COMMONWEALTH OF PENNSYLVANIA

Department of Environmental Protection
March 1, 2024
484-250-5920

SUBJECT: Significant Modification Application
Alternative RACT III Proposal-Revised
Title V Permit 09-00013
Wheelabrator Fall, Inc.
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Falls Township, Bucks County, PA 19067
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Introduction

Wheelabrator Falls, Inc. (Wheelabrator) operates two (2) 800 tons per day municipal waste combustors (MWC) at their 1201 New Ford Mill Rd., Falls Township, Bucks County location. On 12/27/2022, Wheelabrator submitted an application for a significant modification to their Title V operating permit, 09-00013, in order to comply with Pennsylvania RACT III. The application was found administratively complete on 1/09/2023. The application included proof of municipal and county notification, the application fee of $4,000.00, operating permit modification form and a compliance review form. Based on the PennEnviroScreen tool, the facility is not located in or within a half of a mile of an environmental justice area.

Facility RACT III Status

As per 25 Pa. Code § 129.114(a), Wheelabrator Falls, Inc. is subject to requirements of 25 Pa. Code § 129.112 for NOx emissions and petitioned for RACT III alternative compliance. NOx emissions from the facility exceed the 25 tpy limit for RACT III, with controls. The facility is not subject to RACT III for VOC emissions since VOC emissions from all sources at the facility do not exceed 25 tpy, with maximum emissions of 22.5 tpy VOC. The VOC emissions are based on highest emissions rate, 2.45 lb/hr, for the combustors from the August 2022 stack test and other emissions sources totally less than 1 tpy VOCs.

Proposal Adequacy Review as per 25 Pa. Code § 129.114(d)

As per 25 Pa. Code § 129.114(d)(1), the proposal/application was timely. It was submitted on 12/27/2022. The initial submission was found deficient on several items required under 25 Pa. Code § 129.114. DEP sent a denial letter on 3/7/2023. Several meetings were held to discuss the issues that need to be corrected for the RACT proposal to be acceptable.

On 7/5/2023, DEP received the revised alternative RACT III proposal from Wheelabrator. The revised proposal contained all the required steps under 25 Pa. Code § 129.114 and included revisions to the cost estimates and proposed emissions limit. The revised petition requested a 130 ppmdv NOx @ 7% O_2 during steady state operation and 130 ppmdv NOx uncorrected for O_2 during preheat, startup and shutdown limits using enhanced selective non-catalytic reduction (ESNCR) emission controls. This technology was found to be the within the cost-effectiveness threshold of $7,500 while providing more emission reduction than other lower cost technologies. Although the revised proposal is considered acceptable to DEP, some issues remained to be addressed and will be discussed in the Regulatory section of this review.

Sources and Emissions

Wheelabrator is subject to RACT III only for NOx emissions and this review will only consider sources of NOx at the facility. Currently the NOx emissions sources at the facility are the two (2) municipal waste combustors (MWCs), several small natural gas-fired heaters and one (1) diesel fire pump. NOx emissions from each heater is less than 0.5 tpy and the emissions from the fire pump are limited to 0.5 tpy NOx by an enforceable limit in the current permit. These minor sources are not subject to RACT III under 25 Pa. Code § 129.111(c). Only the MWCs are subject to RACT III. The MWC details are provided in Table 1.

Table 1: MWC Design			
Number of Units	2	Hourly Capacity	66667 lbs
Manufacturer	Von Roll/ Babcock & Wilcox	Primary Burner Input	325 MMBtu/hr
Model	750	Secondary Burner Input	50 MMBtu/hr
Installation Date	5/1/1994	Auxillary Fuel	Natural Gas
Rated Throughput	800 tons/day	Boiler Design	Waterwall

As part of the alternative RACT III proposal, Wheelabrator reviewed several available technologies capable of reducing NOx emissions. Since the review, ranking and cost analysis governed under 25 Pa Code §§ 192.92 and 129.114 these items will be covered in the Regulatory section of this review. A decision was made by Wheelabrator to propose the use of ESNCR to reach a limit of 130 ppmdv @ 7% O_2. This section of the review will only cover the use of ESNCR since the other options were found to be not as effective for reducing NOx, unfeasible for technical reasons or considerably higher in cost per ton reduction than the $7,500 screening value. Table 2 below gives a breakdown the NOx reduction and cost per ton of each feasible technology. For more information on how these technologies were considered feasible, please see the Regulatory section of this memo and Attachment 5.

