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Attachment 6

COMMONWEALTH OF VIRGINIA
Department of Environmental Quality
Northern Regional Office

STATEMENT OF LEGAL AND FACTUAL BASIS

Covanta Alexandria/Arlington, Inc. (CAAI)
Alexandria, Virginia
Permit No. NRO-RACT71895

Pursuant to the requirements of § 110 of the Clean Air Act, on December 12, 2017, the Commonwealth of Virginia submitted to EPA Region III, a request for approval for a revision to the Commonwealth of Virginia State Implementation Plan (SIP). This SIP revision consists of Virginia's plan to support reasonably available control technology (RACT) in the Ozone Transport Region of Virginia for the 2008 National Ambient Air Quality Standard for Ozone.

Part of the SIP revision includes Virginia's commitment to providing SIP revisions addressing source-specific 2008 ozone RACT requirements, for which one of those sources is Covanta Alexandria/Arlington, Inc.

The Department has reviewed the proposed RACT Plan for Covanta Alexandria/Arlington, Inc. and has prepared a draft State Operating Permit requiring NO_X RACT, and requisite conditions for recordkeeping, reporting, and testing sufficient to enforce the RACT determinations.

Engineer/Permit Contact: Gary Beeson — Date: 2/5/2018
Gary Beeson
(703) 583-3969

Air Permit Manager: James B. LaFratta — Date: 2/8/2019
James B. LaFratta

Regional Director: Thomas A. Faha — Date: 2-8-19
Thomas A. Faha

FACILITY INFORMATION

Permittee

Covanta Alexandria/Arlington, Inc.
5301 Eisenhower Avenue
Alexandria, Virginia 22304

Facility

Covanta Alexandria/Arlington, Inc.
5301 Eisenhower Avenue
Alexandria, VA 22304

County-Plant Identification Number: 080-0139

FACILITY DESCRIPTION

NAICS Code: 562213 – Solid Waste Combustor and Incinerator.

Covanta Alexandria/Arlington, Inc. (CAAI) operates a municipal solid waste (MSW) combustion facility with energy recovery. The facility maintains three (3) municipal waste combustion (MWC) units, each with the capacity to combust 325 tons of MSW per day (nominal). The MWC units are water wall boilers with integrated reciprocating grate stokers. Each combustor is also equipped with #2 fuel oil-fired auxiliary burners used during startup, shutdown, malfunction, and flame stabilization. Products of combustion from each combustor are controlled by good combustion practices, ammonia injection (selective non-catalytic reduction), a combination of spray dyer and fabric filter, and activated carbon injection to reduce nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM and PM-10), acid gases, metals and complex organics among others. With this RACT permit, the permittee will install additional NO_X controls in the form of Covanta's proprietary Low NO_X combustion system (LN^{TM}). Steam generated by the boilers drive two turbines that each has the capability of generating 14.5 MW of electricity for sale to the electric grid.

RACT REGULATIONS

RACT Overview & General Applicability

9VAC5 Chapter 40, Part II, Article 51, *Emission Standards for Stationary Sources Subject to Case-by-Case RACT Determinations (Rule 4-51)* – 9VAC5-40-7370 *et seq*. contains the requirements for sources seeking case-by-case reasonably available control technology (RACT) determinations required under the 2008 8-hour ozone national ambient air quality standard (NAAQS). EPA approved Rule 4-51 as a revision to Virginia's State Implementation Plan (SIP) on August 17, 2016 (81 FR 54506).

The Clean Air Act mandates that major stationary sources--those with potential to emit (PTE) of at least 50 tons per year (tpy) of volatile organic compounds (VOC) or 100 tpy of nitrogen oxides (NO_X), located within the Ozone Transport Region (OTR)--must implement RACT whenever the

U.S. Environmental Protection Agency (EPA) updates ozone air quality standards. Rule 4-51 contains requirements for the 2008 NAAQS.

Virginia may implement a variety of approaches to determine RACT. Certain emission sources have control technique guidelines published by EPA and adopted by Virginia in 9VAC5 Chapter 40 and Chapter 45 serve as RACT. Another approach is to recertify the previous source-specific RACT determinations made under the 1990 ozone NAAQS or the 1997 ozone NAAQS as RACT for the 2008 ozone NAAQS. Recertification is appropriate where previous RACT determinations continue to represent RACT for that unit or facility, based on a review of existing control technologies and their associated costs and benefits. Virginia may choose to determine that presumptive RACT is appropriate for some sources. Generally, presumptive RACT values are associated with fuel-burning equipment and represent emission rates supported by alternative control technique guidelines published by EPA. Presumptive RACT rates are listed in 9VAC5-40-7430. Virginia may also require a source to provide a unit specific RACT analysis for units located at RACT-applicable facilities.

9VAC5-40-7380 defines two key terms:

"Presumptive RACT" means the emission limit that a particular source is capable of meeting by the application of reasonably available control technology as defined in 9VAC5-40-7430.

"Reasonably Available Control Technology" or "RACT" means the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available, considering technological and economic feasibility.

RACT Applicability to CAAI

CAAI is located in Alexandria, Virginia, part of the OTR. The facility is subject to RACT as the potential emissions of NO_X for the stationary source are in excess of the thresholds set in 9VAC5-40-7420 (> 100 tpy NO_X). The potential emissions of VOC are below the threshold set in 9VAC5-40-7400 (>50 tons/yr VOC) and therefore the facility is not subject to RACT for VOC.

Certain source categories listed in 9VAC5-40-7430, DEQ defines a presumptive RACT for NO_X. The source categories for presumptive RACT are boilers and combustion turbines firing gas, oil and (for boilers only) coal. DEQ does not define a presumptive RACT for MWC's such as at CAAI. The presumptive RACT category most similar to MWC's would be stoker coal boilers, which have a presumptive RACT limit for NO_X of 0.4 lb/MMBtu. This limit is less stringent than the current limitation for the units at CAAI, which is 205 ppmvd (7% O_2 basis) daily, which converts to 0.35 lb/MMBtu. Therefore, the installation of the LN^{TM} with an emission annual limit of 110 ppmvd (7% O_2 basis) would result in a limit of approximately 0.19 lb/MMBtu.

9VAC5-40-7420 addresses RACT requirements for sources without a presumptive RACT, such as at CAAI. RACT is applicable to facilities with site-wide emissions greater than 100 tons/yr, as is the case at CAAI. There are three requirements for sources such as CAAI:

1. Notify DEQ of applicability status;
2. Commit to making a determination of RACT; and,
3. Provide a schedule acceptable to DEQ for making the RACT determination and achieving

compliance with the emission standard no later than January 1, 2017.

CAAI submitted preliminary RACT information to DEQ via letter dated January 28, 2016. DEQ requested that CAAI complete the RACT analysis consistent with the DEQ RACT Analysis Guidelines (updated February 3, 2016). The DEQ guidelines request a three-step version of the top-down control technology approach:

1. Identify all available control alternatives;
2. Assess technical feasibility; and
3. Evaluate remaining technologies in order of control effectiveness considering:
    i. Expected emissions reduction (ton/yr);
    ii. Economic impacts ($/ton of pollutant removed);
    iii. Environmental impacts; and,
    iv. Energy impacts.

If the top control alternative is not selected as RACT, the rationale for rejection must be documented. The next most stringent control alternative is then assessed, and the process continues until RACT is determined.

Covanta's September 2016 submittal assumed that RACT must be implemented no later than January 1, 2017. This revised submittal does not include that time constraint in assessing available RACT options.

Table 1 below lists the "affected facilities" (a.k.a. emission units) at Covanta Alexandria/Arlington, Inc. that must be reviewed for RACT for NO_X. Table 1 also provides a citation for the Commonwealth's RACT rule at 9VAC5 Chapter 40 Article 5 "Stationary Source Subject to Case-by Case RACT Determinations" and identifies the RACT determination for each unit.

Table 1 – Sources Requiring Case-by-Case RACT at CAAI

Source ID	Equipment/Process Description	NOX RACT Basis
001-02	Keeler/Dorr-Oliver municipal waste combustor with Martin stokers (Began commercial operation in February, 1988) 325 tons per day (nominal) waste combustion 121.8 MMBtu/hr (rated heat input)	9VAC5-40-7420 (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)
002-02	Keeler/Dorr-Oliver municipal waste combustor with Martin stokers (Began commercial operation in February, 1988) 325 tons per day (nominal) waste combustion 121.8 MMBtu/hr (rated heat input)	9VAC5-40-7420 (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)
003-02	Keeler/Dorr-Oliver municipal waste combustor with Martin stokers (Began commercial operation in February, 1988) 325 tons per day (nominal) waste combustion 121.8 MMBtu/hr (rated heat input)	9VAC5-40-7420 (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)

The three (3) municipal waste combustors (MWC) are Keeler/Dorr-Oliver equipped with Martin stokers with integrated reciprocating grate stokers and water walls. Each of the three MWC is also equipped with #2 fuel oil-fired auxiliary burners. Each of the three MWC is rated at 325 tons per day (nominal) waste combustion and has a heat input rating of 121.8 MMBtu/hr. These units were constructed prior to the September 20, 1994, designated as the cut-off date in 40 CFR 60, Subpart Cb, and have a combustion capacity greater than 250 tons per day of municipal solid waste therefore applicable to this NSPS (40 CFR 60, Subpart Cb). The facility submitted a unit specific RACT analysis to address Clean Air Act requirements for the 2008 ozone NAAQS as discussed in detail below.

<u>OTHER APPLICABLE NOx CONTROL REQUIREMENTS AND EXISTING CONTROLS</u>

Products of combustion from each combustor are controlled by good combustion practices, ammonia injection (selective non-catalytic reduction), a combination of spray dyer and fabric filter, and activated carbon injection to reduce nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM and PM-10), acid gases, metals and complex organics among others.

The facility is located in the City of Alexandria, which is part of the Northern Virginia Ozone Nonattainment Area. The facility is a Title V major source of sulfur dioxide, nitrogen oxides, carbon monoxide, hazardous air pollutants (hydrogen chloride), and carbon dioxide equivalent emissions. The facility has the potential to emit (PTE) more than 100 tons per year (tpy) of nitrogen oxides (NO_x) and therefore considered a major stationary source for purposes of non-attainment new source review (9 VAC 5-80-2000, et seq.). The facility operates under the Prevention of Significant Deterioration (PSD) Permit dated September 27, 2010, a minor NSR Permit dated September 27, 2010, a Title V Permit dated June 10, 2016, and a Consent Agreement dated July 31, 1998 implementing Reasonably Available Control Technology (RACT). The requirements of the RACT consent agreement, issued on July 31, 1998 have been fulfilled. The facility is also subject to state Rule 4-54 (9VAC5-40-7950 et seq.) of the Virginia Air Pollution Control Board's Regulations for the Control and Abatement of Air Pollution. This rule implements various emissions limitations, operating, compliance, and recordkeeping requirements established by the Emissions Guidelines of 40 CFR 60, Subpart Cb. Rule 4-54 is the approved Clean Air Act Section 111(d)/129 plan for Large Municipal Waste Combustor (MWC) Units regulated under 40 CFR 62, Subpart VV sections 62.11640 through 62.11642 approved on October 29, 2004.

2008 OZONE NAAQS RACT ANALYSIS FOR 001-02, 002-02, and 003-02

<u>Unit description and Impact</u>

001-02, 002-02, and 003-02 are identical Keeler/Dorr-Oliver municipal waste combustor with Martin-stokers boiler system with integrated reciprocating grate stoker and water wall municipal waste combustors (MWC). Each MWC is also equipped with two # 2 oil-fired auxiliary burners. Each of the three MWC rated at 325 tons per day (nominal) waste combustion and a heat input rating of 121.8 MMBtu/hr. These units are currently equipped with ammonia injection (selective non-catalytic reduction) (SNCR), a combination of spray dyer and fabric filter, and activated carbon injection to reduce nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM and PM-10), acid gases, metals, and complex organics among others. The units are classified as *large* *municipal waste combustors* under 40 CFR 60, Subpart Cb, "Emissions Guidelines and Compliance Times for Large Municipal Waste Combustors That are Constructed on or Before September 20, 1994". The regulation requires this classification of units to be greater than 250 tons per day of municipal solid waste and commenced operation prior to September 20, 1994. Additionally, the regulatory rate is 205 ppmvd (corrected to 7% O_2) for mass burn waterwall combustor technology.

Previous RACT Determination

The facility is subject to a previous RACT determination, which includes federally enforceable requirements issued as part of a July 21, 1998 consent order between DEQ and the facility. DEQ determined that NO_X RACT for these three MWC was the implementation of all NO_X emissions requirements of 40 CFR Part 60, Subpart Cb, as amended August 25, 1997. At the time of this determination, the facility concluded that installing SNCR and meeting a NO_X emissions standards of 205 ppm, corrected to 7% O_2, on a twenty-four hour daily geometric mean consistent with the requirements of 40 CFR 60, Subpart Cb, would fulfill NO_X RACT. The DEQ concurred with this determination.

Presumptive NO_X RACT Limitations

In the presumptive NO_X RACT categories listed in 9VAC5-40-7430, DEQ defines a presumptive RACT for NO_X. The source categories for presumptive RACT are boilers and combustion turbines firing gas, oil and (for boilers only) coal. DEQ does not define a presumptive RACT for MWC's such as at CAAI. The presumptive RACT category most similar to MWC's would be stoker coal boilers, which have a presumptive RACT limit for NO_X of 0.4 lb/MMBtu on a 24-hour daily basis. This limit is less stringent than the current limitation for the three units at CAAI, which is 205 ppmvd (7% O_2 basis) on a 24-hour daily basis, which converts to 0.35 lb/MMBtu on a 24-hour daily basis. Therefore, the installation of the LN™ with an emission limit of 110 ppmvd (7% O_2 basis) on a 24-hour basis would result in a limit of approximately 0.19 lb/MMBtu on a 24-hour basis. Therefore, presumptive NO_X RACT is not applicable to these units.

PROPOSED RACT DISCUSSIONS

Optimization of the Selective Non-Catalytic Reduction (SNCR)

SNCR injects ammonia into the high-temperature combustion exhaust gases where the ammonia (NH_3) reacts with NO_X to yield several reaction products including nitrogen (N_2) and water vapor (H_2O). As more ammonia is injected, additional NO_X can be converted, but there are limits to the extent of removal that is possible. In all operational modes, a portion of ammonia is unreacted and is emitted; this ammonia is referred to as ammonia slip. As the amount of ammonia injected increases, ammonia slip may also increase. As such, there is an optimization between the amount of ammonia injected and the amount of ammonia slip. As ammonia slip increases, a detached visible plume can be created by the interaction between ammonia and chlorides or sulfides in the exhaust gases.

CAAI underwent an SNCR optimization study at the request of the Alexandria/Arlington Waste Disposal Trust Fund Board of Trustees. At the time of the study, CAAI was operating with a NO_X setpoint of 185 ppmvd to ensure compliance with the permit limit of 205 ppmvd (7% O_2

basis). Testing at CAAI showed uncontrolled NO_X emissions at approximately 275 ppmvd and that optimization of the system could potentially lower setpoint to as low as 150 ppmvd in limited operating conditions. Key points identified from that study included:

1. NO_X emissions are consistently higher for approximately 30 days after the annual outage. This is attributable to a change in the isotherms in the furnace causing the SNCR process to be less effective;
2. A visible plume can result from hydrogen chloride combining with ammonia as ammonia injection rates increase;
3. Fluctuations in the municipal solid waste (MSW) received can influence the ability of the MWC to achieve an emission rate (e.g., MSW with large concentrations of yard waste can result in more difficulty in maintaining lower NO_X emissions);
4. There are variations on a unit-by-unit basis in the achievable NO_X emissions (based on testing of the three nominally identical units at CAAI);
5. Some reduction from the 185 ppmvd setpoint is likely achievable as CAAI was able to operate with a setpoint as low as 150 ppmvd during limited duration periods;
6. The CAAI boiler cross-section is small and therefore can achieve good contact between the ammonia and the flue gas - additionally, temperatures in the upper furnace are near ideal once an equilibrium ash layer has coated the waterwall tubes;
7. The study duration required approximately six months to design, conduct, and analyze the results; and
8. The external costs to complete the study were $39,880 in 2006 - internal costs were not quantified at that time.

CAAI currently operates at a NO_X setpoint of 160 ppmvd beginning approximately two to four weeks after an outage, consistent with an agreement with the Alexandria/Arlington Waste Disposal Trust Fund Board of Trustees; the setpoint is higher in the two to four weeks after an outage. A setpoint is a distributed control system (DCS) target, where the DCS reads both the ammonia injection rate and the NO_X emission rate and via computer programing continuously adjusts the ammonia injection rate to attempt to maintain a consistent NO_X emission rate. Due to variabilities inherent in the combustion of a heterogeneous fuel such as MSW, NO_X emissions have a degree of variability such that it is necessary to define a setpoint value less than the permit limit. The setpoint is not a fixed emission value at which the unit always operates, but is a target value at the center of a range of emission values, some higher than and some lower than the setpoint, with the average NO_X emissions value targeted to the setpoint value.

Based on the prior SNCR optimization, CAAI is able to operate at a setpoint of 160-180 ppmvd, with the higher range used in the two to four weeks after an outage. Annual actual average emissions as operated with the optimized SNCR at CAAI range from 161 ppmvd to 168 ppmvd by unit (2014-2016) with a weighted average of 163 ppmvd.

Since this SNCR optimization has been previously conducted that is not considered an option for this analysis.

PROPOSED RACT

Municipal Waste Combustors (MWC)

NO_X

As part of the RACT analysis (Attachment A), CAAI included three available options for minimizing NO_X emissions from the three (3) existing MWC's. These options included:

1. Selective Catalytic Reduction (SCR)
2. Low NO_X (LN^{TM}) combustion system/SNCR combination;
3. Very Low NO_X (VLN^{TM})/SNCR combination

Selective Catalytic Reduction (SCR)

The reaction chemistry of a SCR system is similar to SNCR (NH_3 reactions with NO_X); however, SCR can occur at a much lower temperature (550 °F versus 1500 °F) by using a catalyst. Compared to SNCR, a SCR system can operate at lower combustion gas temperatures and can achieve a higher rate of reduction with potentially lower ammonia slip.

DEQ is not aware of any existing MWC units that have retrofitted a SCR nor did the search of the EPA RBLC data base turn up any facilities in which SCR had been retrofit to an existing MWC facility. However, a new construction unit with SCR was built and operating in Florida. It is understood to be achieving a NO_X concentration of ~50 ppmvd on a 24-hour limit and a ~45 ppmvd annual limit (i.e., West Palm No. 2). Given the nature of MSW combustion and the design and layout of the CAAI facility, a tail end catalyst system is required, where the SCR is located downstream of all other air pollution control devices. This design would require that the flue gas be reheated to achieve the proper reaction temperature for the SCR to convert NO_X into nitrogen. To minimize wasted heat from reheating the flue gas, tail end SCR systems incorporate a recuperator, where the heated gas leaving the catalyst is used to pre-heat the exhaust gas that is about to enter the catalyst.

Covanta utilized prior experience with retrofits of existing air pollution control equipment at Covanta facilities to derive the installation costs. Covanta used a ratio of total capital cost (equipment + installation + indirect costs) as a metric for estimating costs on other projects. For this analysis, Covanta evaluated the costs of full-scale baghouse retrofits at two facilities, the Covanta MWC in Essex County NJ and at Covanta Fairfax Inc. (CFI). The Essex County ratio was approximately 4.9:1 with CFI being about 2.75:1. The ratio selected for Alexandria/Arlington was 3.25:1. This ratio reflects the site layout at CAAI, the inherent spatial limitations of the existing infrastructure and ultimately the difficulty of installation, including probable staging of equipment from off-site locations.

The 3.25:1 factor selected for CAAI is higher than the CFI baghouse retrofit, but less than the Essex County retrofit. Essex County is considered more representative of CAAI because Essex used an elevated platform (60 feet above grade) to mount the baghouse over other equipment. The limited space at CAAI suggests that an elevated platform may be the only way to install an SCR at CAAI.

The total capital cost of the project was calculated by multiplying the vendor-supplied purchased equipment cost (PEC) by the calculated 3.25:1 ratio. A 15% contingency factor was than subtracted from the total cost (to avoid double counting the contingencies in the vendor estimate and the installation cost ratio). Then, the cost of the individual direct and indirect cost components, such as foundations, start-up, etc. were prorated based on the relative ratios of the cost allocations from two sources: 1) baghouse retrofits at the aforementioned Covanta facilities and 2) the bid Covanta submitted as part of a proposal for construction of the West Palm Beach MWC in Florida.

