CITY OF PHILADELPHIA
Department of Public Health
Environmental Protection Division
Air Management Services

InterOffice Memo

To: File

From: Edward Wiener & Kassahun Sellassie

Date: June 24, 2015

Subject: 1997 8-Hour RACT Analysis for Exelon Generating Company - Richmond Station

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Introduction:

The Clean Air Act (CAA) requires that moderate (or worse) ozone nonattainment areas implement reasonably available control technology (RACT) controls on all major sources of Volatile Organic Compounds (VOC) and Nitrogen Oxides (NOx). Philadelphia County is part of the Philadelphia-Wilmington-Atlantic City moderate ozone nonattainment area for the 1997 8-hour ozone NAAQS. This document presents the findings of the reevaluation of NOx RACT for the 1997 8-hour ozone standard for this facility

Company Description:

Exelon Generation Company - Richmond Station owns and operates an electric utility at 3901 North Delaware Avenue, Philadelphia, PA, 19137. Equipment used at the facility includes two (2) simple cycle combustion turbines. The facility was owned by PECO Energy Company at the time of the original RACT plan approval, but changed to ownership to Exelon in October 2000.

Applicability for NOx and VOCRACT

Exelon - Richmond is a major source of NOx due to having potential NOx emissions greater than 100 tons per year, the major source threshold in Philadelphia County that is applicable to NOx RACT for the 1997 8-hour ozone NAAQS. They are not a major source of VOC, due to having potential VOC emissions not greater than 50 tons per year, the major source threshold in Philadelphia County that is applicable to NOx RACT for the 1997 8-hour ozone.

The facility is a 1-hour RACT source. As a result of a case-by-case RACT determination, the facility is subject to the RACT plan approval (PA Permit Number 51-4903) dated 7/11/01, approved into the SIP by EPA on 10/30/01 (66 FR 54704). All two simple cycle combustion turbines, were covered by 1-hour RACT determination, and thus are required a re-evaluation for the 1997 8-hour RACT standard.

Process Descriptions:

Exelon - Richmond Station currently has two simple cycle combustion turbines, each rated 66 MW. Each burns No. 2 oil.

NOx RACT Analysis for the 1997 8-hour Ozone Standard:

The two Turbines, each has a NOx emission limit of 0.70 lbs/MMBTU from the 1-hour RACT determination, now the emission limitation reduced to0.68 lbs/MMBTU. AMS has determined the new lbs/MMBTU limits to be RACT because stack test data has shown the boilers can comply with these limits under existing technology.

The following were considered possible NOx controls for each combustion turbine: Water/steam Injections, Selective Catalytic Reduction (SCR), and conversion to natural gas. To switch to NG would result in NOx emissions reductions of around 65%. This option requires the installation of a new gas pipeline and a pressure regulating station. Conversion to natural gas was determined technologically feasible, but there is no gas service to this building currently. Estimation from PGW have been in the neighborhood of four (4) million dollars to run this line

(permits, survey and staking, cleaning & grading, trenching, pipe stringing, lowering in & backfilling, hydrostatic testing, cleanup & restoration, and pipe and accessories cost). This cost does not include the pressure regulating station.

SCR injects ammonia upstream of a catalyst. NOx, ammonia (NH_3), and oxygen (O_2) react on the surface of the catalyst to form nitrogen (N_2) and water (H_20). NOx emissions would be reduced by around 80%. Water/Steam Injection increases thermal mass by dilution which reduces peak temperatures in the flame zone. This control would reduce NOx emissions by around 60%.