Table 2: Cost Effectiveness for Technically Feasible NOx Emissions Controls				
Technology	**Tail End SCR**	**Advanced SNCR (ASNCR)**	**ASNCR with Flue Gas Recirculation**	**Enhanced SNCR (ESNCR)**
Potentital Emissions Limit (ppm)	50	110	110	130
NOx Emissions at Limit (tpy)	201.3	443.5	443.5	524.3
Baseline Average Emissions (ppm)	146	146	146	146
Baseline Emissions (tpy)	587.9	587.9	587.9	587.9
NOx Reduction (tpy)	386.6	144.4	144.4	63.7
Annualized Cost of Technology	$6,510,745	$1,613,302	$1,907,057	$474,886
Cost Effectiveness ($/ton)	$16,841	$11,172	$13,207	$7,455

Note: Cost are in 2023 dollars.

As part of the revised alternative RACT III application (see Attachment 1 for information on original and revised application), Wheelabrator provided emissions estimates using a base emissions rate of 146 ppmdv @ 7% oxygen using SNCR and average operating hours of 7,347 per year. To determine the accuracy of the baseline emission and the potential NOx reduction, DEP used emissions factors from AP-42, Chapter 2.1 – Municipal Waste Combustors to calculate uncontrolled emissions, emissions at the average 146 ppmdv NOx @ 7% O_2 and at the proposed new limit of 130 ppmdv NOx @ 7% O_2 during steady state operation. Table 2 provides the DEP calculations (sample calculations in Attachment 2).

Table 3: PTE for MWCs					
Timeframe	NOx Factors (lb/ton)		Input (tons/hr)	Emissions per unit (tpy)	2 Units (tpy)
8,760 hr/yr	Uncontrolled[1]	3.56	33.33	519.76	1039.53
	SNCR controlled[2]	2.25	33.33	328.21	656.42
	ESNCR controlled[3]	2.00	33.33	292.29	584.59
7,698 hr/yr - 10 year average	Uncontrolled[1]	3.56	33.33	456.75	913.50
	SNCR controlled[2]	2.25	33.33	288.42	576.84
	ESNCR controlled[3]	2.00	33.33	256.86	513.72
7,347 hr/yr[4]	Uncontrolled[1]	3.56	33.33	435.92	871.85
	SNCR controlled[2]	2.25	33.33	275.27	550.54
	ESNCR controlled[3]	2.00	33.33	245.15	490.29

Note- Hours are per combustor; tons/hr based on 66,667 lb/hr combustor capacity; permit does not contain any hours of operation limitations or throughput limits for municipal waste

[1]- based on AP-42 2.1, Table 2.1-4 uncontrolled

[2]- based on 146 ppm average and using conversion factor from Table 2.1-10 of AP-42

[3]- based on 130 ppm average and using conversion factor from Table 2.1-10 of AP-42

[4]- base on average hours given by Wheelabrator for 2021-2022

RACT III is applicable at all times, including preheat, startup, shutdown and malfunction. The EPA considers startup and shutdown a normal form of operation that is not steady state. During preheat, startup and shutdown excess air is often part of the flue gases. This causes an artificial inflation of NOx emissions due to higher oxygen levels in the flue gases (See Attachment 3). To accommodate the RACT III reduction requirements, Wheelabrator has proposed to maintain the 130 ppmdv NOx without correcting to 7% O_2. This limit will also comply with the Good Neighbor Policy which will be discussed in the Regulatory section of this review.

Wheelabrator in their cost analysis gave a base emissions rate of 587.9 tpy total for both combustors (see Attachment 4) using the 146 ppm NOx @ 7% O_2 and 7,347 hr/yr. DEP back calculated using the given baseline of 587.9 tons per year (tpy) and AP-42, Chapter 2.1. DEP found at that tpy emissions rate, the actual average ppm for NOx would have been 155.88 ppm. This exceeds the current permit limit of 150 ppmdv NOx @ 7% O_2. The baseline NOx emissions using the current SNCR configuration, calculated based on 146 ppmdv NOx @ 7% O_2, and operating 7,347 hr/yr per MWC should be 550.54 tpy combined from both MWCs. Also, the average hours of operation used by Wheelabrator for the MWC were based on only two years of data (2021-2022) during which the U.S. was under COVID restriction for part of the time and was in recovery from the impact of such restriction. DEP found when averaging the reported hours of operation from 2012-2022, the average hours of operation per MWC was 7,698 hr/yr.