Direct and indirect annual costs were largely taken from the West Palm Beach (FL) MWC facility PSD BACT analysis, and adjusted to 2017 dollars using the CPI. The cost of reagent was set to be consistent with current reagent costs at CAAI.

The West Palm No. 2 replacement catalyst cost values were adjusted from 2010 to 2017 using the Consumer Price Index (CPI). With economies of scale applied (e.g., equipment size), the six-tenths power law is used to scale costs based on ton/day MSW, as CAAI is a smaller unit (325 tons/day) than West Palm No. 2
(1,000 tons/day).
Detailed cost calculation tables are provided in Appendix A with the results summarized below.

1. NOx available for control — 165 tpy (180 ppmvd)
2. NO_x removed by SCR — 121.4 tpy (controlled to 47.5 ppmvd)
3. Average cost effectiveness — $31,445/ton of NOx removed

The SCR would need to be installed on the tail end of the process. Due to significant space constraints, the only feasible location would be at elevation above the existing baghouse units. That location creates significant challenges and raises questions about the actual viability of that approach. Issues that would need to be addressed to confirm the feasibility of this approach include, but are not limited to, the following:

1. Completion of geological and civil surveys to confirm that the land and subsurface can support the elevated design and overturning moments;
2. Assuming that it is achievable, completion of engineering of the vertical supports around existing equipment and structures; and,
3. Storing equipment off-site for transport to the site for installation. The limited facility area prevents storage of new equipment at the site.

Because of these technical and economic considerations, DEQ does not consider this control option to be an acceptable alternative.

<u>Low NOx (LN™) Combustion System</u>

Covanta has developed a proprietary low NOx combustion system (i.e., LN™) that involves staging of combustion air. The system is a trademarked system and Covanta has received a patent for the technology.

A Martin MWC combustor system involves a moving grate with two sources of combustion air. Primary air (also called underfired air) supplied from underneath the grate and forced through the grate to dry and combust the MSW. The quantity of primary air is adjusted to minimize excess air while at the same time maximizing burnout of materials on the bed. Secondary air (also called overfired air) injected through nozzles located in the furnace sidewalls immediately above the grate provides turbulent mixing to complete the combustion process.

The Covanta LN™ process modifies the secondary air stream. A new series of air nozzles installed higher in the furnace (called tertiary air) diverts a portion of the secondary air to these new nozzles. Controlling the distribution of air between the primary, secondary, and tertiary streams optimizes combustion and temperature to minimize NO_X formation. The tertiary air achieves complete coverage of the furnace cross-section to ensure good mixing with the combustion gases. The tertiary air completes the combustion process, and yields uniform flue gas temperature and velocity profiles, which improves the performance and reliability of downstream boiler equipment. Note that the total airflow to the MWC is not changed, only the distribution of air is changed. The LN™ combustion system works in concert with an SNCR system to achieve even lower NO_X emissions than LN™ or SNCR alone.

A typical required scope of work to implement the LN™ process includes the following steps:

1. Detailed process analysis of current combustion conditions, including evaluation of waste heating values, excess air levels, furnace temperature profiles, and typical range of fouling;
2. Calculations to determine the number, size, and location of tertiary air nozzles;
3. Detailed mechanical and structural design of tertiary air ducting, headers and nozzles;
4. Installation of ductwork to carry the tertiary air from the discharge of the existing secondary air fan up to the elevation of the tertiary air nozzles;
5. Installation of automatic dampers to control the flow of tertiary air;
6. Installation of tertiary air headers on the upper furnace to feed air to individual nozzles;
7. Modifications to the boiler water walls to allow installation of the new tertiary air nozzles – two tube bends required per nozzle with refractory boxes to seal the boiler penetrations;
8. Installation of stainless steel tertiary air nozzles to allow online changes of nozzle diameter without shutting down the boiler;
9. Installation of flexible stainless steel hoses with individual manual butterfly dampers for the air feed to each tertiary air nozzle;
10. Design, installation and tuning of revised combustion controls; and,
11. Installation of additional Inconel on waterwall tubes and refractory tile in the lower furnace (Inconel is an oxidation- and corrosion-resistant nickel alloy).

The LN™ process can be retrofitted to an existing unit, and Covanta has installed the LN™ process at approximately 20 units worldwide, including at the MWC facility in Montgomery County, Maryland.

The LN™ process at the Montgomery County facility has appreciably increased annual maintenance costs due to increased refractory wear and boiler fouling. The result of expanding the combustion zone through a larger volume of the furnace creates a larger area subjected to high-temperature and low-oxygen conditions. Under these conditions, the combustion chamber components wear more quickly than would otherwise occur. The refractory and waterwall tubing are the primary components seeing higher wear rates with the refractory requiring repaired or replaced when damaged. Depending on the location within the boiler, waterwall tubes may require repair or replacement, as well as the application of Inconel cladding to resist the aggressive environment. While Inconel cladding is much more protective than bare tubes, it also wears over time and requires spot repair or re-application.

Estimated capital costs for installation of the LN™ process at CAAI were made by examining each of the boilers at CAAI to determine what initial level of protective cladding would be required to maintain furnace and waterwall tube integrity. Individual costs were developed on a per-boiler basis. The installation cost, which includes items such as fans, dampers, ducting, and process controls, was estimated based on actual expenses from Covanta's Montgomery County (MD) facility.

CAAI provided the cost of the LN™ controls to be around $4,000 per ton of NO_X removed based on estimated equipment cost, capital cost, and from the annual cost, scaled linearly from the Montgomery County project costs to CAAI.

Detailed cost calculation tables are provided in Appendix B with the results summarized below.

1. NO_X available for control   165 tons/yr   (180 ppmvd)
2. NO_X removed by LN™   82.5 tons/yr[1]   (controlled to 90 ppmvd)
3. Average cost effectiveness $4,005/ton of NO_X removed

Information provided by Covanta indicates that the calculated NO_X emissions using the LN™ technology, with a F-factor of 9,570 ft^3/MMBtu (EPA AP-42, Table 2.1-2 footnote, dated 10/96) and heat input of 121.8 MMBtu/hr, shows a reduction of approximately 82 tons of NO_X per year (approximately 50% reduction). The current RACT permit limit is 205 ppmvd corrected to 7% O_2 on a 24-hour basis, as based on the current RACT permit, current PSD permit, and the current Title V permit. Annual actual average emissions at CAAI range from 170 ppmvd to 180 ppmvd by unit considering each of the years 2014-2016 with a weighted average of 175 ppmvd corrected to 7% O_2. Based on the variability of hourly emissions, to achieve a 205 ppmvd corrected to 7% O_2 on a 24-hour basis permit limit, the appropriate equivalent target set point would be 180 ppmvd. With the actual emissions of 180 ppmvd, the facility would emit approximately 165 tons of NO_X per year. With the installation of the LN™, the controlled NO_X would be 90 ppmvd corrected to 7% O_2 on an annual basis, an equivalent of 82 tons of NO_X per year. This would result in an estimated 83 tons of NO_X per year or approximately a 50 percent reduction in NO_X.

The LN™ would be used in combination with the existing SNCR and thus are presented considering usage of the combustion technology plus SNCR.

Very Low NO_X (VLN™)

The VLN™ system is an extension of the concepts used in the LN™ system, where staging of air and fuel is managed to minimize NO_X formation. However, in contrast to the LN™ system, the

[1] Includes optimization of the SNCR is included

VLN™ system requires a different and specially designed combustion chamber. There are two operating Covanta units with the VLN™ system: HPOWER3 in Honolulu and the Durham York Energy Centre in Ontario, Canada.

The VLN™ system employs a unique combustion air system design, which in addition to the conventional primary and secondary air systems, features an internal gas recirculation (IGR) injection system located in the upper furnace above the secondary air nozzles. Flue gas is drawn from above the grate at the rear of the furnace and is re-introduced to the upper furnace above the secondary air injection level. Recirculation of the flue gas reduces the need for combustion air for complete combustion in the furnace. The quantity of primary air in the VLN™ system is adjusted to minimize excess air during combustion of waste on the grate, thereby reducing the overall excess air rate from approximately 100 percent, as used in the design for Martin stoker, boilers (as used at CAAI) to 50 to 55 percent excess air. The combination of the IGR and reduced secondary air extends the combustion zone in the furnace, which in turn inhibits the formation of NO_X. The NO_X permit limit on HPOWER3 is 110 ppmvd NO_X on a 24-hour average basis and 90 ppmvd on an annual basis.

The VLN™ technology is technically infeasible for existing MWC units in that the VLN™ requires a different and specially designed combustion chamber. As such, while it remains a viable technology for new MWC units, the VLN™ system is not technically feasible for an existing unit and therefore eliminated from consideration at CAAI.

RACT CONCLUSIONS

Once VLN™ is eliminated as not feasible for retrofit applications, there are realistically only two remaining technologies that are applicable for the CAAI facility. Leaving the ranked in order of emissions from lower to higher emissions. (i.e., SCR → LN™).

As stated earlier, the SCR has not been installed as a retrofit for the MWC industry and therefore is eliminated from the consideration as applicable RACT.

This would leave the installation of LN™, which would be constructed sequentially for the three units to allow for testing and optimization of the technology. The first of the three units would be completed no later than the 4th quarter 2019. Following an approximately 6-month testing/optimization period, the second unit installation would be completed no later than fourth quarter 2020. Installation of LN™ on the remaining unit would occur no later than the 4th quarter 2021.

The economic analysis in Section 4.3.1.2 of the RACT application dated September 8, 2017 (Attachment A), established that installation of an LN™ system at CAAI is economically feasible. The timing considerations discussed in Section 4.4.2.1 of the RACT application dated September 8, 2017. Based on the results of these analyses, CAAI has determined that LN™ with emission rates of 110 ppmvd (24-hr average) and 90 ppmvd (annual average) is RACT.

Table 2 below provides a summary of the NO_X RACT determinations for CAAI, which form the basis of the requirements for RACT implementation in the proposed State Operating Permit.

Table 2 – Case-by-Case RACT Evaluations

Emission Unit ID	NOX RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
001-02	Low NO_X (LN^{TM}) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NO_X @ 7% O_2 24-hour basis 90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NO_X emission concentrations • All 24-hour daily arithmetic average NO_X emission concentrations • All annual NO_X emission concentrations • Each calendar date for which the minimum number of hours of any of the NO_X data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NO_X emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NO_X and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1. • Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40 CFR 75

002-02	Low NO_X (LN^{TM}) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NO_X @ 7% O_2 24-hour basis 90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NO_X emission concentrations • All 24-hour daily arithmetic average NO_X emission concentrations • All annual NO_X emission concentrations • Each calendar date for which the minimum number of hours of any of the NO_X data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NO_X emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NO_X and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1. • Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40 CFR 75

003-02	Low NO_X (LN[TM]) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NO_X @ 7% O_2 24-hour basis 90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NO_X emission concentrations • All 24-hour daily arithmetic average NO_X emission concentrations • All annual NO_X emission concentrations • Each calendar date for which the minimum number of hours of any of the NO_X data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NO_X emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NO_X and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1. • Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40 CFR 75	

COMPLIANCE DETERMINATION

Table 3 below provides a summary of the monitoring, testing, recordkeeping and reporting requirements included in the draft State Operating Permit to enforce the RACT determination.

Table 3 – RACT Compliance Demonstration

Source ID	RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
001-02, 002-02, and 003-02 Three (3) MSW Combustors with Martin-Stoker boiler system	110 ppmvd NO_X @ 7% O_2 24-hour basis (each unit)	NO_X continuous emission monitoring system (CEMS) Annual NO_X CEM RATA, daily and quarterly QA procedures per 40 CFR 60 Procedure 1 of Appendix F	Daily NO_X concentrations @ 7% O_2 on a 24-hour rolling averages using continuous emission monitoring system.
001-02, 002-02, and 003-02 Three (3) MSW Combustors with Martin-Stoker boiler system	90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Annual NO_X CEM RATA, daily and quarterly QA procedures per 40 CFR 60 Procedure 1 of Appendix F	Annual NO_X concentrations @ 7% O_2 on rolling 365-day averages using continuous monitoring system.

Beginning with the permit issuance and ending with the installation of the LN™ on unit 003-02 in the fourth quarter 2021, the owner will be following a continuous installation process.

PUBLIC PARTICIPATION

Notice of the draft state operating permit and the proposed revision to the Virginia SIP inviting public comment was placed in *The Washington Times* on November 6, 2018. The public comment period began November 6, 2018 and ended December 21, 2018. A public hearing was held on December 6, 2018 in accordance with the applicable provisions of 9VAC5-170-100.

The notice of the public comment period and the public hearing (which contained the link to the applicable supporting draft documents) was sent to EPA on October 31, 2018.

The public hearing report which contains the complete text or account of each person's comments and DEQ's response to such comments are provided in a separate memorandum to the file.

RECOMMENDATION

Recommend approval of the State Operating Permit.

ATTACHMENT

Attachment A – September 8, 2017 RACT Analysis

Attachment 7

COMMONWEALTH OF VIRGINIA
Department of Environmental Quality
Northern Regional Office

STATEMENT OF LEGAL AND FACTUAL BASIS

Covanta Fairfax, Inc.
Fairfax County, Virginia
Permit No. NRO-RACT71920

Pursuant to the requirements of § 110 of the Clean Air Act, on December 12, 2017, the Commonwealth of Virginia submitted to EPA Region III, a request for approval for a revision to the Commonwealth of Virginia State Implementation Plan (SIP). This SIP revision consists of Virginia's plan to support reasonably available control technology (RACT) in the Ozone Transport Region of Virginia for the 2008 National Ambient Air Quality Standard for Ozone.

Part of the SIP revision includes Virginia's commitment to providing SIP revisions addressing source-specific 2008 ozone RACT requirements, for which one of those sources is Covanta Fairfax, Inc.

The Department has reviewed the proposed RACT Plan for Covanta Fairfax, Inc. and has prepared a draft State Operating Permit requiring NO_X RACT, and requisite conditions for recordkeeping, reporting, and testing sufficient to enforce the RACT determinations.

Engineer/Permit Contact: Gary Beeson   Date: 2/5/2019
Gary Beeson
(703) 583-3969

Air Permit Manager: James B. LaFratta   Date: 2/8/2019
James B. LaFratta

Regional Director: Thomas A. Faha   Date: 2-8-19
Thomas A. Faha

FACILITY INFORMATION

Permittee

Covanta Fairfax, Inc.
9898 Furnace Road
Lorton, Virginia 22079

Facility

Covanta Fairfax, Inc.
9898 Furnace Road
Lorton, Virginia 22079
(Fairfax County)

County-Plant Identification Number: 059-00560

FACILITY DESCRIPTION

NAICS Code: 562213 – Solid Waste Combustors and Incinerators

Covanta Fairfax, Inc. (CFI) owns and operates a municipal waste combustion (MWC) facility with energy recovery under an agreement with Fairfax County, Virginia. The facility maintains four 750 ton per day, (nominal) waste combustion units with integrated reciprocating grate stokers and water wall boilers. The MWC units are water wall boilers with integrated reciprocating grate stokers. Each combustor is also equipped with two natural gas-fired auxiliary burners. Products of combustion from each combustor are controlled by good combustion practices, ammonia injection (selective non-catalytic reduction), a combination of spray dyer and fabric filter, and activated carbon injection to reduce nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM and PM-10), acid gases, metals and complex organics among others. With this RACT permit, the permittee will install additional NO_X controls in the form of Covanta's proprietary Low NO_X combustion system (LN^{TM}). Steam generated by the boilers drive turbines that generate electricity for sale to the local electric company.

RACT REGULATIONS

RACT Overview & General Applicability

9VAC5 Chapter 40, Part II, Article 51, *Emission Standards for Stationary Sources Subject to Case-by-Case RACT Determinations (Rule 4-51)* – 9VAC5-40-7370 *et seq*. contains the requirements for sources seeking case-by-case reasonably available control technology (RACT) determinations required under the 2008 8-hour ozone national ambient air quality standard (NAAQS). EPA approved Rule 4-51 as a revision to Virginia's State Implementation Plan (SIP) on August 17, 2016 (81 FR 54506).

The Clean Air Act mandates that major stationary sources--those with potential to emit (PTE) of at least 50 tons per year (tpy) of volatile organic compounds (VOC) or 100 tpy of nitrogen oxides (NO_X), located within the Ozone Transport Region (OTR)--must implement RACT whenever the U.S. Environmental Protection Agency (EPA) updates ozone air quality standards. Rule 4-51 contains requirements for the 2008 NAAQS.

Virginia may implement a variety of approaches to determine RACT. Certain emission sources have control technique guidelines published by EPA and adopted by Virginia in 9VAC5 Chapter 40 and Chapter 45 serve as RACT. Another approach is to recertify the previous source-specific RACT determinations made under the 1990 ozone NAAQS or the 1997 ozone NAAQS as RACT for the 2008 ozone NAAQS. Recertification is appropriate where previous RACT determinations continue to represent RACT for that unit or facility, based on a review of existing control technologies and their associated costs and benefits. Virginia may choose to determine that presumptive RACT is appropriate for some sources. Generally, presumptive RACT values are associated with fuel-burning equipment and represent emission rates supported by alternative control technique guidelines published by EPA. Presumptive RACT rates are listed in 9VAC5-40-7430. Virginia may also require a source to provide a unit specific RACT analysis for units located at RACT-applicable facilities.

9VAC5-40-7380 defines two key terms:

"Presumptive RACT" means the emission limit that a particular source is capable of meeting by the application of reasonably available control technology as defined in 9VAC5-40-7430.

"Reasonably Available Control Technology" or "RACT" means the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available, considering technological and economic feasibility.

RACT Applicability to CFI

CFI is located in Fairfax County, part of the OTR. The facility is only subject to RACT as the potential emissions of NO_X for the stationary source are in excess of the thresholds set in 9VAC5-40-7420 (> 100 tons/yr NO_X) and the potential emissions of VOC are below the threshold set in 9VAC5-40-7400 (>50 tons/yr VOC) and therefore not subject to RACT.

Certain source categories listed in 9VAC5-40-7430, DEQ defines a presumptive RACT for NO_X. The source categories for presumptive RACT are boilers and combustion turbines firing gas, oil and (for boilers only) coal. DEQ does not define a presumptive RACT for MWC's such as at CFI. The presumptive RACT category most similar to MWC's would be stoker coal boilers, which have a presumptive RACT limit for NO_X of 0.4 lb/MMBtu. This limit is less stringent than the current limitation for the units at CFI, which is 205 ppmvd (7% O_2 basis) daily, which converts to 0.35 lb/MMBtu. Therefore, the installation of the LN™ with an emission annual limit of 110 ppmvd (7% O_2 basis) would result in a limit of approximately 0.19 lb/MMBtu. 9VAC5-40-7420 addresses RACT requirements for sources without a presumptive RACT, such as at CFI. RACT is applicable to facilities with site-wide emissions greater than 100 tons/yr, as is the case at CFI. There are three requirements for sources such as CFI:

- Notify DEQ of applicability status;
- Commit to making a determination of RACT; and,
- Provide a schedule acceptable to DEQ for making the RACT determination and achieving compliance with the emission standard no later than January 1, 2017.

CFI submitted preliminary RACT information to DEQ via letter dated January 28, 2016. DEQ requested that CFI complete the RACT analysis consistent with the DEQ RACT Analysis Guidelines (updated February 3, 2016). The DEQ guidelines request a three-step version of the top-down control technology approach:

- Identify all available control alternatives;
- Assess technical feasibility; and
- Evaluate remaining technologies in order of control effectiveness considering:
    - Expected emissions reduction (ton/yr);
    - Economic impacts ($/ton of pollutant removed);
    - Environmental impacts; and,
    - Energy impacts.

If the top control alternative is not selected as RACT, the rationale for rejection must be documented. The next most stringent control alternative is then assessed, and the process continues until RACT is determined.

Covanta's September 2016 submittal assumed that RACT must be implemented no later than January 1, 2017. This revised submittal does not include that time constraint in assessing available RACT options.

Table 1 below lists the "affected facilities" (a.k.a. emission units) at Covanta Alexandria/Arlington, Inc. that must be reviewed for RACT for NO_X. Table 1 also provides a citation for the Commonwealth's RACT rule at 9VAC5 Chapter 40 Article 5 "Stationary Source Subject to Case-by Case RACT Determinations" and identifies the RACT determination for the units.

