ozone nonattainment area during the ozone season, which for the purpose of this study is defined as June 1 to September 30.

IDENTIFYING CONTRIBUTING AREAS

The EPA Technical Support Document for the Final Clean Air Interstate Rule (CAIR) identifies significantly contributing areas as one that contributes at least 2 ppb ozone or 1% of total nonattainment. Using this screening threshold, eleven states, shown in Table 1, are thought to be contributing to the NY-NJ-CT ozone nonattainment area (TSD for CAIR, March 2005).

Table 1. Ozone Contributions to NY-NJ-CT Nonattainment Area (ppb)

State	County	2012 Base Case Ozone Avg Design Values	NJ	NY	PA	CT	VA	OH	MD	WV	KY	NC	DE
CT	Fairfield	81.1	12.1	18.4	7.5	2.5	2.3	2.4	1.5	1.7	0.8	0.3	0.3
	Fairfield	83.9	11.6	18.0	6.5	5.8	2.7	2.2	2.3	1.7	1.6	0.6	0.5
	Fairfield	82.9	10.5	20.4	7.6	3.3	2.9	2.3	1.9	2.0	1.6	0.7	0.6
	Fairfield	80.9	11.7	17.5	7.8	3.1	2.3	2.4	1.9	1.9	1.6	0.4	0.5
	Middlesex	80.9	6.8	15.0	8.6	9.6	3.3	4.3	2.3	3.0	2.5	0.7	0.5
	New Haven	72.8	8.0	15.2	7.3	5.6	3.5	3.3	2.2	2.7	2.2	0.8	0.5
	New Haven	82.7	10.4	18.9	8.3	4.5	4.5	3.3	2.7	2.2	1.5	1.4	0.7
NJ	Bergen	79.4	16.6	11.4	4.9	0.3	1.7	2.9	1.3	1.3	1.8	0.4	0.1
	Hunterdon	79.7	10.5	1.9	18.6	0.1	6.9	3.9	3.7	3.2	1.7	1.7	1.6
	Middlesex	79.2	15.6	2.4	13.8	0.2	3.2	2.0	3.1	1.6	1.7	0.3	1.3
	Monmouth	79.7	20.7	18.6	4.5	1.4	0.1	0.7	0.3	0.0	0.1	0.0	0.4
	Morris	74.7	13.6	4.8	13.4	0.6	4.1	3.1	2.5	2.2	2.0	1.1	0.8
	Passaic	73.4	15.6	11.5	8.2	1.4	2.1	2.2	1.5	1.4	0.3	0.3	0.2
NY	Bronx	68.1	12.5	9.2	7.9	0.4	3.3	1.7	2.2	1.2	0.2	0.3	0.5
	Bronx	70.0	11.0	13.5	6.1	0.5	2.3	1.9	1.3	1.1	0.2	0.3	0.2
	Queens	63.5	11.7	8.6	7.4	0.4	3.1	1.6	2.1	1.1	0.2	0.3	0.5
	Queens	73.7	13.6	14.1	6.5	0.6	2.7	1.5	1.5	1.0	0.2	0.4	0.5
	Suffolk	83.0	14.1	15.1	6.8	0.7	4.1	2.8	2.1	2.5	2.3	1.2	1.0
	Suffolk	77.9	9.5	16.5	7.6	0.8	5.3	3.4	3.1	2.7	1.6	1.5	0.9
	Suffolk	83.2	11.6	14.1	8.4	0.8	4.9	3.5	3.3	2.6	1.9	1.9	1.6
	Westchester	81.1	13.0	18.3	6.9	1.4	2.1	2.5	1.2	1.3	0.3	0.3	0.1

ELECTRIC TRANSMISSION ZONES

Most of the electric transmission grid in the northeastern part of the United States is managed by either ISO New England, ISO New York, or PJM Interconnection. Matching states and electric transmission zones data presents a number of challenges since the electric grid does not always align with geopolitical boundaries. The areas contributing to the NY-NJ-CT ozone nonattainment area are matched with transmission zones, listed in Table 2, in a best-fit approach:

- ISO New England divides their electric transmission area by state zones so the entire state of Connecticut is used in this analysis;
- ISO New York divides their electric transmission area into eleven zones and this analysis includes the Hudson Valley zone and ISO NY zones south of the Hudson Valley including a small area in New Jersey;
- Washington, D.C. is not identified as a significant contributor to the NY-NJ-CT ozone nonattainment area, however, it cannot be separated from the PJM Interconnection transmission zones, so DC is included in this analysis;
- Parts of Ohio and Pennsylvania are not part of PJM Interconnection during the timeframe examined so parts of Ohio and Pennsylvania are not included; and
- Most of Kentucky and North Carolina are not part of PJM Interconnection so most of these states are not part of the analysis.