Though there are differences between the emissions as calculated by Wheelabrator and DEP, both show an 11% reduction in NOx emissions with the use of ESNCR. In order to achieve the reduction, the facility is performing upgrades to the urea injection system and analysis of the boiler for temperature gradients and gas flow. A previously performed trial by the facility showed by running the urea pumps at the maximum flowrate, they were able to reduce the NOx emissions to 130 ppmdv @ 7% O_2. Operation of the existing system at maximum capacity full time is not feasible due to the strain and wear it would cause to the system. Such strain and wear could result in system failure and an increase in NOx emission. To enable the system to consistently achieve 130 ppm NOx, the following will be modified:

- Replacement of metering pumps and distribution panel
- Install new injectors and/or relocate existing injectors based on boiler analysis
- Install rolled furnace tubes for new and relocated injectors
- Adjustments to SNCR controls to optimize for upgraded equipment

Wheelabrator plans to meet the 130 ppmdv @7% O_2 by the August 1, 2024. In addition, the facility is planning for compliance with 40 CFR § 52.46 for MWC which is part of "Good Neighbor Plan" as published in the Federal Register, Vol. 88, No. 107 on 6/5/2023. By May 1st, 2026 the MWCs at Wheelabrator need to comply with 110 ppmdv @7% O_2 based on 24-hour average and 105 ppmdv @7% O_2 based on 30-day averaging. In order to achieve the required reductions, another round of boiler analysis will be done while complying with the 130 ppmdv RACT III limit, an upgrade of the ESNCR will be done to convert it to an advanced selective non-catalytic reduction (ASNCR) system and optimization of the control system will be performed.

Regulatory

On November 12, 2022 new regulations for the control of NOx and VOC, precursor for the formation of ground level ozone, were promulgated (52 Pa. B. 6960). These regulations are known as RACT III, with RACT standing for Reasonably Available Control Technology. The purpose of the new regulations is to address Pennsylvania's compliance with the 2015 8-hour ozone National Ambient Air Quality Standard (NAAQS). Under 25 Pa Code § 129.111(a) the Wheelabrator Falls facility's two MWCs are subject to RACT III.

Wheelabrator submitted their initial alternative RACT III proposal on 12/27/2022 in order to comply with 25 Pa. Code § 129.114(d)(1)(i). As explained in Attachment 1, the first proposal was found deficient and denied on 3/7/2023. A revised application for alternative RACT III was submitted 7/5/2023. The revised proposal followed the requirements under 25 Pa. Code §§ 129.92(a)(1)-(5), (7)-(10), 129.92(b) and 129.114(d). The first step in the RACT analysis requires the identification of available control technologies. Wheelabrator gave the following for available technologies, ranked in order of increasing NOx reduction potential:

1. Good Combustion Practices
2. Enhanced SNCR (ESNCR)
3. Advanced SNCR (ASNCR)
4. Flue Gas Recirculation (FGR) with SNCR
5. FGR with ASNCR
6. Covanta Low NOx (LN™)
7. Covanta Very Low NOx (VLN™)
8. Baghouse with Catalytic Bags
9. Hybrid SNCR and Selective Catalytic Reduction (SCR)
10. Tail End SCR

Wheelabrator then eliminated some technologies as technically not feasible as allowed by 25 Pa. Code § 129.92(b)(2) (see Attachment 5). The remaining feasible technologies were then ranked according to control effectiveness as required by 25 Pa Code § 129.92(b)(3) and each were analyzed for cost. Wheelabrator did combine the ranking and cost into one appendix of the application (see Attachment 3). Table 3 below gives the feasible technology by rank and cost per ton.