Table 1 – Sources Requiring Case-by-Case RACT at CFI

Source ID	Equipment/Process Description	NO_X RACT Basis
001-01	Ogden-Martin MSW Combustor with Martin-Stoker boiler system (Began commercial operation in June 1990) 750 tons per day (nominal) waste combustion 343.75 MMBtu/hr (heat input)	9VAC5-40-7420 Case-by-Case RACT (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)
002-01	Ogden-Martin MSW Combustor with Martin-Stoker boiler system (Began commercial operation in June 1990) 750 tons per day (nominal) waste combustion 343.75 MMBtu/hr (heat input)	9VAC5-40-7420 Case-by-Case RACT (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)
003-01	Ogden-Martin MSW Combustor with Martin-Stoker boiler system (Began commercial operation in June 1990) 750 tons per day (nominal) waste combustion 343.75 MMBtu/hr (heat input)	9VAC5-40-7420 Case-by-Case RACT (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)
004-01	Ogden-Martin MSW Combustor with Martin-Stoker boiler system (Began commercial operation in June 1990) 750 tons per day (nominal) waste combustion 343.75 MMBtu/hr (heat input)	9VAC5-40-7420 Case-by-Case RACT (selective non-catalytic reduction and Covanta proprietary Low NO_X (LN^{TM}) combustion system)

The four (4) municipal waste combustors (MWC) are identical Ogden-Martin equipped with Martin-Stoker boiler system with integrated reciprocating grate stokers and water walls. Each MWC is also equipped with two natural gas-fired auxiliary burners. Each of the four MWC is rated at 750 tons per day (nominal) waste combustion and a heat input rating of 343.75 MMBtu/hr. These units were constructed prior to the September 20, 1994, designated as the cut-off date in 40 CFR 60, Subpart Cb, and have a combustion capacity greater than 250 tons per day of municipal solid waste therefore applicable to this NSPS (40 CFR 60, Subpart Cb). The facility submitted a unit specific RACT analysis to address Clean Air Act requirements for the 2008 ozone NAAQS as discussed in detail below.

OTHER APPLICABLE NO_X CONTROL REQUIREMENTS AND EXISTING CONTROLS

Products of combustion from each combustor are controlled by good combustion practices, ammonia injection (selective non-catalytic reduction), a combination of spray dyer and fabric filter, and activated carbon injection, which reduces nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM and PM-10), acid gases, metals, and complex organics among others.

The facility is located in the Fairfax County, which is part of the Northern Virginia Ozone Nonattainment Area. The facility is a Title V major source of sulfur dioxide, nitrogen oxides, carbon monoxide, hazardous air pollutants (hydrogen chloride), and carbon dioxide equivalent emissions. The facility has the potential to emit (PTE) more than 100 tons per year (tpy) of nitrogen oxides (NO_x) and therefore considered a major stationary source for purposes of non-attainment new source review (9 VAC 5-80-2000, et seq.). The facility operates under the Prevention of Significant Deterioration (PSD) Permit dated January 12, 1987, as amended February 18, 1988 and a Consent Agreement dated April 3, 1998, implementing Reasonably Available Control Technology (RACT). The requirements of the RACT consent agreement, issued on April 3, 1998 have been fulfilled. The facility is also subject to state Rule 4-54 (9VAC5-40-7950 et seq.) of the Virginia Air Pollution Control Board's Regulations for the Control and Abatement of Air Pollution. This rule implements various emissions limitations, operating, compliance, and recordkeeping requirements established by the Emissions Guidelines of 40 CFR 60, Subpart Cb. Rule 4-54 is the approved Clean Air Act Section 111(d)/129 plan for Large Municipal Waste Combustor (MWC) Units regulated under 40 CFR 62, Subpart VV sections 62.11640 through 62.11642 approved on October 29, 2004.

2008 OZONE NAAQS RACT ANALYSIS FOR 001-01, 002-01, 003-01, and 004-01

Unit description and Impact

001-01, 002-01, 003-01, and 004-01 are identical Ogden-Martin equipped with Martin-Stoker boiler system with integrated reciprocating grate stoker and water wall municipal waste combustors (MWC). Each MWC is also equipped with two natural gas-fired auxiliary burners. Each of the four MWC rated at 750 tons per day (nominal) waste combustion and a heat input rating of 343.75 MMBtu/hr. These units are currently equipped with ammonia injection (selective non-catalytic reduction) (SNCR), a combination of spray dyer and fabric filter, and activated carbon injection to reduce nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter (PM and PM-10), acid gases, metals, and complex organics among others. The units are classified as *large municipal waste combustors* under 40 CFR 60, Subpart Cb, "Emissions Guidelines and Compliance Times for Large Municipal Waste Combustors That are Constructed on or Before September 20, 1994". The regulation requires this classification of units to be greater than 250 tons per day of municipal solid waste and commenced operation prior to September 20, 1994. Additionally, the regulatory rate is 205 ppmvd (corrected to 7% O_2) for mass burn waterwall combustor technology.

Previous RACT Determination

The facility is subject to a previous RACT determination, which includes federally enforceable requirements issued as part of an April 3, 1998 consent order between DEQ and the facility, formerly Ogden Martin Systems of Fairfax, Inc. DEQ determined that NO_X RACT for these four MWC's was the implementation of all NO_X emissions requirements of 40 CFR Part 60, Subpart Cb, including but not limited to the applicable emissions standard of 205 ppmvd (7% O_2 basis), on a twenty-four hour daily geometric mean consistent with the requirements of 40 CFR 60, Subpart Cb. In order to meet the requirements of Subpart Cb and the conditions of the consent order, the facility installed selective non-catalytic reduction (SNCR) on each of the four MWC's.

Presumptive NO_X RACT Limitations

In the presumptive NO_X RACT categories listed in 9VAC5-40-7430, DEQ defines a presumptive RACT for NO_X. The source categories for presumptive RACT are boilers and combustion turbines firing gas, oil and (for boilers only) coal. DEQ does not define a presumptive RACT for MWC's such as at CFI. The presumptive RACT category most similar to MWC's would be stoker coal boilers, which have a presumptive RACT limit for NO_X of 0.4 lb/MMBtu on a 24-hour daily basis. This limit is less stringent than the current limitation for the four units at CFI, which is 205 ppmvd (7% O_2 basis) on a 24-hour daily basis, which converts to 0.35 lb/MMBtu on a 24-hour daily basis. Therefore, the installation of the LN™ with an emission limit of 110 ppmvd (7% O_2 basis) on a 24-hour basis would result in a limit of approximately 0.19 lb/MMBtu on a 24-hour basis. Therefore, presumptive NO_X RACT is not applicable to these units.

PROPOSED RACT DISCUSSIONS

Municipal Waste Combustors (MWC)

NO_X

As part of the RACT analysis (Attachment A), CFI included four available options for minimizing NO_X emissions from the four (4) existing MWC's. These options were:

- Selective Catalytic Reduction (SCR)
- Low NO_X (LN™) combustion system/Optimized SNCR combination
- Very Low NO_X (VLN™)/Optimized SNCR combination; and,
- Optimization of the existing SNCR.

Selective Catalytic Reduction (SCR)

The reaction chemistry of a SCR system is similar to SNCR (NH_3 reactions with NO_X); however, SCR can occur at a much lower temperature (550 °F versus 1500 °F) by using a catalyst. Compared to SNCR, a SCR system can operate at lower combustion gas temperatures and can achieve a higher rate of reduction with potentially lower ammonia slip.

DEQ is not aware of any existing MWC units that have retrofitted a SCR nor did the search of the EPA RACT, BACT, LAER Clearinghouse (RBLC) data base turn up any facilities in which SCR had been retrofit to an existing facility. However, a new construction unit with SCR was built and operating in Florida. It is understood to be achieving a NO_X concentration of 50 ppmvd on a 24-hour limit and a 45 ppmvd annual limit (i.e., West Palm No. 2). Given the nature of MSW combustion and the design and layout of the CFI facility, a tail end catalyst system is required, where the SCR is located downstream of all other air pollution control devices. This design would require that the flue gas be reheated to achieve the proper reaction temperature for the SCR to convert NO_X into nitrogen. To minimize wasted heat from reheating the flue gas, tail end SCR systems would incorporate a recuperator, where the heated gas leaving the catalyst is used to pre-heat the exhaust gas that is about to enter the catalyst.

Covanta utilized prior experience with retrofits of existing air pollution control equipment at Covanta facilities to derive the installation costs. Covanta used a ratio of total capital cost (equipment + installation + indirect costs) as a metric for estimating costs on other projects. For this analysis, Covanta evaluated the costs of full-scale baghouse retrofits at two facilities, the Covanta MWC in Essex County NJ and at CFI. The Essex County ratio was approximately 4.9:1 with CFI being about 2.75:1. The CFI ratio reflects the current site layout, the inherent spatial limitations of the existing infrastructure and ultimately the difficulty of installation, including potential staging of equipment from adjacent off-site locations not owned/operated by CFI.

The total capital cost of the project was calculated by multiplying the vendor-supplied purchased equipment cost (PEC) by the calculated 2.75:1 ratio. A 15% contingency factor was than subtracted from the total cost (to avoid double counting the contingencies in the vendor estimate and the installation cost ratio). Then, the cost of the individual direct and indirect cost components, such as foundations, start-up, etc. were prorated based on the relative ratios of the cost allocations from two sources: 1) the aforementioned baghouse retrofit and 2) the bid Covanta submitted as part of a proposal for construction of the West Palm Beach MWC in Florida.

Direct and indirect annual costs were largely taken from the West Palm Beach (FL) MWC facility PSD BACT analysis, and adjusted to 2017 dollars using the CPI. The cost of reagent was set to be consistent with current reagent costs at CFI.
The West Palm No. 2 replacement catalyst cost values were adjusted from 2010 to 2017 using the Consumer Price Index (CPI). With economies of scale applied (e.g., equipment size), the six-tenths power law is used to scale costs based on ton/day MSW, as CFI is a smaller unit (750 tons/day) than West Palm No. 2
(1,000 tons/day).

Covanta provided the cost of SCR controls to be over $15,000 per ton of NO_X removed based on estimated equipment cost, capital cost provided by vendor bids, and from the annual cost at the Covanta West Palm Beach No. 2 facility over the past seven years of operation. As such, the cost estimates are valid for comparative purposes but there is still appreciable uncertainty in actual final costs associated with an SCR installation at CFI.

NO_X available for control	466 tons/yr	(180 ppmvd)
NO_X removable by SCR	123 tons/yr	(controlled to 47.5 ppmvd)
Average cost effectiveness	$15,898/ton of NO_X reduced	

The economic analysis in the RACT analysis demonstrates that SCR has substantial diminishing returns on the dollars spent for pollution control. Based on the results of these analyses, Covanta has determined that SCR is not RACT.

DEQ concurs with this economic assessment of this RACT option as not being economically feasible. However, the prominent reason for rejecting this technology is the fact that it has not been used at any other existing facility and the because of the attempted at an existing facility and now a proven method for NO_X reduction at existing facilities. A review of EPA's Clean Air Technology Center – RACT/BACT/LAER Clearinghouse for the most recent 10-year period did not include any RACT determinations for NO_X for this process type (21.400 – Municipal Waste Combustion)

Low NO_X (LN™) Combustion System

Covanta has developed a proprietary low NO_X combustion system (i.e., LN™) that involves staging of combustion air. The system is a trademarked system and Covanta has received a patent for the technology.

A Martin MWC combustor system involves a moving grate with two sources of combustion air. Primary air (also called underfired air) supplied from underneath the grate and forced through the grate to dry and combust the MSW. The quantity of primary air is adjusted to minimize excess air while at the same time maximizing burnout of materials on the bed. Secondary air (also called overfired air) injected through nozzles located in the furnace sidewalls immediately above the grate provides turbulent mixing to complete the combustion process.

The Covanta LN™ process modifies the secondary air stream. A new series of air nozzles installed higher in the furnace (called tertiary air) diverts a portion of the secondary air to these new nozzles. Controlling the distribution of air between the primary, secondary, and tertiary streams optimizes combustion and temperature to minimize NO_X formation. The tertiary air achieves complete coverage of the furnace cross-section to ensure good mixing with the combustion gases. The tertiary air completes the combustion process, and yields uniform flue gas temperature and velocity profiles, which improves the performance and reliability of downstream boiler equipment. Note that the total airflow to the MWC is not changed, only the distribution of air is changed. The LN™ combustion system works in concert with an SNCR system to achieve even lower NO_X emissions than LN™ or SNCR alone.

A typical required scope of work to implement the LN™ process includes the following steps:

- Detailed process analysis of current combustion conditions, including evaluation of waste heating values, excess air levels, furnace temperature profiles, and typical range of fouling;

- Calculations to determine the number, size, and location of tertiary air nozzles;

- Detailed mechanical and structural design of tertiary air ducting, headers and nozzles;

- Installation of ductwork to carry the tertiary air from the discharge of the existing secondary air fan up to the elevation of the tertiary air nozzles;

- Installation of automatic dampers to control the flow of tertiary air;

- Installation of tertiary air headers on the upper furnace to feed air to individual nozzles;
- Modifications to the boiler water walls to allow installation of the new tertiary air nozzles – two tube bends required per nozzle with refractory boxes to seal the boiler penetrations;

- Installation of stainless steel tertiary air nozzles to allow online changes of nozzle diameter without shutting down the boiler;

- Installation of flexible stainless steel hoses with individual manual butterfly dampers for the air feed to each tertiary air nozzle;

- Design, installation and tuning of revised combustion controls; and,

- Installation of additional Inconel on waterwall tubes and refractory tile in the lower furnace (Inconel is an oxidation- and corrosion-resistant nickel alloy).

The LN™ process can be retrofitted to an existing unit, and Covanta has installed the LN™ process at approximately 20 units worldwide, including at the MWC facility in Montgomery County, Maryland.

The LN™ process at the Montgomery County facility has appreciably increased annual maintenance costs due to increased refractory wear and boiler fouling. The result of expanding the combustion zone through a larger volume of the furnace creates a larger area subjected to high-temperature and low-oxygen conditions. Under these conditions, the combustion chamber components wear more quickly than would otherwise occur. The refractory and waterwall tubing are the primary components seeing higher wear rates with the refractory requiring repaired or replaced when damaged. Depending on the location within the boiler, waterwall tubes may require repair or replacement, as well as the application of Inconel cladding to resist the aggressive environment. While Inconel cladding is much more protective than bare tubes, it also wears over time and requires spot repair or re-application.

Estimated capital costs for installation of the LN™ process at CFI were made by examining each of the boilers at CFI to determine what initial level of protective cladding would be required to maintain furnace and waterwall tube integrity. Individual costs were developed on a per-boiler basis. The installation cost, which includes items such as fans, dampers, ducting, and process controls, was estimated based on actual expenses from Covanta's Montgomery County (MD) facility.

Covanta provided the cost of the LN™ controls to be around $2,900 per ton of NO_X removed based on estimated equipment cost, capital cost, and from the annual cost, scaled linearly from the Montgomery County project costs to CFI.

NO_X available for control	466 tons/yr	(180 ppmvd)
NO_X removable by LN™	233 tons/yr[1]	(controlled to 90 ppmvd)
Average cost effectiveness	$2,888/ton of NO_X reduced	

Although the permit limit for CFI is 205 ppmvd on a 24-hour daily arithmetic average, the facility must set the DCS controller at the facility to run at a lower limit. Annual actual average emissions at CFI range from 170 ppmvd to 180 ppmvd by unit considering each of the years 2014-2016 with a weighted average of 175 ppmvd. Based on the variability of short-term emissions to achieve a 205 ppmvd permit limit on a 24-hour daily arithmetic average, the appropriate equivalent annual permit limit would be 180 ppmvd. With the actual emissions of 180 ppmvd, the facility would emit approximately 466 tons of NO_X per year. Information provided by Covanta indicates that the calculated NO_X emissions using the LN™ technology, with a F-factor of 9,570 cu.ft./MMBtu (EPA AP-42, Table 2.1-2 footnote, dated 10/96) and heat input of 343.7 MMBtu/hr, shows a reduction of approximately 233 tons of NO_X per year (approximately 50% reduction).

<u>Very Low NO_X (VLN™)</u>

The VLN™ system is an extension of the concepts used in the LN™ system, where staging of air and fuel is managed to minimize NO_X formation. However, in contrast to the LN™ system, the VLN™ system requires a different and specially designed combustion chamber. There are two operating Covanta units with the VLN™ system: HPOWER3 in Honolulu and the Durham York Energy Centre in Ontario, Canada.

The VLN™ system employs a unique combustion air system design, which in addition to the conventional primary and secondary air systems, features an internal gas recirculation (IGR) injection system located in the upper furnace above the secondary air nozzles. Flue gas drawn from above the grate at the rear of the furnace is re-introduced to the upper furnace above the secondary air injection level. Recirculation of the flue gas reduces the need for combustion air

[1] Includes optimization of the SNCR is included

for complete combustion in the furnace. The quantity of primary air in the VLN^{TM} system is adjusted to minimize excess air during combustion of waste on the grate, thereby reducing the overall excess air rate from approximately 100 percent, as used in the design for Martin stoker, boilers (as used at CFI) to 50 to 55 percent excess air. The combination of the IGR and reduced secondary air extends the combustion zone in the furnace, which in turn inhibits the formation of NO_X. The NO_X permit limit on HPOWER3 is 110 ppmvd NO_X on a 24-hour average basis and 90 ppmvd on an annual basis.

The VLN^{TM} system is not available for retrofit for an existing MWC unit such as at CFI. As such, while it remains a viable technology for new MWC units, the VLN^{TM} system is not technically feasible for an existing unit and therefore eliminated from consideration at CFI.

Optimization of the Current Selective Non-Catalytic Reduction (SNCR)

SNCR injects ammonia into the high-temperature combustion exhaust gases where the ammonia (NH_3) reacts with NO_X to yield several reaction products including nitrogen (N_2) and water vapor (H_2O). As more ammonia is injected, additional NO_X can be converted, but there are limits to the extent of removal that is possible. In all operational modes, a portion of ammonia is unreacted and is emitted; this ammonia is referred to as ammonia slip. As the amount of ammonia injected increases, ammonia slip may also increase. As such, there is an optimization between the amount of ammonia injected and the amount of ammonia slip. As ammonia slip increases, a detached visible plume can be created by the interaction between ammonia and chlorides or sulfides in the exhaust gases.

Further optimization of the CFI SNCR would be balanced against the potential for ammonia slip and integration with the proposed RACT technology (i.e., LN^{TM}) and not a standalone RACT option.

RACT CONCLUSIONS

Of these four options, there are realistically only two remaining technologies that are applicable for the CFI facility, once VLN^{TM} is eliminated as not feasible for retrofit applications and optimization of the existing SNCR is incorporated with the LN^{TM}. Leaving the ranked in order of emissions from lower to higher emissions. (I.e. SCR $\rightarrow$ LN^{TM}).

As stated earlier, the SCR has not been installed as a retrofit for the MWC industry and therefore is eliminated from the consideration as applicable RACT.

This would leave the installation of LN^{TM}, which would be constructed sequentially for the four units to allow for testing and optimization of the technology. The first of the four units would be scheduled to be completed no later than the 4th quarter 2018. Following an approximately 6-month testing/optimization period, the second unit installation would be completed no later than fourth quarter 2019. Installation of LN^{TM} on the remaining two units would occur in 2020 and

2021, respectively.

The economic analysis in Section 4.3.1.2 of the RACT application dated September 8, 2017 (Attachment A), established that installation of an LN™ system at CFI is economically feasible. The timing considerations are discussed in Section 4.4.2.1 of the RACT application dated September 8, 2017. Based on the results of these analyses, CFI has determined that LN™ with emission rates of 110 ppmvd (24-hr average) and 90 ppmvd (annual average) is RACT.

Table 2 below provides a summary of the NO_X RACT determinations for CFI, which form the basis of the requirements for RACT implementation in the proposed State Operating Permit.