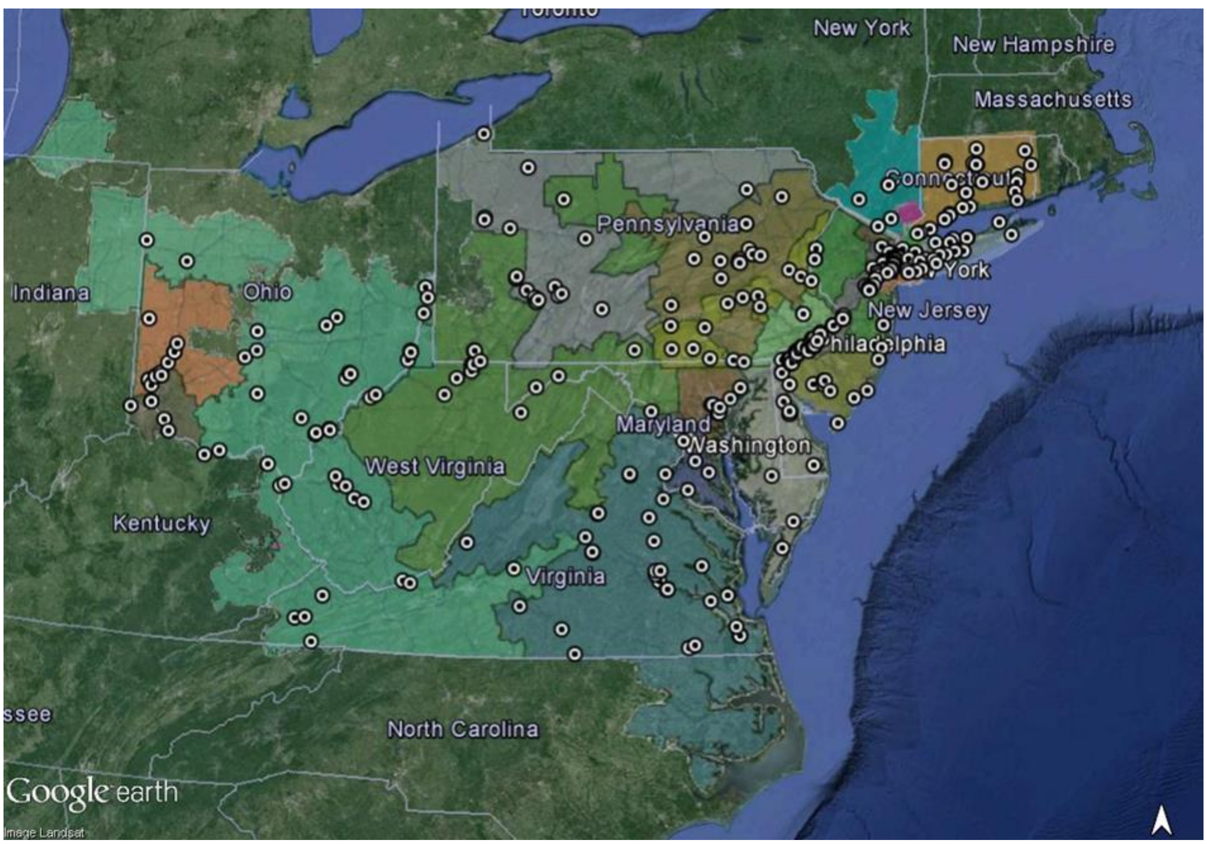
Table 2. Selected Electric Transmission Zones

ISO New England	Connecticut	
ISO New York	Long Island Dunwoodie Hudson Valley	Millwood New York City
PJM Interconnection	Public Service Exelon : PECO PP&L UGI Baltimore Gas & Electric First Energy: Jersey Central First Energy: MetEd First Energy: PennElec PEPCO	Conectiv: Atlantic Electric Conectiv: Delmarva Power & Light Rockland Electric Allegheny Energy AEP Dayton Power & Light Duke Ohio/Kentucky Dominion Virginia

EGU EMISSIONS

EGU emissions data are readily available online from EPA CAMD Air Markets Program Data (AMPD). The daily EGU NOx mass emissions, in tons, were retrieved from AMPD for the 2005, 2008, 2009, 2011, and 2013 ozone seasons. The EGUs were mapped along with the electric transmission zones, as shown in Figure 1, and only the units part of the selected transmission zones were used in this analysis.