Table 4: Ranking of Feasible Technologies

Rank	Technology	NOx Emissions Rate (ppmdv @ 7% O_2)	NOx Reduction (tpy)[1]	Cost per Ton Reduction
1	Tail end SCR	50	386.6	$16,843
2	FGR with ASNCR	110	144.5	$13,537
3	ASNCR	110	144.4	$11,176
4	ESNCR	130	63.7	$7,454

[1]- Reduction based on use of 587.9 tpy baseline emissions rate, combined for MWCs

Since Wheelabrator is using good combustion practices, it was excluded from ranking and cost analysis. Wheelabrator based much of the cost analysis on the cost for upgrades at their Baltimore facility. Both facilities use the same type of boilers manufactured by Babcock & Wilcox, are similar in age and have equivalent tons per day capacities. The differences are that the Wheelabrator Falls location operates at a higher steam cycle than Baltimore and lacks the front waterwall platens found on the Baltimore boilers. These differences do affect the performance of ESNCR and standalone ASNCR resulting in need to do a full cost estimate for these technologies at the Falls facility (see Attachment 4). The cost of tail end SCR or FGR with ASNCR efficiencies are not impacted as much by the design differences; therefore, the use of the Baltimore costs prorated for two (2) MWC at the Falls facility is acceptable.

As explained in the section on Sources and Emissions above, Wheelabrator has chosen the ESNCR as control method and will implement changes to current controls to meet a 130 ppmdv NOx @ 7% O_2 on a 24-hour averaging basis. This is acceptable under RACT III since the other technologies available are in excess of the $7,500 per ton NOx reduction screening level. Additionally, Wheelabrator has committed to reaching the 110 ppmdv NOx limit as required under 40 CFR § 52.46 for the Good Neighbor Plan (GNP). The 110 ppmdv limit on NOx under the GNP is not subject to a cost analysis and has no screening level for cost per ton reduction. The additional two years will allow the facility the time needed to analyze the effectiveness of the changes done to reach 130 ppm and to perform additional modifications. Also, under the GNP, Wheelabrator Falls will need to meet a 105 ppmdv NOx @ 7% O_2 on a 30-day average, which is more stringent than the RACT III presumptive limit of 110 ppmdv. DEP considers this commitment to achieving the GNP limits relevant to RACT III since it shows progress in limiting emissions from the combustors.

As required under 25 Pa. Code § 129.114(c)(5), an interim schedule for the installation and achieving the 130 ppm and 110 ppm emissions rates was sent to DEP on 6/8/2023. Table 4 below gives the planned progress for compliance.

Table 5: Compliance Timeline

Phase	Objective	Description	Completion
1	CFD Modeling	Conduct Computational Fluid Dynamics (CFD) Modeling on both MWCs. Results will provide furnace temperature gradients and gas flow patterns to help locate additional SNCR injectors and relocate any existing injectors if needed.	October 2023
2	Finalize Alternative Limit Approach	From CFD results, finalize SNCR approach to meet alternative limit and place order for new equipment (new metering pumps, distribution panels, additional injectors), finalize injector locations.	December 2023
3	Perform SNCR Upgrade.	Implement SNCR Upgrade: 1) install addtional injectors and relocate other injectors , 2) install new metering module pumps and distribution panels, 3) install rolled furnace tubes for new injectors and relocation of other injectors. 4) Complete optimization of SNCR system with installed upgrades.	June 30 2024
4	Achieve Alternative Limit	Conduct final optimization testing and trial run to achieve alternative limit . Achieve alternative limit.	Aug 2024
5	Alternaitve limit evaluation and 110 ppm limit Feasibility Study	1) Evaluate impacts of alternative limit on furnace and boiler integrity and ability to achieve higher steamflow (208 klb), 2) conduct additional optimization testing to assses acheivability of 110 ppm limit. 3) finalize ASNCR approach and vendor to achieve 110 ppm limit. 4) Issue PO to vendor for 2026 implementation.	Dec 2025
6	Achieve 110 ppm Limit	Install ASNCR to meet 110 ppm limit (new PLCs, metering modules, recirculation modules, furnace temperature monitoring array)	2026

From Table 4, it can be seen that Wheelabrator intends to comply with the proposed 130 ppm by August 2024. The date for compliance under an agreement between the EPA and Pennsylvania is August 3, 2024. This date was determined based on the requirement to meet the 2015 ozone NAAQS and the reclassification of southeastern Pennsylvania (Philadelphia, Montgomery, Chester, Delaware and Bucks Counties). Wheelabrator will need to comply by 8/3/2024 by reaching and maintaining NOx emissions below the 130 ppmdv @ 7% O_2 on a 24-hour averaging period during normal steady-state operation.