Table 2 – Case-by-Case RACT Evaluations

Emission Unit ID	NO_X RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
001-01	Low NO_X (LN™) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NO_X @ 7% O_2 24-hour basis 90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NO_X emission concentrations • All 24-hour daily arithmetic average NO_X emission concentrations • All annual NO_X emission concentrations • Each calendar date for which the minimum number of hours of any of the NO_X data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NO_X emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NO_X and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1. • Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40 CFR 75

Emission Unit ID	NOx RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
002-01	Low NOx (LN™) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NOx @ 7% O_2 24-hour basis 90 ppmvd NOx @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NOx emission concentrations • All 24-hour daily arithmetic average NOx emission concentrations • All annual NOx emission concentrations • Each calendar date for which the minimum number of hours of any of the NOx data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NOx emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NOx and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1. • Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40 CFR 75

Emission Unit ID	NO_X RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
003-01	Low NO_X (LN^{TM}) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NO_X @ 7% O_2 24-hour basis 90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NO_X emission concentrations • All 24-hour daily arithmetic average NO_X emission concentrations • All annual NO_X emission concentrations • Each calendar date for which the minimum number of hours of any of the NO_X data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NO_X emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NO_X and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1. • Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40

			CFR 75

Emission Unit ID	NO_X RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
004-01	Low NO_X (LN^{TM}) combustion system/Optimization of SNCR combination Emission Limit 110 ppmvd NO_X @ 7% O_2 24-hour basis 90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Use of existing CEM system	• All 1-hour average NO_X emission concentrations • All 24-hour daily arithmetic average NO_X emission concentrations • All annual NO_X emission concentrations • Each calendar date for which the minimum number of hours of any of the NO_X data have not been obtained including reasons for not obtaining sufficient data and a description of corrective actions taken. • The NO_X emission data or operational data that have been excluded from the calculation of average emission concentrations or parameters, and the reasons for excluding the data. • The permittee shall record the results of daily drift tests, quarterly accuracy determinations, percent operating time, and RATA for NO_X and O_2 or CO_2 CEMS, as applicable, as required under Appendix F of 40 CFR 60, Procedure 1.

			• Scheduled and unscheduled maintenance and operator training. • Reporting as noted in 40 CFR 75

COMPLIANCE DETERMINATION

Table 3 below provides a summary of the monitoring, testing, recordkeeping and reporting requirements included in the draft State Operating Permit to enforce the RACT determination.

Table 3 – RACT Compliance Demonstration

Source ID	RACT Requirement	Monitoring/Testing	Recordkeeping/Reporting
001-01 through 004-01 Four (4) MSW Combustors with Martin-Stoker boiler system	110 ppmvd NO_X @ 7% O_2 24-hour basis (each unit)	NO_X continuous emission monitoring system (CEMS) Annual NO_X CEM RATA, daily and quarterly QA procedures per 40 CFR 60 Procedure 1 of Appendix F	NO_X concentrations @ 7% O_2 on 24-hour rolling average using continuous emission monitoring systems.
001-01 through 004-01 Four (4) MSW Combustors with Martin-Stoker boiler system	90 ppmvd NO_X @ 7% O_2 annual basis (each unit)	Annual NO_X CEM RATA, daily and quarterly QA procedures per 40 CFR 60 Procedure 1 of Appendix F	NO_X concentrations @ 7% O_2 on rolling 365-day averages using continuous emission monitoring systems. .

Beginning with the permit issuance and ending with the installation of the LN™ on unit 004-01 in the fourth quarter 2021, the owner has agreed to the continuous installation process.

PUBLIC PARTICIPATION

Notice of the draft state operating permit and the proposed revision to the Virginia SIP inviting public comment was placed in *The Washington Times* on November 6, 2018. The public comment period began November 6, 2018 and ended December 21, 2018. A public hearing was held on December 6, 2018 in accordance with the applicable provisions of 9VAC5-170-100.

The notice of the public comment period and the public hearing (which contained the link to the applicable supporting draft documents) was sent to EPA on October 31, 2018.

The public hearing report which contains the complete text or account of each person's comments and DEQ's response to such comments are provided in a separate memorandum to the file.

RECOMMENDATION

Recommend approval of the State Operating Permit.

ATTACHMENT

Attachment A – September 8, 2017 CFI RACT Plan Submittal

Attachment 8

COVANTA

Covanta Fairfax, Inc.
A Covanta Company
9898 Furnace Rd
Lorton, VA 22079
Tel 703 690 6860
Fax 703 690 4223

September 8, 2017

Mr. James LaFratta
Regional Air Permit Manager
Northern Regional Office
Virginia Department of Environmental Quality
13901 Crown Court
Woodbridge, VA 22193

Subject: Covanta Fairfax, Inc.
Registration No. 71920
NOx RACT- Submittal of Paper Copy

Dear Mr. LaFratta:

The Covanta Fairfax, Inc. (CFI) facility located at 9898 Furnace Road, Lorton, VA has prepared a NOx RACT analysis and submitted an electronic version of the analysis to the Department via email on September 8, 2017. Enclosed with this letter is a paper copy of the previously emailed analysis.

Following is the certification statement as required by 9V AC5-20-230B.

> *I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false inforn1ation, including the possibility of fine and imprisonment for knowing violations.*

Please contact me at 703-690-6860 with any questions.

Sincerely,

Frank N. Capobianco
Facility Manager

Encls

cc: W. McDonald (CFI)
J. Walsh (EQM)
J. Herrmann (CFI)

PROJECT REPORT
Covanta Fairfax, Inc.

Reasonably Available Control Technology Determination for NO_X

Prepared By:

TRINITY CONSULTANTS
15 Salem Ave SE
Suite 201
Roanoke VA 24014
540-342-5945

Original Submittal: September 2016
Revised: September 2017

Project 164701.0001

Trinity Consultants

Environmental solutions delivered uncommonly well

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1. EXECUTIVE SUMMARY

Covanta Fairfax, Inc. (CFI) completed an updated Reasonably Available Control Technology (RACT) determination for oxides of nitrogen (NO_X). This update reflects a schedule extension granted by the United States Environmental Protection Agency (U.S. EPA) and subsequent discussions with the Virginia Department of Environmental Quality (DEQ or Department). Three control technology options are considered, and two of those technologies are determined to be technically feasible for CFI and are further evaluated. Based on this evaluation, CFI has determined that Covanta's patented Low NO_X technology (LN™), combined with selective non-catalytic reduction (SNCR), is RACT. Specifically, implementation of LN™ can reasonably achieve an annual NO_X emission limit of 90 parts per million volume dry (ppmvd) (7% O_2) and a daily NO_X limit of 110 ppmvd (7% O_2).

2. DESCRIPTION OF FACILITY

Covanta Fairfax, Inc (CFI or Facility) operates four Municipal Waste Combustor (MWC) units rated at a nominal 750 ton/day throughput. The MWC units use Martin grate technology for combustion, which is an integrated reciprocating grate stoker along with waterwall tube boilers. Each unit includes a suite of air pollution controls, including selective non-catalytic reduction (SNCR), a spray dryer absorber, a fabric filter baghouse, and an activated carbon injection system. Table 2-1 provides key parameters for the MWC at CFI.

Table 2-1. CFI Facility Design Information

Parameter	Units	Value
Number of Units		4
Nominal Capacity (design)	tpd MSW	750
MSW Heat Input (design)	MMBtu/hr	343.75
MSW Heat Content (design)	BTU/lb, HHV	5,500
Steaming Rate (design)	lb/hr steam	205,625

CFI operates pursuant to Title V operating permit NRO71920 issued by DEQ with an effective date of June 10, 2016. Each unit is subject to a daily NO_X limit of 205 ppmvd (7% O_2 basis) as outlined in Chapter 40, Article 54, Large Municipal Waste Combustors, and is consistent with federal MWC Emission Guidelines pursuant to 40 CFR 60 Subpart Cb.[1] CFI is also subject to NO_X limits on each unit of 206.3 lb/hr and 716.2 tons/year. The concentration limit is monitored via NO_X CEMS.

The CFI units did not originally include SNCR control for NO_X but instead SNCR was installed as part of a prior RACT determination for NO_X; that determination was made in 1998 with compliance required no later than December 19, 2000. The prior NO_X RACT determination identified that NO_X RACT would be SNCR with a NO_X limit at 205 ppmvd, consistent with the then pending Subpart Cb Emission Guidelines and implemented no later than the schedule required by Subpart Cb. Thus, the current RACT determination is 205 ppmvd and is identical to the current Subpart Cb limit.

[1] All ppmvd values referenced in this report at 7% O_2 basis unless otherwise noted.

3. RACT BACKGROUND

On May 21, 2012, designations for nonattainment areas for the 2008 ozone National Ambient Air Quality Standards (NAAQS) were published in the Federal Register (77 FR 30088). A portion of northern Virginia near Washington, DC was designated as a nonattainment area. The following Virginia counties and cities are included in the Washington DC-MD-VA nonattainment area (i.e., the Northern Virginia Emissions Control Area).

- Alexandria City
- Arlington County
- Fairfax City
- Fairfax County
- Falls Church City
- Loudoun County
- Manassas City
- Manassas Park City
- Prince William County

On March 6, 2015, the State Implementation Plan (SIP) Requirements Rule (SRR) for the 2008 ozone nonattainment areas was finalized (80 FR 12264). Areas are required to implement RACT no later than January 1 of the fifth year after the nonattainment designation, which was January 1, 2017.

CFI is located in Fairfax County, which is one of the Virginia locations subject to the requirement to implement RACT for the 2008 ozone standard. As such, CFI must address RACT. [2]

CFI submitted preliminary RACT information to DEQ via letter dated January 28, 2016. In that letter, CFI proposed to submit its RACT determination in the third quarter 2016. CFI submitted a RACT determination September 19, 2016 that was prefaced upon the imminent implementation of RACT.

The September 2016 NOx RACT analysis provided to DEQ included an evaluation of RACT technologies that were commercially available and proven for retrofit at existing MWC sources in order to meet DEQ's requested submittal schedule. The RACT analysis included the use of LN™ cost estimates derived from the installation and operation of LN™ at the Montgomery County (MD) MWC facility that is operated by Covanta Montgomery Inc. and selective catalytic reduction (SCR) cost estimates derived from the West Palm Beach (FL) MWC facility Prevention of Significant Deterioration (PSD) Best Available Control Technology (BACT) analysis; the permit application for the SCR project was prepared by Malcolm Pirnie and the project was constructed by Babcock & Wilcox. Cost estimates from these reference facilities were adjusted for size and date.

Covanta and DEQ met to discuss the draft on April 25, 2017. At that meeting, DEQ requested additional detail on the control technology analyses, specifically for SCR and LN™. Covanta responded via letter, dated May 5, 2017,

[2] This analysis explicitly addresses the 2008 ozone standard RACT analysis. EPA has proposed (81 FR 81276, November 17, 2016) but not finalized the plan requirements for the 2015 ozone standard, of which RACT will be a part. While this submittal explicitly addresses the 2008 ozone standard RACT, this submittal is likely to meet the requirements for a future 2015 ozone standard RACT.

which requested four months to obtain facility-specific cost data for SCR and LN™. This revised RACT report incorporates refined price quotes for both SCR and LN™.

Covanta developed and submitted bid requests to four third-party air pollution control vendors, including Babcock & Wilcox, to obtain new SCR capital cost estimates as described in more detail in Section 4.3.1. During that bid process, Covanta determined that the data used in the West Palm Beach (FL) MWC facility PSD BACT were not provided by the air pollution control subsidiary of Babcock & Wilcox but instead were estimates developed by a European consulting firm not affiliated with the project. This new information casts some doubt on the accuracy and appropriateness of the prior SCR cost data that Covanta used as inputs to the 2016 RACT submittal. Covanta has revised the SCR capital cost estimates using the third-party bids and prior experience with the cost of retrofit air pollution control devices at Covanta facilities. The third-party SCR bids provided to Covanta reflect the difficulty of estimating the cost of installing a complicated and large system at an existing, operating facility that has inherent spatial limitations when considered relative to a 'greenfield' development such as the West Palm Beach facility (where installation of the SCR is part of the facility design and the layout specifically accommodates all of its inherent piping, wiring, supports and other considerations). A review of the third-party bids indicated the following limitations:

- All bids are budgetary and limited to an equipment-only scope without any estimate of accuracy;
- None of the firms visited the facility to enable a true and accurate assessment of how and where the SCR system would be located;
- None of the bids included a mass and energy balance for an assessment of the functional viability of the system and associated implications on facility performance; and
- None of the bids included an indication that the system would or could be guaranteed as proposed.

In addition, Covanta also revised the LN™ cost estimates to reflect specific, anticipated boiler reinforcements at CFI necessary to accommodate the installation of LN™, on a per-boiler basis. These updated cost estimates are based on an inspection of the CFI boilers as well as Covanta's experience at several MWC facilities and did not require input by other firms. As a result, the LN™ cost estimates are considered to be more accurate and representative of actual costs that could be incurred as compared to the SCR costs.

3.1. REGULATORY REQUIREMENTS

9VAC5 Chapter 40 Article 51 (Rule 4-51) addresses requirements for case-by-case RACT determinations in Virginia. RACT is defined in Rule 4-51 as:

> *... the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available, considering technological and economic feasibility.*

For certain source categories listed in 9VAC5-40-7430, DEQ defines a presumptive RACT for NO_X. The source categories for presumptive RACT are boilers and combustion turbines firing gas, oil and (for boilers only) coal. DEQ does not define a presumptive RACT for MWCs such as at CFI. The presumptive RACT category most similar to MWCs would be stoker coal boilers, which have a presumptive RACT limit for NO_X of 0.4 lb/MMBtu that is less stringent than the current NO_X limit at CFI.[3]

9VAC5-40-7420 addresses RACT requirements for sources without a presumptive RACT, such as at CFI. RACT is applicable to facilities with site-wide emissions greater than 100 tons/yr, as is the case at CFI. There are three requirements for sources such as CFI:

- Notify DEQ of applicability status;
- Commit to making a determination of RACT; and,
- Provide a schedule acceptable to DEQ for making the RACT determination and achieving compliance with the emission standard no later than January 1, 2017.

CFI submitted preliminary RACT information to DEQ via letter dated January 28, 2016. DEQ requested that CFI complete the RACT analysis consistent with the DEQ RACT Analysis Guidelines (updated February 3, 2016). The DEQ guidelines request a three step version of the top-down control technology approach:

1. Identify all available control alternatives;
2. Assess technical feasibility; and
3. Evaluate remaining technologies in order of control effectiveness considering:
    a. Expected emissions reduction (ton/yr);
    b. Economic impacts ($/ton of pollutant removed);
    c. Environmental impacts; and,
    d. Energy impacts.

If the top control alternative is not selected as RACT, the rationale for rejection must be documented. The next most stringent control alternative is then assessed, and the process continues until RACT is determined.

Covanta's September 2016 submittal assumed that RACT must be implemented no later than January 1, 2017. This revised submittal does not include that time constraint in assessing available RACT options.

[3] The current 205 ppmvd limit converts to 0.35 lb/MMBtu based on an F-factor value of 9,570 dscf/MMBtu.

4. RACT ANALYSIS

4.1. POTENTIAL RACT OPTIONS

Following the RACT methodology and discussions with DEQ, potential RACT options have been identified for NO_X control at CFI. They include:

- SNCR system;
- Low NO_X (LN™) combustion system/SNCR combination;
- Very Low NO_X [VLN™]/SNCR combination; and,
- Selective catalytic reduction (SCR).

The technologies are each described in this section. Two of the technologies (LN™ and VLN™) are used in combination with SNCR and thus are presented considering usage of the combustion technology plus SNCR. One technology (VLN™) is technically infeasible for existing MWC units.

4.1.1. SNCR

SNCR injects ammonia into the high-temperature combustion exhaust gases where the ammonia (NH_3) reacts with NO_X to yield several reaction products including nitrogen (N_2) and water vapor (H_2O). As more ammonia is injected, additional NO_X can be converted, but there are limits to the extent of removal that is possible. In all operational modes, a portion of ammonia is unreacted and is emitted; this ammonia is referred to as ammonia slip. As the amount of ammonia injected increases, ammonia slip may also increase. As such, there is an optimization between the amount of ammonia injected and the amount of ammonia slip. As ammonia slip increases, a detached visible plume can be created by the interaction between ammonia and chlorides or sulfides in the exhaust gases.

CFI currently operates at a NO_X setpoint of 180-185 ppmvd to ensure compliance with the 205 ppmvd permit limit. A setpoint is a distributed control system (DCS) target, where the DCS reads both the ammonia injection rate and the NO_X emission rate and via computer programing continuously adjusts the ammonia injection rate to attempt to maintain a consistent NO_X emission rate. Due to variabilities inherent in the combustion of a heterogeneous fuel such as MSW, NO_X emissions have a degree of variability such that it is necessary to define a setpoint value less than the permit limit; the setpoint is not a fixed emission value at which the unit always operates, but is a target value at the center of a range of emission values, some higher than and some lower than the setpoint, with the average NO_X emissions value targeted to the setpoint value. Annual actual average emissions at CFI range from 170 ppmvd to 180 ppmvd by unit (2014-2016) with a weighted average of 175 ppmvd. Further optimization of the CFI SNCR would be balanced against the potential for ammonia slip and integration with the proposed RACT technology (i.e., LN™).

4.1.2. Low NO_X (LN™) Combustion System

Covanta has developed a proprietary low NO_X combustion system (i.e., LN™) that involves staging of combustion air. The system is a trademarked system and Covanta has received a patent for the technology.

A Martin MWC combustor system involves a moving grate with two sources of combustion air. Primary air (also called underfire air) is supplied from underneath the grate and is forced through the grate to dry and combust the MSW. The quantity of primary air is adjusted to minimize excess air while at the same time maximizing burnout of materials on the bed. Secondary air (also called overfire air) is injected through nozzles located in the furnace side walls immediately above the grate and provides turbulent mixing to complete the combustion process.

The Covanta LN™ process modifies the secondary air stream. A new series of air nozzles are installed higher in the furnace (tertiary air) and a portion of the secondary air is diverted to these new nozzles. The distribution of air between the primary, secondary, and tertiary streams is then controlled to yield the optimal gas composition and temperature to minimize NO_X formation and control combustion. The tertiary air achieves complete coverage of the furnace cross-section to ensure good mixing with the combustion gases. The tertiary air completes the combustion process, and yields uniform flue gas temperature and velocity profiles, which improves the performance and reliability of downstream boiler equipment. Note that the total air flow to the MWC is not changed, only the distribution of air is changed. The LN™ combustion system works in concert with an SNCR system to achieve lower NO_X emissions.

A typical required scope of work to implement the LN™ process includes the following steps:

1. Detailed process analysis of current combustion conditions, including evaluation of waste heating values, excess air levels, furnace temperature profiles, and typical range of fouling;
2. Calculations to determine the number, size, and location of tertiary air nozzles;
3. Detailed mechanical and structural design of tertiary air ducting, headers and nozzles;
4. Installation of ductwork to carry the tertiary air from the discharge of the existing secondary air fan up to the elevation of the tertiary air nozzles;
5. Installation of automatic dampers to control the flow of tertiary air;
6. Installation of tertiary air headers on the upper furnace to feed air to individual nozzles;
7. Modifications to the boiler waterwalls to allow installation of the new tertiary air nozzles – two tube bends required per nozzle with refractory boxes to seal the boiler penetrations;
8. Installation of stainless steel tertiary air nozzles to allow online changes of nozzle diameter without shutting down the boiler;
9. Installation of flexible stainless steel hoses with individual manual butterfly dampers for the air feed to each tertiary air nozzle;
10. Design, installation and tuning of revised combustion controls; and,
11. Installation of additional Inconel on waterwall tubes and refractory tile in the lower furnace (Inconel is an oxidation- and corrosion-resistant nickel alloy).

The LN™ process can be retrofitted to an existing unit, and Covanta has installed the LN™ process at approximately 20 units worldwide, including at the MWC facility in Montgomery County, Maryland. The Maryland Department of Environment (MDE) is evaluating NO_X applicability for the Montgomery County facility and anticipates issuing a final rule in 2017.

The LN™ process at Montgomery County has appreciably increased annual maintenance costs due to increased refractory wear and boiler fouling. The result of expanding the combustion zone through a larger volume of the furnace creates a larger area subjected to high-temperature, low-oxygen conditions. Under these conditions, the combustion chamber components wear more quickly than would otherwise occur. The refractory and waterwall tubing are the primary components seeing higher wear rates. Refractory must be repaired or replaced when damaged. Depending on the location within the boiler, waterwall tubes may require repair or replacement, as well as application of Inconel cladding to better resist the aggressive environment. While Inconel cladding is much more protective than bare tubes, it also wears over time and requires spot repair or re-application.

4.1.3. Very Low NO_X (VLN™)

The VLN™ system is an extension of the concepts used in the LN™ system, where staging of air and fuel is managed to minimize NO_X formation. However, in contrast to the LN™ system, the VLN™ system requires a different and specially designed combustion chamber. There are two operating Covanta units with the VLN™ system: HPOWER3 in Honolulu and the Durham York Energy Centre in Ontario, Canada.