Baseline NOx emissions for each unit was determined based on an 838 MMBTU/hr capacity, 8,760 hours per year, a proposed 0.68 lbs/MMBTU NOx emission limit, and a 15% capacity factor limit from the original RACT Plan Approval (PA Permit Number 51-4903) issued on July, 2001. Baseline emissions are 374.38 tons per year for each unit. The proposed 0.68 lbs/MMBTU limit lowers a 0.7 lbs/MMBTU limit in the original RACT plan approval and isbased based on past stack test results. The sulfur in fuel limit was added because a 2005 study from the Brookhaven National Laboratory indicates that ultra low sulfur fuel can reduce NOx emissions

Source	Control Technologies	Baseline NOx Emissions (tpy)	NOx Reduction (%)	NOx Reduction (tpy)	Total Annualized Cost	Cost Effectiveness ($/Ton)
Exelon Richmond	Water/Steam Injection	374.38	60	224.63	$725,492	3,230
	SCR	374.38	80	299.50	$2,913,987	9,730
	Conversion to NG	374.38	65	243.34	$1,664,829	6,842

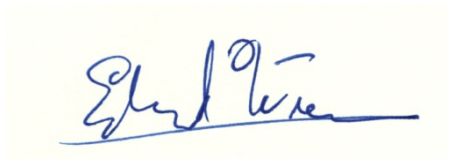
All of these control options have been determined economically unreasonable. Additionally, these units typically operate no more than 10 hours in a month or 20 hours annually, with actual emissions a fraction of their potential to emit

Thus, AMS proposes as RACT foreach combustion turbine a rolling 12-month capacity factor limit of less than 15% (based on net generation), a NOx emission limit of 0.68 pounds per MMBTU, and a requirement to install, maintain, and operate the unit in accordance with manufacturer's specifications.

Conclusions and Recommendations:

AMS proposes as RACT for the 8-hour ozone standard the following revisions to the SIP-approved RACT Plan Approval (PA Permit Number 51-4903) for the Exelon - Richmond Station:

- Replacing the NOx emission limits of each combustion turbine, of 0.7 lbs/MMBTU, with 0.68 lbs/MMBTU and 569.84 lbs/hr.



6/24/15

Edward Wiener, Chief of Source Registration **Date**

Detail Calculations Summary **Estimating Approach and Basis**

Estimates of Total Capital Investment (TCI), annual costs, Potential emission reductions, and cost effectiveness are prepared for each of the feasible control technology cases above.

- EPA's Air Pollution Control Cost Estimate Manual, January 2002, 6th edition was used The following costs are calculated in order to evaluate the cost effectiveness of each emission control technology:

  - Total Capital Investment (TCI)
  - Direct Annual Cost (DAC) ($/yr)
  - NOx Emission Reduction (tons/yr)
  - Cost Effectiveness ($/ton)

  o **Capital Recovery** = Convert from P (present) to A(Annual amount), A=P(A/P,i%,n),

$$CR = \frac{i(1+i)^n}{(1+i)^n - 1}$$ 15% interest and 20 yrs = A/P=0.1598

Where i= Annual interest Rate; n= control system life; Annual cost = TCI x CRF

References for Cost Calculations for all cost elements

North East States for Coordinated Air Use Management (NESCAUM); Office of Air Quality Planning and Standards (OAQPS) - Environmental Protection Agency (EPA) Air Pollution Control Manual, Six Edition, EPA/452/B-02-001, January 2002; Cost analysis and engineering economics book (Michael R. Lindeburg) and PADEP Guidelines for RACT SIP revision under the 8-hr Ozone NAAQS, Sep 2006 (Most elements of costs are taken from this document of pages 5 and 18) and from Office of Air Quality Planning and standards (OAQPS) Environmental Protection Agency (EPA) Air Pollution Control Manual, Six Edition, EPA/452/B-02-001, January 2002 (page 2-27(2.5.5), I-52 table 1.13, Appendix A) and from other States

Reference for Consumer Price Index (CPI) is used to adjusted for inflation by taking percentage increases from 1999 to 2014 (for each $1,000,000 of 2013 it is $1,004,000 for 2014 (0.4%) from United States Department of Labor-Bureau of Labor Statistics, which is considered as very minimum increment**.** **www.bls.gov**