Under RACT III, emissions are subject to some limiting factors at all times. This includes startup, shutdown and malfunction. The EPA on 6/12/2015 published in the Federal Register (Vol. 80, No. 113. Pg. 33840-33980) a policy that requires provisions for reducing emissions during startup, shutdown and malfunction (SSM). In the policy, EPA states that startup and shutdown are normal operating modes and cannot be exempted from emission limitations in state implementation plans (SIPs). For Wheelabrator Falls, this means there needs to be some limiting factor applied at all times, even though some federal regulations allow exemptions during SSM (40 CFR Part 60 Subpart Ea has an SSM exemption). In order to conform to the RACT III requirements, Wheelabrator proposed using the same 130 ppm NOx but not correcting values to 7% O_2. The reasoning behind this was explained in the Sources and Emissions section above.

RACT III limits for Wheelabrator shall be as follows:

(a) Prior to August 1, 2024 NOx emissions per combustor, expressed as NO2, shall not exceed 150 ppmvd, 24-hour daily average, corrected to 7% oxygen using selective noncatalytic reduction (SNCR). This limit applies at all time when waste is being combusted, except startup and shutdown which are limited to 3 hours per occurrence.

(b) On and after August 1, 2024, NOx emissions per combustor, expressed as NO2, shall not exceed 130 ppmvd, 24-hour daily average, measured as follows:

(1) during normal operation, values shall be corrected to 7% O2 and enhanced selective noncatalytic reduction (ESNCR) shall be used; and

(2) during preheat, startup and shutdown, values shall be used at stack oxygen content.

(A) Normal operation is defined as the state for which the combustor was design to operate, excluding preheat, startup and shutdown. Normal operation shall include any form of operation done for the purpose of performance testing, including operation at higher steam loads.

(B) The definition of preheat period for this condition means times when only the natural gas burners of the combustor are operated in order to bring the system up to temperature where the ESNCR can be operated.

(C) The definition of startup for this condition means to commence the introduction of municipal waste to an empty combustor and does not include any warmup period when the combustor is combusting only a fossil fuel or any other auxiliary fuel, approved by the Department, and no municipal waste is being combusted.

(D) The definition of shutdown for this condition means the cessation of charging municipal waste for the express purpose of shutting down the combustor.

(E) The duration of the startup or shutdown shall not exceed three (3) hours per occurrence.

(3) An ESNCR optimization program will be designed for the Department to maximize the control of NOx concentrations and minimize associated problems such as ammonia slip and visible plume formation. The permittee shall provide the Department with a copy (paper or digital) of the optimization program within 180 days of 8/1/2024.

As a separate condition, the current combined tpy limit will be applied as follows:

Total NOx emissions from both combustors shall not exceed 898.8 tons in any 12 consecutive month period.

In addition to the alternative limits for NOx under RACT III, compliance with the 110 ppmdv NOx for the GNP will be added to the permit. The compliance date for GNP is only 26 months away and by adding the condition now, it shows a commitment to reduce emissions to the presumptive RACT III level though at a somewhat later date than for 25 Pa Code § 129.112. The conditions above used for the RACT III limits will be amended for the 110 ppmdv NOx, the compliance date set to May 1, 2026 and the following conditions added:

The combustors shall meet a 105 ppmdv NOx limit on a 30-day rolling average on or before May 1, 2026, measured as follows:

(1) during normal operation, values shall be corrected to 7% O2 and enhanced selective noncatalytic reduction (ASNCR) shall be used; and

(2) during preheat, startup and shutdown, values shall be used at stack oxygen content.

For DEP to know what progress has been made on achieving each limit, the facility will be required to inform DEP of the date they are in compliance with each limit and provide supporting CEMs data as proof. Proof shall be due 30 days after coming into compliance with the 24-hour limits and 60 days after compliance with 30-day rolling average limit. The facility shall also supply DEP with the ESNCR and ASNCR optimization plans within 180 days of each limit's applicability date.

<u>Recommendation</u>

I recommend approving the significant modification of Title V permit 09-00013 to allow modifications of the SNCR system to Enhanced Selective Non-Catalytic Reduction in order to meet alternative RACT III emissions limits, on a 24-hr basis, of 130 ppmdv NOx @ 7% oxygen under normal operation and 130 ppmdv NOx at stack oxygen content during preheat, startup and shutdown. Additionally, this modification shall allow for the continued improvements need to adapt the ESNCR to Advanced Selective Non-Catalytic Reduction to achieve the Good Neighbor Plan emissions limits, one of which is equivalent to presumptive RACT III, of 110 ppmdv NOx on a 24-hr basis and 105 ppmdv NOx on a 30-day rolling average.