Figure 1. Focus Area: EGUs in Contributing Areas with Corresponding Electric Zones



ANALYSIS AND DISCUSSION

Hourly electric demand values from the selected transmission zones were tallied to create an hourly sum across the focus area for each hour in the ozone seasons. Then each calendar day's highest electric demand hour was selected to represent the daily peak electric demand as megawatt hour (MW-hr).

The daily peak demand was matched with the corresponding daily NOx mass emissions and graphed as a scatter plot with trend lines, see Figure 2. The same dataset was modified to show peak demand in bins to better illustrate the year-to-year variations for similar peak electric demand conditions, see Figure 3.

Figure 2. Ozone Season Daily NOx Emissions vs. Peak Electric Demand (Trend Lines)

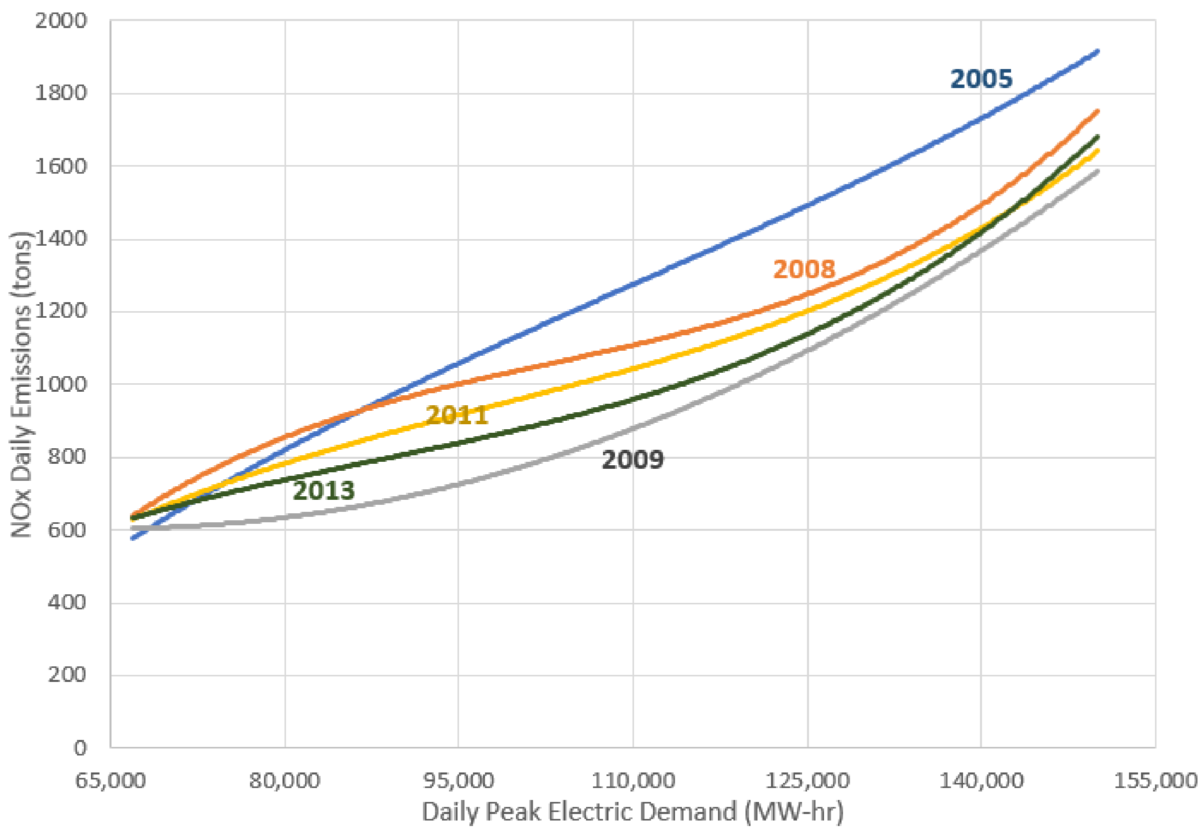
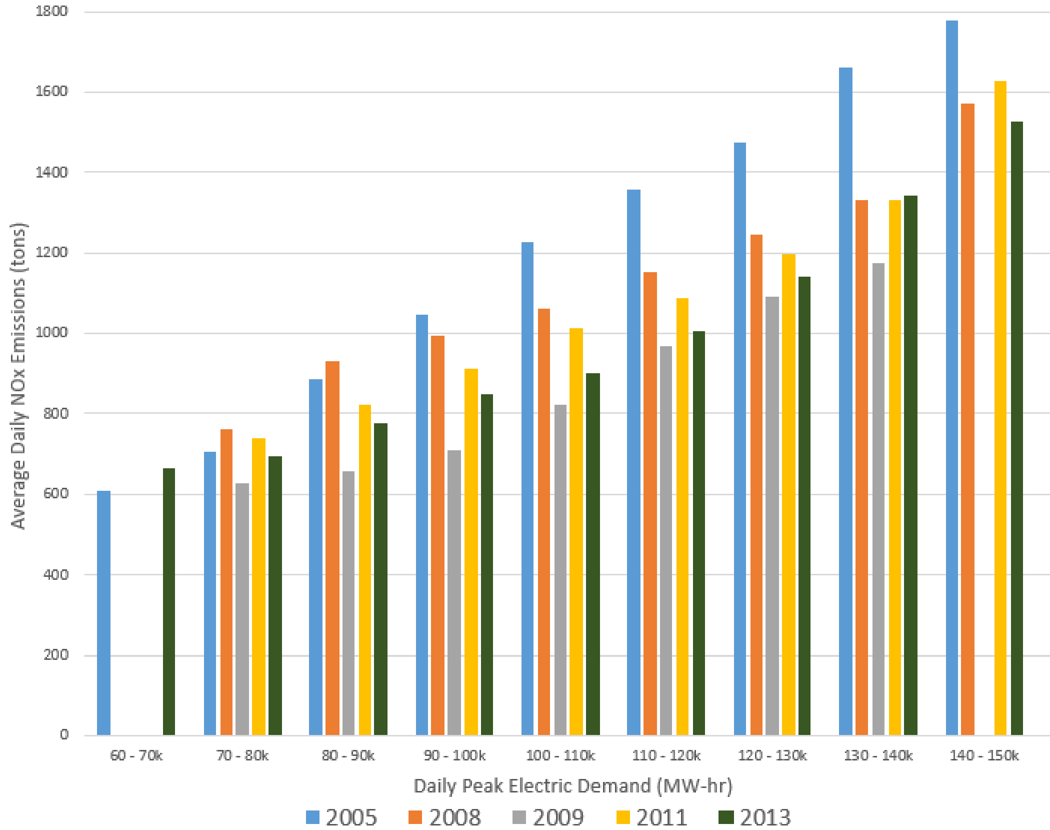