The VLN™ system employs a unique combustion air system design, which in addition to the conventional primary and secondary air systems, features an internal gas recirculation (IGR) injection system located in the upper furnace above the secondary air nozzles. Gas is drawn from above the grate at the rear of the furnace and is re-introduced to the upper furnace above the secondary air injection level. Recirculation of the flue gas reduces the need for combustion air for complete combustion in the furnace. The quantity of primary air in the VLN™ system is adjusted to minimize excess air during combustion of waste on the grate, thereby reducing the overall excess air rate from approximately 100 percent, as used in the design for previous boilers with Martin stokers, to 50 to 55 percent excess air. The combination of the IGR and reduced secondary air extends the combustion zone in the furnace, which in turn inhibits the formation of NO_X. The NO_X permit limit on HPOWER3 is 110 ppmvd NO_X on a 24-hour average basis and 90 ppmvd on an annual basis.

The VLN™ system is not available for retrofit for an existing MWC unit such as at CFI. As such, while it remains a viable technology for new MWC units, the VLN™ system is not technically feasible for an existing unit.

4.1.4. Selective Catalytic Reduction

The reaction chemistry of an SCR system is similar to SNCR (NH_3 reactions with NO_X), however SCR can occur at a much lower temperature (550 °F versus 1500 °F) through the use of a catalyst. Compared to SNCR, an SCR system can operate at lower combustion gas temperatures and can achieve a higher rate of reduction with potentially lower ammonia slip.

Covanta is not aware of any existing MSW units that have been retrofitted with SCR. However, a unit with SCR has been built and is operating in Florida and is understood to be achieving a 50 ppmvd 24-hour limit and a 45 ppmvd annual limit (i.e., West Palm No. 2). Given the nature of MSW combustion and the design and layout of CFI, a tail end catalyst system is required, where the SCR is located downstream of all other air pollution control devices, and the flue gas requires reheating to achieve the proper reaction temperature for the SCR to convert NO_X into nitrogen. To minimize wasted heat from reheating the flue gas, tail end SCR systems incorporate a recuperator, where the heated gas leaving the catalyst is used to pre-heat the exhaust gas that is about to enter the catalyst.

4.2. ELIMINATE TECHNICALLY INFEASIBLE OPTIONS

The VLN™ system is not technically feasible for an existing MWC unit and is therefore eliminated from further consideration. The remaining technologies (SCR, LN™, SNCR) are technically feasible.

4.3. RACT ECONOMIC ANALYSIS

The remaining technologies are analyzed to determine RACT for CFI. The technologies are ranked in order of emissions, from lower to higher emissions, in Table 4.1.

Table 4-1. NO_X Removal Rates

Control Technology	Base case NO_X		Controlled NO_X		NO_X to be Removed
	ppmdv [1]	*tpy* [2]	*ppmdv* [1]	*tpy* [2]	*tpy*
SNCR	180	466	180	466	0
LN™	180	466	90	233	233
SCR	180	466	47.5	123	343

1. ppm basis is 7% O_2.

2. Converted using an F-Factor of 9,570 ft^3/MMBtu (EPA AP-42, Table 2.1-2 footnote, dated 10/96) and a heat input of 343.7 MMBtu/hr.

As discussed in Section 2, CFI is subject to a daily NO_X limit of 205 ppmvd (7% O_2). There is no corresponding annual limit for the site and RACT cost calculations are based on annual tonnage emitted. It is not appropriate to base an annual limit on the daily value because to meet the daily limit of 205 ppmvd the boiler must be set to run at a lower value. Annual actual average emissions at CFI range from 170 ppmvd to 180 ppmvd by unit considering each of the years 2014-2016 with a weighted average of 175 ppmvd. Based on the variability of short-term emissions to achieve a 205 ppmvd permit limit, the appropriate equivalent annual permit limit would be 180 ppmvd.

In this section, the economic impacts of each technology are calculated and compared to the others in terms of cost per ton of NO_X removed, from a base case of 180 ppmvd.

4.3.1. Cost Calculation Assumptions

4.3.1.1. SCR

4.3.1.1.1 Equipment Costs

Covanta solicited engineering estimate level bids from four third-party Engineering, Procurement, and Construction (EPC) firms. The four firms are:

Babcock and Wilcox
20 South Van Buren Avenue P.O. Box 351, Barberton, OH 44203-0351
330.753.4511

AMEC Foster Wheeler
501 Grant St. Suite 400, Pittsburgh, PA 15219
412.562.7300

Mitsubishi Hitachi
645 Martinsville Rd, Basking Ridge, NJ 07920
908.605.2800

Haldor TopSOE
17629 El Camino Real, Houston, TX 77058
281.228.5000

The selection of these firms was based on prior contract interactions, air pollution control experience, and industry reputation. B&W was the last firm to install an SCR system at a large US MWC facility (West Palm Beach). Mitsubishi Hitachi (MH) has extensive international experience with SCR systems at MWC facilities.

Covanta's request for bid stated that the SCR system should include the following: SCR reactor; gas-to-gas recuperative heat exchanger; steam coil heater; reagent feed injection, and mixing system; and all associated support steel, piping, and controls. The vendors were to design the SCR to receive NO_X at 90-180 ppmdv (24-hour average) and control it to 50 ppmdv (24-hour average).

The AMEC Foster Wheeler bid did not include several key elements of the project scope, including, but not limited to, the cost of the flue gas reheat system and the gas-to-gas recuperative heat exchanger. Without this crucial information, the AMEC Foster Wheeler bid could not be accurately compared to the other bids; therefore, the AMEC Foster Wheeler bid was deemed invalid.

Haldor TopSOEs's bid remains in development and was not available for inclusion in this revised RACT report.

The two remaining bids from B&W and MH were advanced for further evaluation. It is important to note that these bids are at the budgetary engineering estimate level and that neither firm completed a site walk-down or detailed appraisal of site limitations. The budgetary nature of these proposals also include a variety of limitations that impact the representative nature of the estimated costs and the need for the cost analysis to include contingency factors. Additional limitations include, but are not limited to:

- No mass and energy balances were performed by the vendors;
- No performance guarantees were provided by the vendors, therefore no risk was assumed by the vendors;
- Quotes represent prices for a standard "off-the-shelf" system and may not represent the exact design that the firm would quote after a detailed evaluation of performance requirements and spatial limitations. According to both firms, Covanta would need to spend at least an additional $100,000 per firm for an in-depth engineering analysis;
- Vendor cost estimates only included equipment costs; and
- There was no description of the extent of shop assembly, if any, provided with this large equipment – therefore, the assumption is that a complete field erected system would be more expensive than a shop assembled system.

As such, the cost estimates are valid for comparative purposes but there is still appreciable uncertainty in actual final costs associated with an SCR installation at CFI.

The absence of a mass and energy balance indicates that both companies utilized a generic approach and that many assumptions are inherent in the budgetary design. Comparison of the B&W and MH bids indicates that the primary differentiator is the proposed methodology to reheat the flue gas for optimal operation of the catalyst. B&W has proposed the use of existing steam generation capacity to achieve the required flue gas temperature. MH has proposed use of duct burners to achieve the required flue gas reheat and has stated that the steam temperatures are insufficient to heat the flue gas without supplementing with natural gas duct burners. While both approaches are technically viable in general, it is not possible to fully evaluate the engineering and operational constraints these proposals would have on CFI without additional detailed engineering. While the cost difference of duct burners versus steam reheat on an installed and operating basis is not known, gas reheat is a safer design until a complete mass and energy balance is available. Therefore, the cost evaluation utilizes the higher vendor cost estimate (MH) for the purchased equipment cost.

4.3.1.1.2 Installation Costs

Covanta utilized prior experience with retrofits of existing air pollution control equipment at Covanta facilities to derive the installation costs instead of the original RACT analysis that used estimates from the West Palm Beach MWC PSD BACT. Covanta used a ratio of total capital cost (equipment + installation + indirect costs) as a metric for estimating costs on other projects. For this analysis, Covanta evaluated the costs of full scale baghouse retrofits at two facilities; the Covanta MWC in Essex County NJ and at CFI. The Essex County ratio was approximately 4.9:1 with CFI being about 2.75:1. The CFI ratio reflects the current site layout, the inherent spatial limitations of the existing infrastructure and ultimately the difficulty of installation, including potential staging of equipment from adjacent off-site locations not owned/operated by CFI.

The total capital cost of the project was calculated by multiplying the vendor-supplied purchased equipment cost (PEC) by the calculated 2.75:1 ratio. A 15% contingency factor was than subtracted from the total cost (to avoid double-counting the contingencies in the vendor estimate and the installation cost ratio). Then, the cost of the individual direct and indirect cost components, such as foundations, start-up, etc. were prorated based on the relative ratios of the cost allocations from two sources: 1) the aforementioned baghouse retrofit and 2) the bid Covanta submitted as part of a proposal for construction of the West Palm Beach MWC in Florida.

4.3.1.1.3 Annual Costs

Direct and indirect annual costs were largely taken from the West Palm Beach (FL) MWC facility PSD BACT analysis, and adjusted to 2017 dollars using the CPI. The cost of reagent was set to be consistent with current reagent costs at CFI.

The West Palm No. 2 replacement catalyst cost values were adjusted from 2010 to 2017 using the Consumer Price Index (CPI). With economies of scale applied (e.g., equipment size), the six-tenths power law is used to scale costs based on ton/day MSW, as CFI is a smaller unit (750 tons/day) than West Palm No. 2 (1,000 tons/day).

Detailed cost calculation tables are provided in Appendix A with the results summarized below.

- NO_X available for control 466 tpy (180 ppmdv)
- NO_X removed by SCR 123 tpy (controlled to 47.5 ppmdv)
- Average cost effectiveness $15,898/ton

4.3.1.2. Low NO_X

Capital costs for installation of the LN™ process at CFI were estimated by examining each of the boilers at CFI to determine what initial level of protective cladding would be required to maintain furnace and waterwall tube integrity. Individual costs were developed on a per-boiler basis. An average cost is presented in the cost analysis. The installation cost, which includes items such as fans, dampers, ducting, and process controls was estimated based on actual expenses from the Montgomery County (MD) facility.

The annual costs were scaled linearly from the Montgomery County project costs to CFI.

Detailed cost calculation tables are provided in Appendix B with the results summarized below.

- NO_X available for control 466 tpy (180 ppmdv)
- NO_X removed by LN™ 233 tpy (controlled to 90 ppmdv)
- Average cost effectiveness $2,888/ton

4.3.1.3. SNCR

SNCR has been implemented at CFI and has allowed the facility to achieve the current 205 ppmdv daily permit limit. There are no additional costs to consider for SNCR.

4.3.2. Incremental Cost

The incremental cost (sometimes called marginal cost) is the additional cost to reduce emissions after one control technology has already been applied. In other words, the incremental cost is the cost to reduce emissions from the level achieved by the first control device compared to the new level achieved by the second device. The following list shows incremental costs of control; note that for the first control option, LN™, incremental and average cost are the same.

- LN™ (90 ppmvd) vs. SNCR (180 ppmvd) $2,888/ton
- SCR (47.5 ppmvd) vs LN™ (90 ppmvd) $43,449/ton
- Shutdown (0 ppmvd) vs SCR (47.5 ppmvd) $191,695/ton

The shutdown case shows the social cost of carbon (SCC), as estimated by a U.S. government multi-agency assessment[4], assuming that CFI ceases operation and all MSW is diverted into a landfill. An in-depth discussion of the greenhouse gas emissions impacts associated with the SCR may be found in Section 4.4.1.2.

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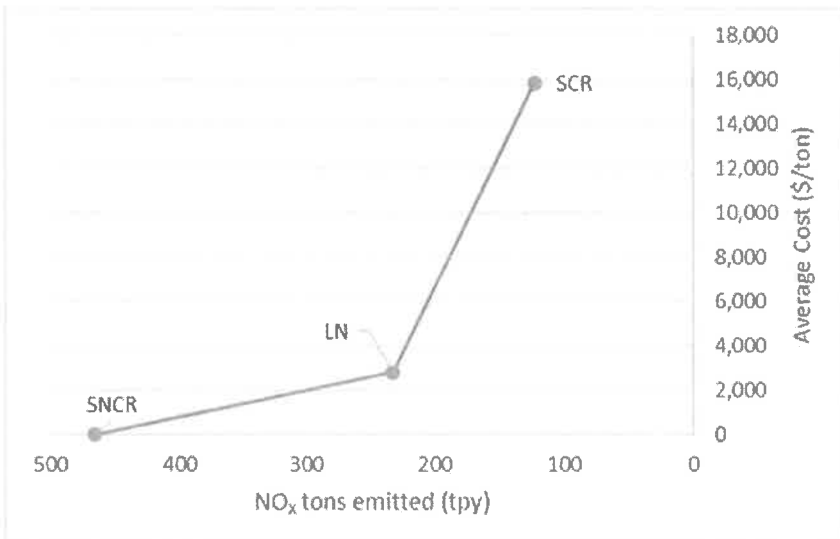
[4] Based on a 2015 social cost of carbon of $36 / metric tonne, associated with a 3% discount rate as reported by Interagency Working Group of Social Cost of carbon, United States Government (2015) *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866.*

Covanta prepared cost curves using the same methodology used by EPA in the Clean Air Interstate Rule (69 FR 4615), which graphs the tons emitted vs. the average cost as shown in Figure 4-1. In these curves, the incremental cost is represented by the slope of the line (e.g. average cost divided by tons of NO_X emitted).

As seen in Figure 4-1, the curve has a visible "knee" or point of inflection where the cost of control is increasing at a higher rate than the amount of NO_X removed. Above the "knee", there are significant diminishing returns on the dollars spent for pollution control; therefore, the most cost-effective options may be found at or below the "knee". In this case, the "knee" occurs after the LN™ cost, showing that the SCR cost has significant diminishing returns in terms of dollars spent per amount of NO_X removed when compared to LN and SNCR.

Figure 4-1. Incremental Cost



4.4. RACT DISCUSSION

The economic discussion in Section 4.3 only represents a fraction of the factors to review when considering which control technology and emission limit is appropriate for RACT for CFI. This section will discuss environmental, energy, and timing concerns related to the three proposed technologies.

4.4.1. SCR

4.4.1.1. Construction Considerations

The time required to design and install an SCR system on a unit such as CFI must be considered. Given that there is one operating SCR system on a MWC unit in the US, there is not a large body of experience such as exists with boilers. As discussed in Section 4.3.1.1.1, the engineering design specifics were not well articulated by the vendor quotes. As such, it is expected that additional design and planning time would be required beyond that which is typical for a new boiler SCR installation.

As previously discussed, the SCR would need to be installed on the tail end of the process. Due to site space constraints, the likely feasible location would be at a raised elevation in proximity to the existing baghouse units in order to accommodate existing truck traffic patterns and maintenance access needs. Issues that will have to be addressed to confirm the feasibility of this approach include, but are not limited to, the following:

- Completion of geological and civil surveys to confirm that the land and subsurface can support an elevated design;
- Assuming that it is achievable, completion of engineering of the vertical supports around existing equipment, including potential subsurface obstructions due to proximity to the CFI cooling towers; and,
- Potential for equipment storage at adjacent non-CFI off-site locations for transport to the site for installation.

4.4.1.2. Greenhouse Gas Considerations

MWC facilities, such as those operated by Covanta, are internationally recognized as a source of greenhouse gas (GHG) emissions mitigation, including by the U.S. EPA;[5] [6] U.S. EPA scientists;[7] the Intergovernmental Panel on

[5] U.S. EPA Webpage, Energy Recovery from the Combustion of Municipal Solid Waste (MSW), accessed September 19, 2016. https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw

[6] U.S. EPA Archived Webpage, Air Emissions from MSW Combustion Facilities, accessed September 19, 2016. https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/airem.html

[7] Kaplan, P.O, J. DeCarolis, and S. Thorneloe, 2009, Is it better to burn or bury waste for clean electricity generation? *Environ. Sci. Technology* 43 (6) pp1711-1717. Available at: http://pubs.acs.org/doi/abs/10.1021/es802395e

Climate Change ("IPCC");[8] the World Economic Forum;[9] the European Union;[10] [11] CalRecycle;[12] California Air Resources Board;[13] and the Joint Institute for Strategic Energy Analysis (NREL).[14] MWC generate carbon offsets credits under both the Clean Development Mechanism (CDM) of the Kyoto Protocol and voluntary carbon offset markets. [15] [16]

The basis for this widespread recognition is the lower GHG footprint of MWC relative to landfilling. MWC reduces GHG emissions, even after consideration of stack emissions from combustion, by:

1. Generating steam and/or electricity that would likely be generated by fossil-fueled facilities;
2. Diverting solid waste from landfills where it would have emitted methane even with consideration of landfill gas collection systems in place; and
3. Recovering metals for recycling, thereby saving the GHGs and energy associated with the production of products and materials from virgin inputs.

By reducing emissions that would have otherwise occurred, MWC is the only major source of electricity that actually reduces GHG emissions. Although the Clean Power Plan (CPP) is currently under review, MWC was recognized as a compliance option for reducing GHG emissions from electricity generation in the final version of

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[8] EfW identified as a "key mitigation measure" in IPCC, "Climate Change 2007: Synthesis Report. Contribution of Work Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp. Available at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

[9] EfW identified as a key technology for a future low carbon energy system in World Economic Forum. *Green Investing: Towards a Clean Energy Infrastructure.* January 2009. Available at: http://www.weforum.org/pdf/climate/Green.pdf

[10] EU policies promoting EfW as part of an integrated waste management strategy have been an overwhelming success, reducing GHG emissions over 72 million metric tonnes per year, see European Environment Agency, *Greenhouse gas emission trends and projections in Europe 2009: Tracking progress towards Kyoto targets http://www.eea.europa.eu/publications/eea_report_2009_9*

[11] European Environmental Agency (2008) Better management of municipal waste will reduce greenhouse gas emissions. Available at: http://www.eea.europa.eu/publications/briefing_2008_1/EN_Briefing_01-2008.pdf

[12] CalRecycle. 2012. CalRecycle Review of Waste-to-Energy and Avoided Landfill Methane Emissions. Available at: http://www.calrecycle.ca.gov/Actions/PublicNoticeDetail.aspx?id=735&aiid=689

[13] See Table 5 of California Air Resources Board (2014) *Proposed First Update to the Climate Change Scoping Plan: Building on the Framework, Appendix C – Focus Group Working Papers, Municipal Solid Waste Thermal Technologies*

[14] Joint Institute for Strategic Energy Analysis (2013) *Waste Not, Want Not: Analyzing the Economic and Environmental Viability of Waste-to-Energy (WTE) Technology for Site-Specific Optimization of Renewable Energy Options.* http://www.nrel.gov/docs/fy13osti/52829.pdf

[15] Clean Development Mechanism Executive Board: "Approved baseline and monitoring methodology AM0025: Avoided emissions from organic waste through alternative waste treatment processes." Available at: http://www.cdm.unfcc.int/methodologies/DB/3STKBX3UY84WXOQWIO9W7J1B40FMD

[16] Verified Carbon Standard Project Database, http://www.vcsprojectdatabase.org/ See Project ID 290, Lee County Waste to Energy Facility 2007 Capital Expansion Project VCU, and Project ID 1036 Hillsborough County Waste to Energy (WTE) Facility 2009 Capital Expansion Unit 4.

the promulgated CPP. New MWC facilities are eligible to generate Emission Rate Credits (ERCs).[17] Existing facilities were not a covered source and were considered a source of zero carbon energy under the program.[18]

MWC's climate attributes are an important benefit to the Commonwealth of Virginia. On average, the U.S. EPA has determined that MWC reduces GHG emissions by one ton of CO_2 equivalents (CO_2e) for every ton of MSW diverted from landfill and processed.[19] Based on Virginia specific data and information, including the emissions intensity of the local electrical grid and operating data from Covanta's Virginia MWC facilities and assuming that Virginia's MWC's displace landfills equipped with modern landfill gas to energy systems, every ton of MSW diverted to MWC reduces GHG emissions by roughly 0.7 tons CO_2e. Covanta's Virginia facilities (CAAI and CFI) annually *reduce* net GHG emissions by approximately over 900,000 tons of CO_2e a year relative to landfilling.

The monetary value of this net GHG reduction is roughly $29M / year, based on a midpoint value of the social cost of carbon (SCC) emissions, as estimated by a U.S. government multi-agency assessment. The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, as well as the value of damages avoided for an emission reduction.[20]

This benefit is especially important in light of current efforts to reduce GHG emissions from Virginia's electricity generation facilities under the Governor's Executive Orders (EO) 57 and 11. As articulated above, MWC facilities were recognized as a compliance tool under those CPP requirements established pursuant to §111(d) of the federal Clean Air Act specifically identified in EO 57. Furthermore, MWC facilities do not incur a compliance obligation under the Regional Greenhouse Gas Initiative (RGGI). As the country's only multi-state trading program, RGGI is under consideration for the development of the regulatory proposal called for by EO 11.