1. From US Bureau of Labor Statics
2. EPA Cost Manual, 6th Edition , Jan 2002, Appendix A.2.3

The big change is from 2004 through 2007 control equipment increase by 70%

For the Catalyst, The catalyst life is 5 years. The annual cost is given by the sinking fund factor, the amount of money the facility will need to set aside each year to be able to replace the catalyst at the end of its life, based on the lifespan of the catalyst and the interest rate.
Sinking Fund Factor (SFF) = Convert from F (Future) to A(Annual amount), A=F(A/F,i%,n),

$$SFF = \frac{i}{(1+i)^n - 1}$$ 8% interest and 5 yrs = A/F=0.1705

Where i= Annual interest Rate (8%); n= catalyst system life (5 years);

Catalyst Annual Cost = SFF x Catalyst Cost

EXELON RICHMOND

Table 1 Detail Calculations for Exelon Richmond Turbines SCR

Exelon Richmond Data			Factors used
Turbine Capacity	66 MW (each)		15 % Capacity Factor
Total capital Cost			
Total Capital Investment Cost (TCI)	$17,414,613		TCI from original RACT proposal plus inflation adjustment. Original TCI includes equipment cost estimates from vendor-supplied estimates for similar units or industry data gathered for similar projects.
Annual Operating Costs			
Direct Annual Cost			
Electricity Cost[3]	$70,080		100kw @ $0.08/kwh, 8760 hrs/yr (PA DEP RACT State Implementation Plan (SIP) revision, Sep, 2006, page 18)
Operator[4]	$16,425		0.5hr/shift, 3 shift/day, $30/hr
Supervisor[4]	$2,463.75		15% of Operator
Maintenance[4]	$19,162.50		0.5hr/shift, 3 shift/day, $35/hr
Material[4]	$19,162.50		100% of Maintenance
Catalyst cost[4]			$190,000 total catalyst
Sinking Fund Factor	0.1705		
Total catalyst Replacement Cost[2]	$32,395		
Total Direct Annual Cost	$159,689		
Indirect Annual Cost			
Overhead[4]	$11,497		60% of maintenance-OAQPS[1]
Administrative Charge[4]	$348,292		2% of TCI-OAQPS[1]
Property Taxes[4]	$174,146		1% of TCI-OAQPS[1]
Insurance[4]	$174,146		1% of TCI-OAQPS[1]
Capital Recovery	$2,046,217		20 yrs @10% -OAQPS[1]
Total Indirect Annual Cost	$2,754,298		
Total Annual Operating Costs	$2,913,987		
NOx Emission Reduction (TPY)	299.50		
Cost Effectiveness ($/ton NOx removed)	$9,730		

- [1]Office of Air Quality Planning and standards (OAQPS) Environmental Protection Agency (EPA) Air Pollution Control Manual, Six Edition, EPA/452/B-02-001, January 2002.
- [2] **Sinking Fund Factor**: For the Catalyst, The catalyst life is 5 years. The annual cost is given by the sinking fund factor. Sinking Fund Factor (SFF) = Convert from F (Future cost) to A(Annual amount), A=F(A/F,i%,n), Catalyst Annual Cost = SFF x Catalyst Total Cost
- [3] **Electricity cost**: we assume 75 kw@ $0.08/kw-hr for one year. Reference PA DEP RACT State Implementation Plan (SIP) revision, Sep, 2006, page 18; EPA Cost Calculation, Appendix A- NOx Control Analysis, A.1 Vendor Information, A-2 Cost Calculation
- [4]**Cost calculations for each elements** are from references: North East States for Coordinated Air Use Management (NESCAUM), EPA' s Office of Air Quality Planning and standards (OAQPS) edition 6, 2002; Cost analysis and engineering economics book (Michael R. Lindeburg), from Facility, and **PADEP Guidelines for RACT SIP revision under the 8-hr Ozone NAAQS, Sep 2006** (Most elements of costs are taken from this doc of page 5 and 18) and from [1]Office of Air Quality Planning and standards (OAQPS) Environmental Protection Agency (EPA) Air Pollution Control Manual, Six Edition, EPA/452/B-02-001, January 2002 (page 2-27(2.5.5), I-52 table 1.13, Appendix A) and from other States