Attachment 1: Discussion of Original and Revised Significant Modification Applications

In March 2022, DEP began reaching out to Wheelabrator Falls via email dated 3/15/2022 to inform them that new requirements under RACT III were in the process of being promulgated. The email advised that the new limit could be 110 ppm NOx and that the facility should begin planning for any applications they may need to submit. DEP reached out again on 8/9/2022, 10/19/2022 and 12/8/2022 concerning Wheelabrator's plans for RACT III.

Wheelabrator, after reviewing the presumptive RACT III limit of 110 ppmdv NOx at 7% oxygen for municipal waste combustors, determined that they would not be able to comply with the limit before the 8/3/2024 deadline. Instead, the facility opted to apply for alternative RACT III limits. To meet the 12/31/2022 deadline for submission of an application for alternative RACT III limits, Wheelabrator submitted an application on 12/27/2022. The facility offered a 150 ppmdv NOx at 7% oxygen with good combustion practices as an alternative RACT III limit. Currently, their permit has a 150 ppmdv NOx @7% oxygen limit to allow the facility to participate in the NJ Renewable Energy Credit program.

DEP reviewed the application and found it deficient on several levels. Wheelabrator failed to do the following as required under 25 Pa Code § 129.92(b):

- Under 25 Pa. Code § 129.92(b)(1) – Wheelabrator failed to investigate all reasonably available controls and failed to rank the controls reviewed by their effectiveness.
- Under 25 Pa. Code § 129.92(b)(2) – The evaluation of technical feasibility did not include a description of how Good Operating Practices would allow the facility to meet the proposed limit, SCR was eliminated based on cost and technical descriptions of ESNCR and ASNCR were not presented until the economic feasibility step when they should have been included in second step for 129.92(b)(2)
- Under 25 Pa. Code § 129.92(b)(3) – Regulation requires ranking of technologically feasible controls according to effectiveness. Wheelabrator used old (2003) documentation for control efficiency and did not list ESNCR and ASNCR separately. Their table had only SNCR with no indication if it was the technically feasible upgrades or just SNCR.
- Under 25 Pa. Code § 129.92(b)(4) – Under this part of the regulation, the cost estimate was to use the latest edition of the EPA cost manual. The current Chapter 1.4.1 (dated 4/2019) which covers SNCR was not used. Instead, the old Chapter 2 which gives general cost estimating information was used. Although Chapter 1.4.1 does not specifically apply to MWC, it gives a better understanding of the cost involved in an SNCR retrofit. Additionally, the baseline emissions were to be calculated using stack test data or an approved emissions factor with historical data. Wheelabrator used its current permit limit which does not satisfy 25 Pa. Code § 129.92(b)(4)(iii).

A letter of denial was sent to Wheelabrator on 3/7/2023. Wheelabrator requested a meeting with DEP which was held on 3/23/2023 to discuss the issues with the denied significant modification application. DEP Central Office Air Quality staff were included on the call. In the call, DEP stressed that the requirements of 25 Pa Code § 129.92(b) must be followed, the cost estimates must be revised to correct for overestimation of utilities and retro fit costs and must show progress toward reducing emissions below the current 150 ppm NOx limit in the permit. Weekly meetings were held for three weeks following the initial 3/23/2023 meeting for Wheelabrator to update DEP on progress and confirm they were on track to submit an acceptable RACT III proposal.

On 4/23/2023, Wheelabrator submitted the first of the revisions to the original RACT III application for review. During the remainder of April 2023, Wheelabrator submitted several revised sections for the RACT III application, including a revised technology review, technology ranking, cost estimates for technically feasible technologies, and the final selection of enhanced SNCR for RACT III compliance. Several meetings with Wheelabrator were also held to guide and gauge progress on the revisions. A final complete revised application was received on 6/30/2023. In the ensuing months, DEP did request some additional information to ensure the proposed RACT III modifications would perform as planned in the proposal and that changes to the permit would be achievable by the facility. The decision by DEP to approval the proposed alternative RACT III is based on the revised application received on 6/30/2023 and the supplemental information provided as requested by DEP.