Figure 3. Ozone Season Daily NOx Emissions vs. Peak Electric Demand (Bar Chart)



There is a decrease in NOx emissions rates from 2005 through 2009. The 2009 ozone season was relatively cool with fewer HEDDs and the bar graph shows that 2009 is the only year in the analysis that did not exceed 140,000 MW-hr peak demand. However, the 2009 ozone season is also the first season after the January 1, 2009 CAIR regulatory compliance date. So while there were fewer HEDD in 2009, this analysis shows that on the days with similar peak electric demand the 2009 emission rates are the lowest analyzed.

After 2009, NOx rates increases but for the most part do not exceed the 2005 or 2008 rate. This increase is thought to be attributed to an abundance NOx CAIR allowances creating a lower economic incentive for EGUs to operate their installed pollution control devices where not otherwise regulatorily required.

LIMITATIONS AND OPPORTUNITIES FOR IMPROVEMENT

This analysis does not address the conditions in which ozone is formed and transported to nonattainment areas.

The analysis only accounts for EGUs that are major stationary sources. A more detailed analysis could be performed if detailed data were available for non-major EGUs including those that do not transmit across the electric grid. Also, non-EGU stationary sources account for 37% of annual NOx emissions in the focus area and it is unclear if these source emissions fluctuate during the ozone season. Some of the larger non-EGU stationary sources include, pipeline transportation of natural gas (5.6%), airport operations (3.3%), cement manufacturing (3.3%), paper mills (2.6%), and solid waste combustors and incinerators (2.6%) (2011 NEI v2, March 2015).

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US EPA Clean Air Markets Division (CAMD) Air Markets Program Data (AMPD), data retrivals http://ampd.epa.gov/ampd/

DISCLAIMER

KEY WORDS

Electric Generation
Emissions Inventory
Nitrous oxides
Ozone