A determination that SCR is RACT for CFI could put these benefits in jeopardy. In the most optimistic case, should CFI be economically sustainable with the significant capital investment, operating and maintenance expenses incurred with SCR, the net GHG benefits will decrease. Higher in-house energy consumption associated with SCR, resulting from required reheating of the flue gas and additional pressure drop across the catalyst, would reduce the annual GHG benefit by approximately 40,000 tons CO_2e (assuming a 10% reduction in net electrical output). However, implementation of SCR at Covanta's Virginia MWC facilities could render them economically infeasible; the Commonwealth stands to lose over 700,000 MWh of low carbon renewable energy and 900,000 tons of CO_2e savings annually.

4.4.1.3. Conclusion

The economic analysis in Section 4.3.1.1 demonstrates that SCR has substantial diminishing returns on the dollars spent for pollution control. The timing and GHG concerns further demonstrate that design time is extensive for retrofitting an SCR for existing equipment and that installation of the SCR has the potential to

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[17] 40 CFR 60.5800

[18] 40 CFR 60.5845

[19] See U.S. EPA Office of Solid Waste, *Air Emissions from MSW Combustion Facilities*, https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/airem.html and Center for American Progress (2013) *Energy from Waste Can Help Curb Greenhouse Gas Emissions* https://cdn.americanprogress.org/wp-content/uploads/2013/04/EnergyFromWaste-PDF1.pdf

[20] U.S. EPA (2016) *Fact Sheet: Social Cost of Carbon*, https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

decrease the net GHG benefits derived from MWC's. Based on the results of these analyses, Covanta has determined that SCR is not RACT.

4.4.2. Low NO_X (LN™)

4.4.2.1. Timing Considerations

Installation of LN™ would be sequenced to allow for testing and optimization of the technology. Consistent with DEQ's goal of initiating implementation of RACT reductions to coincide with the 2019 ozone season, Covanta proposes the installation of LN™ on the first of the four CFI units to commence with the scheduled fall 2018 outages (currently anticipated to occur October/November 2018). Following an approximately 6-month testing/optimization period, the second unit installation would commence in 2019. Installation of LN™ on the remaining two units would occur in 2020 and 2021, respectively. This schedule is contingent on issuance of a final RACT permit by DEQ in the 4th quarter of 2018 and does not account for any additional DEQ permits that may be required for the installation and operation of the LN™ technology.

4.4.2.2. Conclusion

The economic analysis in Section 4.3.1.2 established that installation of an LN™ system at CFI is economically feasible. The timing considerations discussed in Section 4.4.2.1, demonstrated that the design and installation schedule can fit within the confines of DEQ's RACT compliance schedule. Based on the results of these analyses, Covanta has determined that LN™ with emission rates of 110 ppmdv (24-hr average) and 90 ppmdv (annual average) is RACT.

APPENDIX A: SCR COST CALCULATIONS

Table A-1 Capital Cost Analysis for SCR

Capital Cost Summary				
DIRECT COSTS				
Purchased Equipment Costs				
SCR equipment		$	8,479,000	a
Ancillary Equipment		$	405,000	b
Instrumentation		$	888,000	c
Freight		$	444,000	c
Purchased Equipment Cost (PEC)	PEC=	**$**	**10,216,000**	
DIRECT COSTS				
Foundations and Supports		$	923,000	d
Handling and Erection		$	4,563,000	d
Electrical		$	521,000	d
Piping		$	1,087,000	d
Insulation		$	137,000	d
Painting		$	137,000	d
Building Expansion for SCR Components		$	3,204,000	d, e
Direct Installation Cost (DC)	DIC=	**$**	**10,572,000**	
INDIRECT COSTS				
Installation				
Engineering and Home office Fees		$	2,104,000	f
Construction and Field Expenses		$	846,000	
Contractor Fees		$	1,766,000	
Start-up		$	259,000	
Performance Test		$	130,000	
Process Contingency		$	3,940,000	g
Lost Production due to Extended Downtime for Installation		$	480,000	h
Total Indirect Installation Cost (IC)	IIC=	**$**	**9,525,000**	
TOTAL CAPITAL INVESTMENT (TCI=PEC+DC+IC)	TCI=	$	30,313,000	

a Based on a quote from Mitsubishi Hitachi (2017 dollars) for a single unit. Cost assumes continuous sequential installation.

b Includes cost of ID fan and variable frequency drive.

c Instrumentation is 10% of the cost of the SCR and ancillary equipment. Freight is 5% of the cost of the SCR and ancillary equipment.

d Prorated based on the bid Covanta submitted for construction of the West Palm Beach MWC in Florida and the ratio of total cost to capital cost from two baghouse retrofits (Essex County, NJ and Fairfax County, VA). Location and productivity factors have been applied. Values have been updated to 2017 dollars using either Consumer Price Index or Producer Price Index.

e Includes cost of boiler reinforcement, ID fan foundations and erection, modifications to existing baghouse, demolition, and relocation. Includes productivity factors which consider complexities of retrofit construction in an operating facility.

f Based on historic data for Covanta staffing and third party design/engineering services and fees.

g Contingency factor estimated at 15% of total cost. Contingency factor accounts for unknowns related to the preliminary nature of capital cost estimates and the need to install the SCR as a retrofit.

h Assumes $32,000 per unit per day, and downtime duration of 15 days.

Table A-2 Annual Costs for SCR

Annual Cost Summary					
DIRECT ANNUAL COSTS					
Operating Labor			$	61,309	b
Supervisory Labor			$	9,196	b
Maintenance (Labor and Materials)			$	122,617	b
Reagent Costs			$	154,051	c
Electricity Cost			$	317,356	d
Natural gas power costs			$	457,578	e
Catalyst Costs			$	136,629	a
TOTAL DIRECT COST (DC)		DC =	$	**1,258,735**	
INDIRECT ANNUAL COSTS					
Overhead			$	115,873	b
Administrative and Insurance			$	1,212,520	b
Capital Recovery (CRF x TCI)					
20 years @ 7.00% interest	CRF =	0.0944	$	2,861,333	b
TOTAL INDIRECT COST (IC)		IC =	$	**4,189,726**	
TOTAL ANNUALIZED COST (TAC = DC + IC)		TAC=	$	**5,448,461**	

a Based on the Palm Beach Renewable Energy Facility #2 Application, Submitted May 17, 2010. Value is updated to 2017 YTD (Jan-July) Consumer Price Index and scaled using the six-tenths power law to account for the size difference between West Palm Beach and Covanta.

b Based on the Palm Beach Renewable Energy Facility #2 Application, Submitted May 17, 2010. Value is updated to 2017 YTD (Jan-July) Consumer Price Index .

c Based on the Palm Beach Renewable Energy Facility #2 Application, Submitted May 17, 2010. Cost of reagent set to $0.55/lb NH3 consistent with current costs at CFI.

d Based on an 28 inches of water pressure drop from Hitachi bid for recuperator and SCR, cost of $0.063/kWh (updated to 2017 YTD [Jan-July] Consumer Price Index) from West Palm No. 2 application. Remainder calculated Equation 2.48 from EPA's Cost Control Manual (CCM) Section 4, Chapter 2 (EPA/452/B-02-001), October 2000.

e Hitachi bid shows gas leaving existing baghouse at 340 F entering recuperator that pre-heats to 500 F, then a natural gas burner adding heat to 550 F, and ending in discharge from recuperator at 390 F. Covanta engineers suggest a 70 F heat by natural gas to be most realistic, given the space constraints. Design airflow for CFI is 147,400 acfm at 340 F based on data provided by Covanta. The specific heat of air is approximately 0.27 Btu/lb*F (see http://www.engineeringtoolbox.com/air-properties-d_156.html) and weight is approximately 0.05 lb/ft^3 at 340 F. 80% efficiency basis for conversion of natural gas energy into the heated air and cost of natural gas at $5/MMBtu.

Table A-3 Cost Effectiveness Summary for SCR

Cost Effectiveness Summary		
Annual Control Cost	$	5,448,461
NOx at 180 ppmvd 7% O2, tpy		465.6
NOx at 47.5 ppmvd 7% O2, tpy		122.9
NO_X to be Removed, tpy		342.7
Average Control Cost ($/ton)	$	15,898

APPENDIX B: LOW NO_X (LN^{TM}) COST CALCULATIONS

Table B-1 Capital Cost Analysis for LN ™

Capital Cost Summary		Capital Cost	
DIRECT COSTS			
Purchased Equipment Costs			
Boiler Reinforcement		$	392,550 [a]
Purchased Equipment Cost (PEC)	PEC=	$	392,550
Total Direct Cost (DC)	DC=	$	392,550
INDIRECT COSTS			
Installation			
Installation Costs			$1,011,692 [b]
Lost Production due to Extended Downtime for Installation		$	160,000 [c]
Total Indirect Cost (IC)	IC=	$	1,171,692
TOTAL CAPITAL INVESTMENT (TCI=DC+IC)	TCI=	$	1,564,242

a Average PEC for cladding derived from inspection of CFI boilers.

b Cost derived from LN™ installation at the Montgomery County (MD) MWC facility.

c Assumes $32,000 per unit per day, and downtime duration of 5 days.

Table B-2 Annual Costs for LN ™

Annual Cost Summary							Annual Cost
DIRECT ANNUAL COSTS							
Increased Inconel CapEx due to LN ™						$	243,875 [a]
Increased Annual Expenses due to LN ™						$	249,447 [a]
TOTAL DIRECT COST (DC)					DC =	$	493,322
INDIRECT ANNUAL COSTS							
Administrative Charges (2% of TCI)						$	31,285
Capital Recovery (CRF x TCI)							
	20 years @	7.00%	interest	CRF =	0.0944	$	147,653
TOTAL INDIRECT COST (IC)					IC =	$	178,938
TOTAL ANNUALIZED COST (TAC = DC + IC)					TAC=	$	672,260

[a] Cost derived from LN™ operational experience at the Montgomery County (MD) MWC facility.

Table B-3 Cost Effectiveness Summary for LN [IM]

Cost Effectiveness Summary		
Annual Control Cost	$	672,260
NOx at 180 ppmvd 7% O2, tpy	tpy	465.6
NOx at 90 ppmvd 7% O2, tpy	tpy	232.8
NO_x to be Removed, tpy	tpy	232.8
Average Control Cost ($/ton)	$	2,888

Attachment 9

COVANTA
Powering Today. Protecting Tomorrow.

September 8, 2017

Mr. James LaFratta
Regional Air Permit Manager
Northern Regional Office
Virginia Department of Environmental Quality
13901 Crown Court
Woodbridge, VA 22193

Subject: Covanta Alexandria/Arlington, Inc.
Registration No. 71895
NO_X RACT – Submittal of Paper Copy

Dear Mr. LaFratta:

The Covanta Alexandria/Arlington, Inc. (CAAI) facility located at 5301 Eisenhower Avenue, Alexandria VA has prepared a NO_X RACT analysis and submitted an electronic version of the analysis to the Department via email on September 8, 2017. Enclosed with this letter is a paper copy of the previously emailed analysis.

Following is the certification statement as required by 9VAC5-20-230B.

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Please contact me at 703-370-7722 with any questions.

Sincerely,

Bryan Donnelly

Bryan Donnelly
Facility Manager

PROJECT REPORT
Covanta Alexandria/Arlington, Inc.

Reasonably Available Control Technology Determination for NO_X

Prepared By:

TRINITY CONSULTANTS
15 Salem Ave SE
Suite 201
Roanoke VA 24014
540-342-5945

Original Submittal: September 2016
Revised: September 2017

Project 164701.0002

Trinity Consultants

Environmental solutions delivered uncommonly well

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1. EXECUTIVE SUMMARY

Covanta Alexandria/Arlington, Inc. (CAAI) completed an updated Reasonably Available Control Technology (RACT) determination for oxides of nitrogen (NO_X). This update reflects a schedule extension granted by the United States Environmental Protection Agency (U.S. EPA) and subsequent discussions with the Virginia Department of Environmental Quality (DEQ or Department). Three control technology options are considered, and two of those technologies are determined to be technically feasible for CAAI and are further evaluated. Based on this evaluation, CAAI has determined that Covanta's patented Low NO_X technology (LN™), combined with optimized selective non-catalytic reduction (SNCR), is RACT. Specifically, implementation of LN™ can reasonably achieve an annual NO_X emission limit of 90 parts per million volume dry (ppmvd) (7% O_2) and a daily NO_X limit of 110 ppmvd (7% O_2).

2. DESCRIPTION OF FACILITY

Covanta Alexandria/Arlington, Inc (CAAI or Facility) operates three Municipal Waste Combustor (MWC) units rated at a nominal 325 ton/day throughput. The MWC units use Martin grate technology for combustion, which is an integrated reciprocating grate stoker along with waterwall tube boilers. Each unit includes a suite of air pollution controls, including selective non-catalytic reduction (SNCR), a spray dryer absorber, a fabric filter baghouse, and an activated carbon injection system. Table 2-1 provides key parameters for the MWC at CAAI.

Table 2-1. CAAI Facility Design Information

Parameter	Units	Value
Number of Units		3
Nominal Capacity (design)	tpd MSW	325
MSW Heat Input (design)	MMBtu/hr	121.8
MSW Heat Content (design)	BTU/lb, HHV	4,500
Steaming Rate (design)	lb/hr steam	77,000

CAAI operates pursuant to Title V operating permit NRO71895 issued by DEQ with an effective date of June 10, 2016. Each unit is subject to a daily NO_X limit of 205 ppmvd (7% O_2 basis) as outlined in Chapter 40, Article 54, Large Municipal Waste Combustors, and is consistent with federal MWC Emission Guidelines pursuant to 40 CFR 60 Subpart Cb.[1] CAAI is also subject to NO_X limits on each unit of 0.55 lb/MMBtu and 177 tons/yr. The concentration limit is monitored via NO_X CEMS.

The CAAI units did not originally include SNCR control for NO_X but instead SNCR was installed as part of a prior RACT determination for NO_X; that determination was made in 1998 with compliance required no later than December 19, 2000. The prior NO_X RACT determination identified that NO_X RACT would be SNCR with a NO_X limit at 205 ppmvd, consistent with the then pending Subpart Cb Emission Guidelines and implemented no later than the schedule required by Subpart Cb. Thus, the current RACT determination is 205 ppmvd and is identical to the current Subpart Cb limit.

[1] All ppmvd values referenced in this report at 7% O_2 basis unless otherwise noted.

3. RACT BACKGROUND

On May 21, 2012, designations for nonattainment areas for the 2008 ozone National Ambient Air Quality Standards (NAAQS) were published in the Federal Register (77 FR 30088). A portion of northern Virginia near Washington, DC was designated as a nonattainment area. The following Virginia counties and cities are included in the Washington DC-MD-VA nonattainment area (i.e., the Northern Virginia Emissions Control Area).

- Alexandria City
- Arlington County
- Fairfax City
- Fairfax County
- Falls Church City
- Loudoun County
- Manassas City
- Manassas Park City
- Prince William County

On March 6, 2015, the State Implementation Plan (SIP) Requirements Rule (SRR) for the 2008 ozone nonattainment areas was finalized (80 FR 12264). Areas are required to implement RACT no later than January 1 of the fifth year after the nonattainment designation, which was January 1, 2017.

CAAI is located in the City of Alexandria, which is one of the Virginia locations subject to the requirement to implement RACT for the 2008 ozone standard. As such, CAAI must address RACT.[2]

CAAI submitted preliminary RACT information to DEQ via letter dated January 28, 2016. In that letter, CAAI proposed to submit its RACT determination in the third quarter 2016. CAAI submitted a RACT determination September 19, 2016 that was prefaced upon the imminent implementation of RACT.

The September 2016 NOx RACT analysis provided to DEQ included an evaluation of RACT technologies that were commercially available and proven for retrofit at existing MWC sources in order to meet DEQ's requested submittal schedule. The RACT analysis included the use of LN™ cost estimates derived from the installation and operation of LN™ at the Montgomery County (MD) MWC facility that is operated by Covanta Montgomery Inc. and selective catalytic reduction (SCR) cost estimates derived from the West Palm Beach (FL) MWC facility Prevention of Significant Deterioration (PSD) Best Available Control Technology (BACT) analysis; the permit application for the SCR project was prepared by Malcolm Pirnie and the project was constructed by Babcock & Wilcox. Cost estimates from these reference facilities were adjusted for size and date.

Covanta and DEQ met to discuss the draft on April 25, 2017. At that meeting, DEQ requested additional detail on the control technology analyses, specifically for SCR and LN™. Covanta responded via letter, dated May 5, 2017,

[2] This analysis explicitly addresses the 2008 ozone standard RACT analysis. EPA has proposed (81 FR 81276, November 17, 2016) but not finalized the plan requirements for the 2015 ozone standard, of which RACT will be a part. While this submittal explicitly addresses the 2008 ozone standard RACT, this submittal is likely to meet the requirements for a future 2015 ozone standard RACT.

which requested four months to obtain facility-specific cost data for SCR and LN™. This revised RACT report incorporates refined price quotes for both SCR and LN™.

Covanta developed and submitted bid requests to four third-party air pollution control vendors, including Babcock & Wilcox, to obtain new SCR capital cost estimates as described in more detail in Section 4.3.1. During that bid process, Covanta determined that the data used in the West Palm Beach (FL) MWC facility PSD BACT were not provided by the air pollution control subsidiary of Babcock & Wilcox but instead were estimates developed by a European consulting firm not affiliated with the project. This new information casts some doubt on the accuracy and appropriateness of the prior SCR cost data that Covanta used as inputs to the 2016 RACT submittal. Covanta has revised the SCR capital cost estimates using the third-party bids and prior experience with the cost of retrofit air pollution control devices at Covanta facilities. The third-party SCR bids provided to Covanta reflect the difficulty of estimating the cost of installing a complicated and large system at an existing, operating facility that has inherent spatial limitations when considered relative to a 'greenfield' development such as the West Palm Beach facility (where installation of the SCR is part of the facility design and the layout specifically accommodates all of its inherent piping, wiring, supports and other considerations). A review of the third-party bids indicated the following limitations:

- All bids are budgetary and limited to an equipment-only scope without any estimate of accuracy;
- None of the firms visited the facility to enable a true and accurate assessment of how and where the SCR system would be located;
- None of the bids included a mass and energy balance for an assessment of the functional viability of the system and associated implications on facility performance; and
- None of the bids included an indication that the system would or could be guaranteed as proposed.

In addition, Covanta also revised the LN™ cost estimates to reflect specific, anticipated boiler reinforcements at CAAI necessary to accommodate the installation of LN™, on a per-boiler basis. These updated cost estimates are based on an inspection of the CAAI boilers as well as Covanta's experience at several MWC facilities and did not require input by other firms. As a result, the LN™ cost estimates are considered to be more accurate and representative of actual costs that could be incurred as compared to the SCR costs.

3.1. REGULATORY REQUIREMENTS

9VAC5 Chapter 40 Article 51 (Rule 4-51) addresses requirements for case-by-case RACT determinations in Virginia. RACT is defined in Rule 4-51 as:

> *... the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available, considering technological and economic feasibility.*

For certain source categories listed in 9VAC5-40-7430, DEQ defines a presumptive RACT for NO_X. The source categories for presumptive RACT are boilers and combustion turbines firing gas, oil and (for boilers only) coal. DEQ does not define a presumptive RACT for MWCs such as at CAAI. The presumptive RACT category most similar to MWCs would be stoker coal boilers, which have a presumptive RACT limit for NO_X of 0.4 lb/MMBtu that is less stringent than the current NO_X limit at CAAI.[3]

9VAC5-40-7420 addresses RACT requirements for sources without a presumptive RACT, such as at CAAI. RACT is applicable to facilities with site-wide emissions greater than 100 tons/yr, as is the case at CAAI. There are three requirements for sources such as CAAI:

- Notify DEQ of applicability status;
- Commit to making a determination of RACT; and,
- Provide a schedule acceptable to DEQ for making the RACT determination and achieving compliance with the emission standard no later than January 1, 2017.