Table 2 Detail Calculations for Exelon Richmond Turbines Water Injection

Exelon Richmond Data			Factors used
Turbine Capacity	66 MW (each)		15 % Capacity Factor
Total capital Cost			
Total Capital Investment Cost (TCI)	$3,725,099		TCI from original RACT proposal plus inflation adjustment. Original TCI includes equipment cost estimates from vendor-supplied estimates for similar units or industry data gathered for similar projects.
Annual Operating Costs			
Direct Annual Cost			
Electricity Cost	$70,080		100kw @ $0.08/kwh, 8760 hrs/yr
Operator	$16,425		0.5hr/shift, 3 shift/day, $30/hr
Supervisor	$2,463.75		15% of Operator
Maintenance	$19,162.50		0.5hr/shift, 3 shift/day, $35/hr
Material	$19,162.50		100% of Maintenance
Total Direct Annual Cost	$127,294		
Indirect Annual Cost			
Overhead	$11,497		60% of maintenance-OAQPS
Administrative Charge	$74,501		2% of TCI-OAQPS[1]
Property Taxes	$37,251		1% of TCI-OAQPS[1]
Insurance	$37,251		1% of TCI-OAQPS[1]
Capital Recovery	$437,699		20 yrs @10%-OAQPS[1]
Total Indirect Annual Cost	$598,198		
Total Annual Operating Costs	$725,492		
NOx Emission Reduction (TPY)	224.63		
Cost Effectiveness ($/ton NOx removed)	$3,230		

o [1]Office of Air Quality Planning and standards (OAQPS) Environmental Protection Agency (EPA) Air Pollution Control Manual, Six Edition, EPA/452/B-02-001, January 2002.

Table 3 Detail Calculations for Exelon Richmond switching to NG from fuel oil

Exelon Richmond			Factors used
Turbine Capacity	838 MMBTU/hr (66 MW)		
Sub Total Capital Investment Cost (TCI)	$4,438,629		Natural gas price from USA Energy Information Administration (EIA)4 =($6.5/1000 ft3)* (1/127 kwh/1000 ft3) *(66000 kw * 8760 hr/yr*15%)[5]
Sub TCI with NG Line	$4,000,000	For NG Line construction from PGW $4.0 million	TCI from other similar source (Veolia Edisson) RACT proposal plus inflation adjustment and Prorated based on capacity.
Total TCI	$8,438,629		
Capital Recovery	$1,348,493	0.1598	20 yrs @15% -Original RACT Proposal
Annual Operating Costs			
Direct Annual Cost			
Electricity Cost[3]	$70,080		100kw @ $0.08/kwh, 8760 hrs/yr (PA DEP RACT State Implementation Plan (SIP) revision, Sep, 2006, page 18)[4]
Operator	$16,425		0.5hr/shift, 3 shift/day, $30/hr
Supervisor	$2,463.75		15% of Operator
Maintenance	$19,162.50		0.5hr/shift, 3 shift/day, $35/hr
Material	$19,162.50		100% of Maintenance
Total Direct Annual Cost	$127,294		
Indirect Annual Cost			
Overhead	$11,498		60% of maintenance-OAQPS[1]
Administrative Charge	$88,773		2% of TCI-OAQPS[1]
Property Taxes	$44,386		1% of TCI-OAQPS[1]
Insurance	$44,386		1% of TCI-OAQPS[1]
Total Indirect Annual Cost	$189,043		
Total Annual Operating Costs	$1,664,829		
NOx Emission Reduction (TPY)	243.34		
Cost Effectiveness ($/ton NOx removed)	$6,842		

- [5]**US Energy Information Administration (EIA)**
  http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SPA_m.htm
  http://www.eia.gov/naturalgas/weekly/
  127 kwh per Mcf of NG; $6.5/Mcf natural gas; 15% capacity factor