CAAI submitted preliminary RACT information to DEQ via letter dated January 28, 2016. DEQ requested that CAAI complete the RACT analysis consistent with the DEQ RACT Analysis Guidelines (updated February 3, 2016). The DEQ guidelines request a three step version of the top-down control technology approach:

1. Identify all available control alternatives;
2. Assess technical feasibility; and
3. Evaluate remaining technologies in order of control effectiveness considering:
    a. Expected emissions reduction (ton/yr);
    b. Economic impacts ($/ton of pollutant removed);
    c. Environmental impacts; and,
    d. Energy impacts.

If the top control alternative is not selected as RACT, the rationale for rejection must be documented. The next most stringent control alternative is then assessed, and the process continues until RACT is determined.

Covanta's September 2016 submittal assumed that RACT must be implemented no later than January 1, 2017. This revised submittal does not include that time constraint in assessing available RACT options.

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[3] The current 205 ppmvd limit converts to 0.35 lb/MMBtu based on an F-factor value of 9,570 dscf/MMBtu.

4. RACT ANALYSIS

4.1. POTENTIAL RACT OPTIONS

Following the RACT methodology and discussions with DEQ, potential RACT options have been identified for NO_X control at CAAI. They include:

- Optimized SNCR system;
- Low NO_X (LN™) combustion system/SNCR combination;
- Very Low NO_X [VLN™]/SNCR combination; and,
- Selective catalytic reduction (SCR).

The technologies are each described in this section. Two of the technologies (LN™ and VLN™) are used in combination with SNCR and thus are presented considering usage of the combustion technology plus SNCR. One technology (VLN™) is technically infeasible for existing MWC units.

4.1.1. Optimized SNCR

SNCR injects ammonia into the high-temperature combustion exhaust gases where the ammonia (NH_3) reacts with NO_X to yield several reaction products including nitrogen (N_2) and water vapor (H_2O). As more ammonia is injected, additional NO_X can be converted, but there are limits to the extent of removal that is possible. In all operational modes, a portion of ammonia is unreacted and is emitted; this ammonia is referred to as ammonia slip. As the amount of ammonia injected increases, ammonia slip may also increase. As such, there is an optimization between the amount of ammonia injected and the amount of ammonia slip. As ammonia slip increases, a detached visible plume can be created by the interaction between ammonia and chlorides or sulfides in the exhaust gases.

CAAI underwent an SNCR optimization study at the request of the Alexandria/Arlington Waste Disposal Trust Fund Board of Trustees. At the time of the study, CAAI was operating with a NO_X setpoint of 185 ppmvd to ensure compliance with the permit limit of 205 ppmvd. Testing at CAAI showed uncontrolled NO_X emissions at approximately 275 ppmvd and that optimization of the system could potentially lower setpoints to as low as 150 ppmvd in limited operating conditions. Key points identified from that study included:

- NO_X emissions are consistently higher for approximately 30 days after the annual outage. This is attributable to a change in the isotherms in the furnace causing the SNCR process to be less effective;
- A visible plume can result from hydrogen chloride combining with ammonia as ammonia injection rates increase;
- Fluctuations in the municipal solid waste (MSW) received can influence the ability of the MWC to achieve an emission rate (e.g., MSW with large concentrations of yard waste can result in more difficulty in maintaining lower NO_X emissions);
- There are variations on a unit-by-unit basis in the achievable NO_X emissions (based on testing of the three nominally identical units at CAAI);
- Some reduction from the 185 ppmvd setpoint is likely achievable as CAAI was able to operate with a setpoint as low as 150 ppmvd during limited duration periods;

- The CAAI boiler cross-section is small and therefore can achieve good contact between the ammonia and the flue gas – additionally, temperatures in the upper furnace are near ideal once an equilibrium ash layer has coated the waterwall tubes;
- The study duration required approximately six months to design, conduct, and analyze the results; and
- The external costs to complete the study were $39,880 in 2006 – internal costs were not quantified at that time.

CAAI currently operates at a NO_X setpoint of 160 ppmvd beginning approximately two to four weeks after an outage, consistent with an agreement with the Alexandria/Arlington Waste Disposal Trust Fund Board of Trustees; the setpoint is higher in the two to four weeks after an outage. A setpoint is a distributed control system (DCS) target, where the DCS reads both the ammonia injection rate and the NO_X emission rate and via computer programing continuously adjusts the ammonia injection rate to attempt to maintain a consistent NO_X emission rate. Due to variabilities inherent in the combustion of a heterogeneous fuel such as MSW, NO_X emissions have a degree of variability such that it is necessary to define a setpoint value less than the permit limit; the setpoint is not a fixed emission value at which the unit always operates, but is a target value at the center of a range of emission values, some higher than and some lower than the setpoint, with the average NO_X emissions value targeted to the setpoint value.

Based on the prior SNCR optimization at CAAI, CAAI is able to operate at a setpoint of 160-180 ppmvd, with the higher range used in the two to four weeks after an outage. Annual actual average emissions as operated with the optimized SNCR at CAAI range from 161 ppmvd to 168 ppmvd by unit (2014-2016) with a weighted average of 163 ppmvd.

4.1.2. Low NO_X (LN™) Combustion System

Covanta has developed a proprietary low NO_X combustion system (i.e., LN™) that involves staging of combustion air. The system is a trademarked system and Covanta has received a patent for the technology.

A Martin MWC combustor system involves a moving grate with two sources of combustion air. Primary air (also called underfire air) is supplied from underneath the grate and is forced through the grate to dry and combust the MSW. The quantity of primary air is adjusted to minimize excess air while at the same time maximizing burnout of materials on the bed. Secondary air (also called overfire air) is injected through nozzles located in the furnace side walls immediately above the grate and provides turbulent mixing to complete the combustion process.

The Covanta LN™ process modifies the secondary air stream. A new series of air nozzles are installed higher in the furnace (tertiary air) and a portion of the secondary air is diverted to these new nozzles. The distribution of air between the primary, secondary, and tertiary streams is then controlled to yield the optimal gas composition and temperature to minimize NO_X formation and control combustion. The tertiary air achieves complete coverage of the furnace cross-section to ensure good mixing with the combustion gases. The tertiary air completes the combustion process, and yields uniform flue gas temperature and velocity profiles, which improves the performance and reliability of downstream boiler equipment. Note that the total air flow to the MWC is not changed, only the distribution of air is changed. The LN™ combustion system works in concert with an optimized SNCR system to achieve lower NO_X emissions.

A typical required scope of work to implement the LN™ process includes the following steps:

1. Detailed process analysis of current combustion conditions, including evaluation of waste heating values, excess air levels, furnace temperature profiles, and typical range of fouling;
2. Calculations to determine the number, size, and location of tertiary air nozzles;
3. Detailed mechanical and structural design of tertiary air ducting, headers and nozzles;
4. Installation of ductwork to carry the tertiary air from the discharge of the existing secondary air fan up to the elevation of the tertiary air nozzles;
5. Installation of automatic dampers to control the flow of tertiary air;
6. Installation of tertiary air headers on the upper furnace to feed air to individual nozzles;
7. Modifications to the boiler waterwalls to allow installation of the new tertiary air nozzles – two tube bends required per nozzle with refractory boxes to seal the boiler penetrations;
8. Installation of stainless steel tertiary air nozzles to allow online changes of nozzle diameter without shutting down the boiler;
9. Installation of flexible stainless steel hoses with individual manual butterfly dampers for the air feed to each tertiary air nozzle;
10. Design, installation and tuning of revised combustion controls; and
11. Installation of additional Inconel on waterwall tubes and refractory tile in the lower furnace (Inconel is an oxidation- and corrosion-resistant nickel alloy).

The LN™ process can be retrofitted to an existing unit, and Covanta has installed the LN™ process at approximately 20 units worldwide, including at the MWC facility in Montgomery County, Maryland. The Maryland Department of Environment (MDE) is evaluating NO_X applicability for the Montgomery County facility and anticipates issuing a final rule in 2017.

The LN™ process at Montgomery County has appreciably increased annual maintenance costs due to increased refractory wear and boiler fouling. The result of expanding the combustion zone through a larger volume of the furnace creates a larger area subjected to high-temperature, low-oxygen conditions. Under these conditions, the combustion chamber components wear more quickly than would otherwise occur. The refractory and waterwall tubing are the primary components seeing higher wear rates. Refractory must be repaired or replaced when damaged. Depending on the location within the boiler, waterwall tubes may require repair or replacement, as well as application of Inconel cladding to better resist the aggressive environment. While Inconel cladding is much more protective than bare tubes, it also wears over time and requires spot repair or re-application.

4.1.3. Very Low NO_X (VLN™)

The VLN™ system is an extension of the concepts used in the LN™ system, where staging of air and fuel is managed to minimize NO_X formation. However, in contrast to the LN™ system, the VLN™ system requires a different and specially designed combustion chamber. There are two operating Covanta units with the VLN™ system: HPOWER3 in Honolulu and the Durham York Energy Centre in Ontario, Canada.

The VLN™ system employs a unique combustion air system design, which in addition to the conventional primary and secondary air systems, features an internal gas recirculation (IGR) injection system located in the upper furnace above the secondary air nozzles. Gas is drawn from above the grate at the rear of the furnace and is re-introduced to the upper furnace above the secondary air injection level. Recirculation of the flue gas reduces the need for combustion air for complete combustion in the furnace. The quantity of primary air in the VLN™ system is adjusted to minimize excess air during combustion of waste on the grate, thereby reducing the overall excess air rate from approximately 100 percent, as used in the design for previous boilers with Martin stokers, to 50 to 55 percent excess air. The combination of the IGR and reduced secondary air extends the combustion zone in the furnace, which in turn inhibits the formation of NO_X. The NO_X permit limit on HPOWER3 is 110 ppmvd NO_X on a 24-hour average basis and 90 ppmvd on an annual basis.

The VLN™ system is not available for retrofit for an existing MWC unit such as at CAAI. As such, while it remains a viable technology for new MWC units, the VLN™ system is not technically feasible for an existing unit.

4.1.4. Selective Catalytic Reduction

The reaction chemistry of an SCR system is similar to SNCR (NH_3 reactions with NO_X), however SCR can occur at a much lower temperature (550 °F versus 1500 °F) through the use of a catalyst. Compared to SNCR, an SCR system can operate at lower combustion gas temperatures and can achieve a higher rate of reduction with potentially lower ammonia slip.

Covanta is not aware of any existing MSW units that have been retrofitted with SCR. However, a unit with SCR has been built and is operating in Florida and is understood to be achieving a 50 ppmvd 24-hour limit and a 45 ppmvd annual limit (i.e., West Palm No. 2). Given the nature of MSW combustion and the design and layout of CAAI, a tail end catalyst system is required, where the SCR is located downstream of all other air pollution control devices, and the flue gas requires reheating to achieve the proper reaction temperature for the SCR to convert NO_X into nitrogen. To minimize wasted heat from reheating the flue gas, tail end SCR systems incorporate a recuperator, where the heated gas leaving the catalyst is used to pre-heat the exhaust gas that is about to enter the catalyst.

4.2. ELIMINATE TECHNICALLY INFEASIBLE OPTIONS

The VLN™ system is not technically feasible for an existing MWC unit and is therefore eliminated from further consideration. The remaining technologies (SCR, LN™, SNCR) are technically feasible.

4.3. RACT ECONOMIC ANALYSIS

The remaining technologies are analyzed to determine RACT for CAAI. The technologies are ranked in order of emissions, from lower to higher emissions, in Table 4.1.

Table 4-1. NO_X Removal Rates

Control Technology	Base case NO_X		Controlled NO_X		NO_X to be Removed
	ppmvd[1]	*tpy*[2]	*ppmvd*[1]	*tpy*[2]	*tpy*
SNCR	180	165	180	165	0
LN™	180	165	90	82	82
SCR	180	165	47.5	44	121

1. ppm basis is 7% O_2.
2. Converted using an F-Factor of 9,570 ft^3/MMBtu (EPA AP-42, Table 2.1-2 footnote, dated 10/96) and a heat input of 121.8 MMBtu/hr.

As discussed in Section 2, CAAI is subject to a daily NO_X limit of 205 ppmvd (7% O_2). There is no corresponding annual limit for the site and RACT cost calculations are based on annual tonnage emitted. It is not appropriate to base an annual limit on the daily value because to meet the daily limit of 205 ppmvd the boiler must be set to run at a lower value. Since CAAI is operated to achieve a lower daily limit, as discussed in Section 4.1.1, Covanta reviewed data from the Covanta Fairfax, Inc. (CFI) MWC facility which is operated to achieve a 205 ppmvd daily limit. Annual actual average emissions at CFI range from 170 ppmvd to 180 ppmvd by unit considering each of the years 2014-2016 with a weighted average of 175 ppmvd. Based on the variability of short-term emissions to achieve a 205 ppmvd permit limit, the appropriate equivalent annual permit limit would be 180 ppmvd.

In this section, the economic impacts of each technology are calculated and compared to the others in terms of cost per ton of NO_X removed, from a base case of 180 ppmvd.

4.3.1. Cost Calculation Assumptions

4.3.1.1. SCR

4.3.1.1.1 Equipment Costs

Covanta solicited engineering estimate level bids from four third-party Engineering, Procurement, and Construction (EPC) firms. The four firms are:

Babcock and Wilcox
20 South Van Buren Avenue P.O. Box 351, Barberton, OH 44203-0351
330.753.4511

AMEC Foster Wheeler
501 Grant St. Suite 400, Pittsburgh, PA 15219
412.562.7300

Mitsubishi Hitachi
645 Martinsville Rd, Basking Ridge, NJ 07920
908.605.2800

Haldor TopSOE
17629 El Camino Real, Houston, TX 77058
281.228.5000

The selection of these firms was based on prior contract interactions, air pollution control experience, and industry reputation. B&W was the last firm to install an SCR system at a large US MWC facility (West Palm Beach). Mitsubishi Hitachi (MH) has extensive international experience with SCR systems at MWC facilities.

Covanta's request for bid stated that the SCR system should include the following: SCR reactor; gas-to-gas recuperative heat exchanger; steam coil heater; reagent feed injection, and mixing system; and all associated support steel, piping, and controls. The vendors were to design the SCR to receive NO_X at 90-180 ppmdv (24-hour average) and control it to 50 ppmdv (24-hour average).

The AMEC Foster Wheeler bid did not include several key elements of the project scope, including, but not limited to, the cost of the flue gas reheat system and the gas-to-gas recuperative heat exchanger. Without this crucial information, the AMEC Foster Wheeler bid could not be accurately compared to the other bids; therefore, the AMEC Foster Wheeler bid was deemed invalid.

Haldor TopSOEs's bid remains in development and was not available for inclusion in this revised RACT report.

The two remaining bids from B&W and MH were advanced for further evaluation. It is important to note that these bids are at the budgetary engineering estimate level and that neither firm completed a site walk-down or a detailed appraisal of site limitations. The budgetary nature of these proposals also include a variety of limitations that impact the representative nature of the estimated costs and the need for the cost analysis to include contingency factors. Additional limitations include, but are not limited to:

- No mass and energy balances were performed by the vendors;
- No performance guarantees were provided by the vendors, therefore no risk was assumed by the vendors;
- Quotes represent prices for a standard "off-the-shelf" system and may not represent the exact design that the firm would quote after a detailed evaluation of performance requirements and spatial limitations. According to both firms, Covanta would need to spend at least an additional $100,000 per firm for an in-depth engineering analysis;
- Vendor cost estimates only included equipment costs; and
- There was no description of the extent of shop assembly, if any, provided with this large equipment – therefore, the assumption is that a complete field erected system would be more expensive than a shop assembled system.

As such, the cost estimates are valid for comparative purposes but there is still appreciable uncertainty in actual final costs associated with an SCR installation at CAAI.

The absence of a mass and energy balance indicates that both companies utilized a generic approach and that many assumptions are inherent in the budgetary design. Comparison of the B&W and MH bids indicates that the primary differentiator is the proposed methodology to reheat the flue gas for optimal operation of the catalyst. B&W has proposed the use of existing steam generation capacity to achieve the required flue gas temperature. MH has proposed use of duct burners to achieve the required flue gas reheat and has stated that the steam temperatures are insufficient to heat the flue gas without supplementing with natural gas duct burners.[4] While both approaches are technically viable in general, it is not possible to fully evaluate the engineering and operational constraints these proposals would have on CAAI without additional detailed engineering. While the cost difference of duct burners versus steam reheat on an installed and operating basis is not known, gas reheat is a safer design until a complete mass and energy balance is available. Therefore, the cost evaluation utilizes the higher vendor cost estimate (MH) for the purchased equipment cost.

4.3.1.1.2 Installation Costs

Covanta utilized prior experience with retrofits of existing air pollution control equipment at Covanta facilities to derive the installation costs instead of the original RACT analysis that used estimates from the West Palm Beach MWC PSD BACT. Covanta used a ratio of total capital cost (equipment + installation + indirect costs) as a metric for estimating costs on other projects. For this analysis, Covanta evaluated the costs of full scale baghouse retrofits at two facilities; the Covanta MWC in Essex County NJ and at Covanta Fairfax, Inc. (CFI). The Essex County ratio was approximately 4.9:1 with CFI being about 2.75:1. The ratio selected for Alexandria/Arlington was 3.25:1. This ratio reflects the site layout at CAAI, the inherent spatial limitations of the existing infrastructure and ultimately the difficulty of installation, including probable staging of equipment from off-site locations.

The 3.25:1 factor selected for CAAI is higher than the CFI baghouse retrofit, but less than the Essex County retrofit. Essex County is considered more representative of CAAI because Essex used an elevated platform (60 feet above grade) to mount the baghouse over other equipment. The limited space at CAAI suggests that an elevated platform may be the only way to install an SCR at CAAI.

The total capital cost of the project was calculated by multiplying the vendor-supplied purchased equipment cost (PEC) by the calculated 3.25:1 ratio. A 15% contingency factor was than subtracted from the total cost (to avoid double-counting the contingencies in the vendor estimate and the installation cost ratio). Then, the cost of the individual direct and indirect cost components, such as foundations, start-up, etc. were prorated based on the relative ratios of the cost allocations from two sources: 1) baghouse retrofits at the aforementioned Covanta facilities and 2) the bid Covanta submitted as part of a proposal for construction of the West Palm Beach MWC in Florida.

4.3.1.1.3 Annual Costs

Direct and indirect annual costs were largely taken from the West Palm Beach (FL) MWC facility PSD BACT analysis, and adjusted to 2017 dollars using the CPI. The cost of reagent was set to be consistent with current reagent costs at CAAI.

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[4] Note that CAAI relies on fuel oil for auxiliary fuel usage. The existing natural gas line adjacent to the facility is undersized. Additional costs (not included in this analysis) would be incurred to upgrade the natural gas line to meet facility needs.

The West Palm No. 2 replacement catalyst cost values were adjusted from 2010 to 2017 using the Consumer Price Index (CPI). With economies of scale applied (e.g., equipment size), the six-tenths power law is used to scale costs based on ton/day MSW, as CAAI is a smaller unit (325 tons/day) than West Palm No. 2 (1,000 tons/day).

Detailed cost calculation tables are provided in Appendix A with the results summarized below.

- NO_X available for control 165 tpy (180 ppmdv)
- NO_X removed by SCR 121.4 tpy (controlled to 47.5 ppmdv)
- Average cost effectiveness $31,445/ton

4.3.1.2. Low NO_X

Capital costs for installation of the LN™ process at CAAI were estimated by examining each of the boilers at CAAI to determine what initial level of protective cladding would be required to maintain furnace and waterwall tube integrity. Individual costs were developed on a per-boiler basis. An average cost is presented in the cost analysis. The installation cost, which includes items such as fans, dampers, ducting, and process controls was estimated based on actual expenses from the Montgomery County (MD) facility.

The annual costs were scaled linearly from the Montgomery County project costs to CAAI.

Detailed cost calculation tables are provided in Appendix B with the results summarized below.

- NO_X available for control 165 tpy (180 ppmdv)
- NO_X removed by LN™ 82.5 tpy (controlled to 90 ppmdv)
- Average cost effectiveness $4,005/ton

4.3.1.3. Optimized SNCR

Optimized SNCR has already been achieved at CAAI and is capable of achieving emission levels below the current 205 ppmdv daily permit limit. There are no additional costs to consider SNCR. However, since CAAI has identified LN™ as RACT, optimized SNCR is not addressed further.

4.3.2. Incremental Cost

The incremental cost (sometimes called marginal cost) is the additional cost to reduce emissions after one control technology has already been applied. In other words, the incremental cost is the cost to reduce emissions from the level achieved by the first control device compared to the new level achieved by the second device. The following list shows incremental costs of control; note that for the first control option, LN™, incremental and average cost are the same.

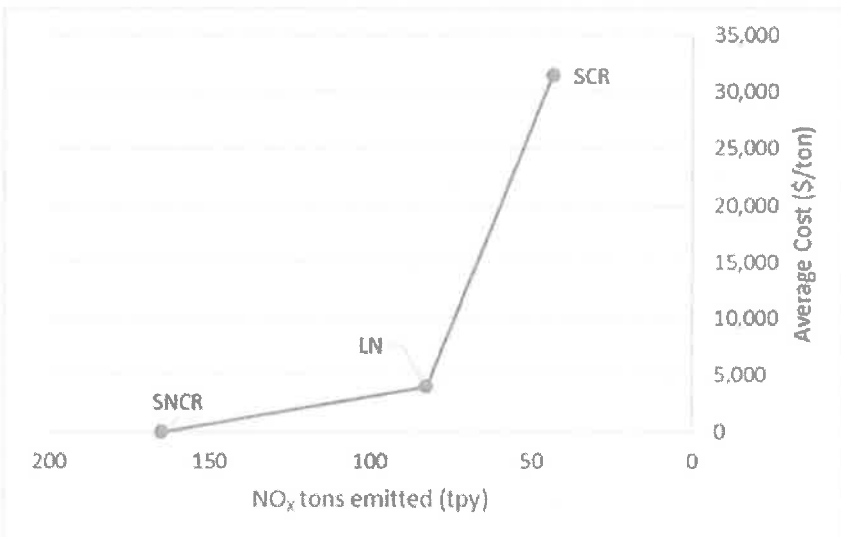
- LN™ (90 ppmvd) vs. SNCR (180 ppmvd) $4,005/ton
- SCR (47.5 ppmvd) vs LN™ (90 ppmvd) $89,554/ton
- Shutdown (0 ppmvd) vs SCR (47.5 ppmvd) $578,457/ton

The shutdown case shows the social cost of carbon (SCC), as estimated by a U.S. government multi-agency assessment[5], assuming that CAAI ceases operation and all MSW is diverted into a landfill. An in-depth discussion of the greenhouse gas emissions impacts associated with the SCR may be found in Section 4.4.1.2.

Covanta prepared cost curves using the same methodology used by EPA in the Clean Air Interstate Rule (69 FR 4615), which graphs the tons emitted vs. the average cost as shown in Figure 4-1. In these curves, the incremental cost is represented by the slope of the line (e.g., average cost divided by tons of NO_X emitted).

As seen in Figure 4-1, the curve has a visible "knee" or point of inflection where the cost of control is increasing at a higher rate than the amount of NO_X removed. Above the "knee", there are significant diminishing returns on the dollars spent for pollution control; therefore, the most cost-effective options may be found at or below the "knee". In this case, the "knee" occurs after the LN™ cost, showing that the SCR cost has significant diminishing returns in terms of dollars spent per amount of NO_X removed when compared to LN and SNCR.

Figure 4-1. Incremental Cost



[5] Based on a 2015 social cost of carbon of $36 / metric tonne, associated with a 3% discount rate as reported by Interagency Working Group of Social Cost of carbon, United States Government (2015) *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866.*

4.4. RACT DISCUSSION

The economic discussion in Section 4.3 only represents a fraction of the factors to review when considering which control technology and emission limit is appropriate for RACT for CAAI. This section will discuss environmental, energy, and timing concerns related to the three proposed technologies.

4.4.1. SCR

4.4.1.1. Construction Considerations

The time required to design and install an SCR system on a unit such as CAAI must be considered. Given that there is one operating SCR system on a MWC unit in the US, there is not a large body of experience such as exists with boilers. As discussed in Section 4.3.1.1.1, the engineering design specifics were not well articulated by the vendor quotes. As such, it is expected that additional design and planning time would be required beyond that which is typical for a new boiler SCR installation.

As previously discussed, the SCR would need to be installed on the tail end of the process. Due to significant space constraints, the only feasible location would be at elevation above the existing baghouse units. That location creates significant challenges and raises questions about the actual viability of that approach. Issues that will have to be addressed to confirm the feasibility of this approach include, but are not limited to, the following:

- Completion of geological and civil surveys to confirm that the land and subsurface can support the elevated design and overturning moments;
- Assuming that it is achievable, completion of engineering of the vertical supports around existing equipment and structures; and,
- Storing equipment off-site for transport to the site for installation. The limited facility area prevents storage of new equipment at the site.

4.4.1.2. Greenhouse Gas Considerations

MWC facilities, such as those operated by Covanta, are internationally recognized as a source of greenhouse gas (GHG) emissions mitigation, including by the U.S. EPA;[6] [7] U.S. EPA scientists;[8] the Intergovernmental Panel on

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[6] U.S. EPA Webpage, Energy Recovery from the Combustion of Municipal Solid Waste (MSW), accessed September 19, 2016. https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw

[7] U.S. EPA Archived Webpage, Air Emissions from MSW Combustion Facilities, accessed September 19, 2016. https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/airem.html

[8] Kaplan, P.O, J. DeCarolis, and S. Thorneloe, 2009, Is it better to burn or bury waste for clean electricity generation? *Environ. Sci. Technology* 43 (6) pp1711-1717. Available at: http://pubs.acs.org/doi/abs/10.1021/es802395e

Climate Change ("IPCC");[9] the World Economic Forum;[10] the European Union;[11] [12] CalRecycle;[13] California Air Resources Board;[14] and the Joint Institute for Strategic Energy Analysis (NREL).[15] MWC generate carbon offsets credits under both the Clean Development Mechanism (CDM) of the Kyoto Protocol and voluntary carbon offset markets. [16] [17]

The basis for this widespread recognition is the lower GHG footprint of MWC relative to landfilling. MWC reduces GHG emissions, even after consideration of stack emissions from combustion, by:

1. Generating steam and/or electricity that would likely be generated by fossil-fueled facilities;
2. Diverting solid waste from landfills where it would have emitted methane even with consideration of landfill gas collection systems in place; and
3. Recovering metals for recycling, thereby saving the GHGs and energy associated with the production of products and materials from virgin inputs.

By reducing emissions that would have otherwise occurred, MWC is the only major source of electricity that actually reduces GHG emissions. Although the Clean Power Plan (CPP) is currently under review, MWC was recognized as a compliance option for reducing GHG emissions from electricity generation in the final version of

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[9] EfW identified as a "key mitigation measure" in IPCC, "Climate Change 2007: Synthesis Report. Contribution of Work Groups I, II, and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp. Available at: http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

[10] EfW identified as a key technology for a future low carbon energy system in World Economic Forum. *Green Investing: Towards a Clean Energy Infrastructure.* January 2009. Available at: http://www.weforum.org/pdf/climate/Green.pdf

[11] EU policies promoting EfW as part of an integrated waste management strategy have been an overwhelming success, reducing GHG emissions over 72 million metric tonnes per year, see European Environment Agency, *Greenhouse gas emission trends and projections in Europe 2009: Tracking progress towards Kyoto targets* *http://www.eea.europa.eu/publications/eea_report_2009_9*

[12] European Environmental Agency (2008) Better management of municipal waste will reduce greenhouse gas emissions. Available at: http://www.eea.europa.eu/publications/briefing_2008_1/EN_Briefing_01-2008.pdf

[13] CalRecycle. 2012. CalRecycle Review of Waste-to-Energy and Avoided Landfill Methane Emissions. Available at: http://www.calrecycle.ca.gov/Actions/PublicNoticeDetail.aspx?id=735&aiid=689

[14] See Table 5 of California Air Resources Board (2014) *Proposed First Update to the Climate Change Scoping Plan: Building on the Framework, Appendix C – Focus Group Working Papers, Municipal Solid Waste Thermal Technologies*

[15] Joint Institute for Strategic Energy Analysis (2013) *Waste Not, Want Not: Analyzing the Economic and Environmental Viability of Waste-to-Energy (WTE) Technology for Site-Specific Optimization of Renewable Energy Options.* http://www.nrel.gov/docs/fy13osti/52829.pdf

[16] Clean Development Mechanism Executive Board: "Approved baseline and monitoring methodology AM0025: Avoided emissions from organic waste through alternative waste treatment processes." Available at: http://www.cdm.unfcc.int/methodologies/DB/3STKBX3UY84WXOQWIO9W7J1B40FMD

[17] Verified Carbon Standard Project Database, http://www.vcsprojectdatabase.org/ See Project ID 290, Lee County Waste to Energy Facility 2007 Capital Expansion Project VCU, and Project ID 1036 Hillsborough County Waste to Energy (WTE) Facility 2009 Capital Expansion Unit 4.

the promulgated CPP. New MWC facilities are eligible to generate Emission Rate Credits (ERCs).[18] Existing facilities were not a covered source and were considered a source of zero carbon energy under the program.[19]

MWC's climate attributes are an important benefit to the Commonwealth of Virginia. On average, the U.S. EPA has determined that MWC reduces GHG emissions by one ton of CO_2 equivalents (CO_2e) for every ton of MSW diverted from landfill and processed.[20] Based on Virginia specific data and information, including the emissions intensity of the local electrical grid and operating data from Covanta's Virginia MWC facilities and assuming that Virginia's MWC's displace landfills equipped with modern landfill gas to energy systems, every ton of MSW diverted to MWC reduces GHG emissions by roughly 0.7 tons CO_2e. Covanta's Virginia facilities (CAAI and Covanta Fairfax in nearby Lorton VA) annually *reduce* net GHG emissions by approximately over 900,000 tons of CO_2e a year relative to landfilling.

The monetary value of this net GHG reduction is roughly $29M / year, based on a midpoint value of the social cost of carbon (SCC) emissions, as estimated by a U.S. government multi-agency assessment. The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO_2) emissions, as well as the value of damages avoided for an emission reduction.[21]

This benefit is especially important in light of current efforts to reduce GHG emissions from Virginia's electricity generation facilities under the Governor's Executive Orders (EO) 57 and 11. As articulated above, MWC facilities were recognized as a compliance tool under those CPP requirements established pursuant to §111(d) of the federal Clean Air Act specifically identified in EO 57. Furthermore, MWC facilities do not incur a compliance obligation under the Regional Greenhouse Gas Initiative (RGGI). As the country's only multi-state trading program, RGGI is under consideration for the development of the regulatory proposal called for by EO 11.

A determination that SCR is RACT for CAAI could put these benefits in jeopardy. In the most optimistic case, should CAAI be economically sustainable with the significant capital investment, operating and maintenance expenses incurred with SCR, the net GHG benefits will decrease. Higher in-house energy consumption associated with SCR, resulting from required reheating of the flue gas and additional pressure drop across the catalyst, would reduce the annual GHG benefit by approximately 40,000 tons CO_2e (assuming a 10% reduction in net electrical output). However, implementation of SCR at Covanta's Virginia MWC facilities could render them economically infeasible; the Commonwealth stands to lose over 700,000 MWh of low carbon renewable energy and 900,000 tons of CO_2e savings annually.

4.4.1.3. Conclusion

The economic analysis in Section 4.3.1.1 demonstrates that SCR has substantial diminishing returns on the dollars spent for pollution control. The timing and GHG concerns further demonstrate that design time is

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[18] 40 CFR 60.5800

[19] 40 CFR 60.5845

[20] See U.S. EPA Office of Solid Waste, *Air Emissions from MSW Combustion Facilities*, https://archive.epa.gov/epawaste/nonhaz/municipal/web/html/airem.html and Center for American Progress (2013) *Energy from Waste Can Help Curb Greenhouse Gas Emissions* https://cdn.americanprogress.org/wp-content/uploads/2013/04/EnergyFromWaste-PDF1.pdf

[21] U.S. EPA (2016) *Fact Sheet: Social Cost of Carbon*, https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

extensive for retrofitting an SCR for existing equipment and that installation of the SCR has the potential to decrease the net GHG benefits derived from MWC's. Based on the results of these analyses, Covanta has determined that SCR is not RACT.

4.4.2. Low NO_X (LN™)

4.4.2.1. Timing Considerations

Installation of LN™ would be sequenced to allow for testing and optimization of the technology. Consistent with DEQ's goal of initiating implementation of RACT reductions to coincide with the 2019 ozone season and to allow for adequate sequencing, Covanta proposes the installation of LN™ on the first of the three CAAI units to commence with the scheduled fall 2019 outages (currently anticipated to occur September/October 2018). Following an approximately 6-month testing/optimization period, the second unit installation would commence in 2020. Installation of LN™ on the final unit would occur in 2021. This schedule is contingent on issuance of a final RACT permit by DEQ in the 4th quarter of 2018 and does not account for any additional DEQ permits that may be required for the installation and operation of the LN™ technology.

4.4.2.2. Conclusion

The economic analysis in Section 4.3.1.2 established that installation of an LN™ system at CAAI is economically feasible. The timing considerations discussed in Section 4.4.2.1 demonstrated that the design and installation schedule can fit within the confines of DEQ's RACT compliance schedule. Based on the results of these analyses, Covanta has determined that LN™ with emission rates of 110 ppmdv (24-hr average) and 90 ppmdv (annual average) is RACT.

APPENDIX A: SCR COST CALCULATIONS

Table A-1 Capital Cost Analysis for SCR

Capital Cost Summary				
DIRECT COSTS				
Purchased Equipment Costs				
SCR equipment		$	5,797,000	a
Ancillary Equipment		$	250,000	b
Instrumentation		$	605,000	c
Freight		$	302,000	c
Purchased Equipment Cost (PEC)	**PEC=**	**$**	**6,954,000**	
DIRECT COSTS				
Foundations and Supports (Earthwork, Concrete, Structural Steel)		$	836,000	d
Handling and Erection		$	3,548,000	d
Electrical		$	622,000	d
Piping		$	786,000	d
Insulation		$	131,000	d
Painting		$	131,000	d
Building Expansion for SCR Components		$	1,972,000	d, e
Direct Installation Cost (DC)	**DIC=**	**$**	**8,026,000**	
INDIRECT COSTS				
Installation				
Engineering and Home office Fees		$	2,250,000	f
Construction and Field Expenses		$	642,000	
Contractor Fees		$	1,340,000	
Start-up		$	293,000	
Performance Test		$	147,000	
Process Contingency		$	2,963,000	g
Lost Production due to Extended Downtime for Installation		$	216,000	h
Total Indirect Installation Cost (IC)	**IIC=**	**$**	**7,851,000**	
TOTAL CAPITAL INVESTMENT (TCI=PEC+DC+IC)	**TCI=**	**$**	**22,831,000**	

a Based on a quote from Mitsubishi Hitachi (2017 dollars) for a single unit. Cost assumes continuous sequential installation.

b Includes cost of ID fan and variable frequency drive.

c Instrumentation is 10% of the cost of the SCR and ancillary equipment. Freight is 5% of the cost of the SCR and ancillary equipment.

d Prorated based on the bid Covanta submitted for construction of the West Palm Beach MWC in Florida and the ratio of total cost to capital cost from two baghouse retrofits (Essex County, NJ and Fairfax County, VA). Location and productivity factors have been applied. Values have been updated to 2017 dollars using either Consumer Price Index or Producer Price Index.

e Includes cost of boiler reinforcement, ID fan foundations and erection, modifications to existing baghouse, demolition, and relocation. Includes productivity factors which consider complexities of retrofit construction in an operating facility.

f Based on historic data for Covanta staffing and third party design/engineering services and fees.

g Contingency factor estimated at 15% of total cost. Contingency factor accounts for unknowns related to the preliminary nature of capital cost estimates and the need to install the SCR as a retrofit.

h Assumes $18,000 per unit per day, and downtime duration of 12 days.

Table A-2 Annual Costs for SCR

Annual Cost Summary				
DIRECT ANNUAL COSTS				
Operating Labor		$	61,309	b
Supervisory Labor		$	9,196	b
Maintenance (Labor and Materials)		$	122,617	b
Reagent Costs		$	47,637	c
Electricity Cost		$	112,448	d
Natural gas power costs		$	198,286	e
Catalyst Costs		$	82,725	a
TOTAL DIRECT COST (DC)	DC =	$	**634,218**	
INDIRECT ANNUAL COSTS				
Overhead		$	115,873	b
Administrative and Insurance		$	913,240	b
Capital Recovery (CRF x TCI)				
20 years @ 7.00% interest	CRF = 0.0944	$	2,155,085	
TOTAL INDIRECT COST (IC)	IC =	$	**3,184,198**	
TOTAL ANNUALIZED COST (TAC = DC + IC)	TAC=	$	**3,818,416**	

a Based on the Palm Beach Renewable Energy Facility #2 Application, Submitted May 17, 2010. Value is updated to 2017 YTD (Jan-July) Consumer Price Index and scaled using the six-tenths power law to account for the size difference between West Palm Beach and Covanta.

b Based on the Palm Beach Renewable Energy Facility #2 Application, Submitted May 17, 2010. Value is updated to 2017 YTD (Jan-July) Consumer Price Index .

c Based on the Palm Beach Renewable Energy Facility #2 Application, Submitted May 17, 2010. Cost of reagent set to $0.48/lb NH3 consistent with current costs at CAAI.

d Based on an 28 inches of water pressure drop from Hitachi bid for recuperator and SCR, cost of $0.063/kWh (updated to 2017 YTD [Jan-July] Consumer Price Index) from West Palm No. 2 application. Remainder calculated Equation 2.48 from EPA's Cost Control Manual (CCM) Section 4, Chapter 2 (EPA/452/B-02-001), October 2000

e Hitachi bid shows gas leaving existing baghouse at 340 F entering recuperator that pre-heats to 500 F, then a natural gas burner adding heat to 550 F, and ending in discharge from recuperator at 390 F. Covanta engineers suggest a 70 F heat by natural gas to be most realistic, given the space constraints. Design airflow for CAAI is 63,874 acfm at 340 F based on data provided by Covanta. The specific heat of air is approximately 0.27 Btu/lb*F (see http://www.engineeringtoolbox.com/air-properties-d_156.html) and weight is approximately 0.05 lb/ft^3 at 340 F. 80% efficiency basis for conversion of natural gas energy into the heated air and cost of natural gas at $5/MMBtu.

Table A-3 Cost Effectiveness Summary for SCR

Cost Effectiveness Summary		
Annual Control Cost	$	3,818,416
NOx at 180 ppmvd 7% O2, tpy		165.0
NOx at 47.5 ppmvd 7% O2, tpy		43.5
NO_X to be Removed, tpy		121.4
Average Control Cost ($/ton)	$	31,445

APPENDIX B: LOW NO_X (LN^{TM}) COST CALCULATIONS

Table B-1 Capital Cost Analysis for LN ™

Capital Cost Summary			Capital Cost	
DIRECT COSTS				
Purchased Equipment Costs				
Boiler Reinforcement		$	224,133	[a]
Purchased Equipment Cost (PEC)	PEC=	$	**224,133**	
Total Direct Cost (DC)	DC=	$	**224,133**	
INDIRECT COSTS				
Installation				
Installation Costs		$	614,572	[b]
Lost Production due to Extended Downtime for Installation		$	180,000	[c]
Total Indirect Cost (IC)	IC=	$	**794,572**	
TOTAL CAPITAL INVESTMENT (TCI=DC+IC)	TCI=	$	**1,018,705**	

a Average PEC for cladding derived from inspection of CAAI boilers.

b Cost derived from LN™ installation at the Montgomery County (MD) MWC facility.

c Assumes $18,000 per unit per day, and downtime duration of 10 days.

Table B-2 Annual Costs for LN™

Annual Cost Summary				Annual Cost
DIRECT ANNUAL COSTS				
Increased Inconel CapEx due to LN™			$	105,679 [a]
Increased Annual Expenses due to LN™			$	108,094 [a]
TOTAL DIRECT COST (DC)		DC =	$	**213,773**
INDIRECT ANNUAL COSTS				
Administrative Charges (2% of TCI)			$	20,374
Capital Recovery (CRF x TCI)				
20 years @ 7.00% interest	CRF =	0.0944	$	96,159
TOTAL INDIRECT COST (IC)		IC =	$	116,533
TOTAL ANNUALIZED COST (TAC = DC + IC)		TAC=	$	330,306

[a] Cost derived from LN™ operational experience at the Montgomery County (MD) MWC facility.

Table B-3 Cost Effectiveness Summary for LN IM

Cost Effectiveness Summary	
Annual Control Cost	$ 330,306
NOx at 180 ppmvd 7% O2, tpy	165.0
NOx at 90 ppmvd 7% O2, tpy	82.5
NO_X to be Removed, tpy	82.5
Average Control Cost ($/ton)	$ 4,005