Attachment 2 – Sample Calculations

Given information:

- Conversion factor for NOx lb/ton waste to ppmv from AP-42 Table 2.1-10: 0.0154
- Combustor capacity: 66,667 lb/hr waste
- 1 ton = 2,000 lb
- 1 year = 8,760 hr

To calculate the tons per year (tpy) for operation at current 146 ppmdv NOx average-

$$\left[\frac{\left(0.0154\ \frac{\cancel{lb}/\cancel{ton\ waste}}{\cancel{ppm}} * 146\ \cancel{ppm}\ NOx\right) * \left(\frac{66{,}667\ \frac{\cancel{lb}}{\cancel{hr}}\ \cancel{waste}}{2000\ \frac{\cancel{lb}}{\cancel{ton}}}\right) * 8{,}760\ \frac{\cancel{hr}}{yr}}{2000\ \frac{\cancel{lb}}{ton}}\right] * 2\ combustors = \ 656.42\ tpy\ NOx$$

Attachment 3: Emissions Impact of Stack Oxygen Content

During preheat, startup and shutdown, the oxygen content of the stack gases is much greater than the average 7% found during combustion of waste. The reason is that the amount of fuel (natural gas), and thus combustion, is several magnitudes lower than when waste is the fuel. But the system is designed for the combustion of waste, including supplying a slightly higher than needed amount of air for waste combustion. When operating on natural gas the same amount of air, as supplied for waste combustion, is in the system. This increases the oxygen content of the stack gases. The extra stack oxygen, which is approximately atmospheric oxygen levels, causes NOx readings corrected to 7% oxygen (which is normally seen during waste combustion) to bias high even though the actual amount of NOx being released to the atmosphere. While combusting natural gas, the combustors produce low levels of NOx emissions that, if corrected to 7% oxygen, would appear much greater than they actually are, as demonstrated in Table A below.

Using the MMBtu rating of both the primary (325MMBtu/hr) and the auxiliary (51 MMBtu/hr) with both burning natural gas, the emissions would be 70 lb/hr NOx. Average stack exhaust is 8,271,000 ft^3/hr, the molecular weight (MW) of NOx as NO_2 (46 lb/lb-mol) and the conversion for lb/ft^3 is (385.1 x 10^6)/ MW which gives an emissions rate of 71.2 ppmdv at stack oxygen content when operating all burners on natural gas. If corrected to 7% oxygen using the formula below, when the stack oxygen content is higher, the corrected emissions rate would appear as in Table A below.

$$measured\ ppm * \left(\frac{13.9}{20.9 - stack\ oxygen\ content}\right) = ppm\ @\ 7\%\ oxygen$$

Table A: Conversion of 71.2 ppm Measured NOx to NOx at 7% O2 for Different Stack O2			
Measured ppm	Stack O2	Multiplier	ppm at 7%O2
71.2	7	1.0	71.2
71.2	8	1.1	77
71.2	9.0	1.2	83
71.2	10.0	1.3	91
71.2	11.0	1.4	100
71.2	12.0	1.6	111
71.2	13.0	1.8	125
71.2	14.0	2.0	143
71.2	15.0	2.4	168
71.2	16.0	2.8	202
71.2	17.0	3.6	254
71.2	18.0	4.8	341
71.2	19.0	7.3	521
71.2	20.0	15.4	1100
71.2	20.1	17.4	1237
71.2	20.2	19.9	1414
71.2	20.3	23.2	1649
71.2	20.4	27.8	1979
71.2	20.5	34.8	2474
71.2	20.6	46.3	3299
71.2	20.7	69.5	4948
71.2	20.8	139.0	9897

As can be seen the NOx ppm balloons to an extremely high number that would be the equivalent of 9,740 lb/hr NOx which is not possible for the burners using natural gas. From one of the units during a preheating cycle, a reading of 974 ppmdv @7% oxygen was measured. But because the combustor was not combusting waste and the oxygen content of the stack was much greater than 7%, the actual NOx emissions should have been closer to the values at the bottom of Table B below.

Table B: Conversion of NOx Measured During Startup			
ppm @ 7% O2	Stack O2	Correction factor	ppm Actual
974	7	1.000	974
974	8	0.928	903.93
974	9.0	0.856	833.86
974	10.0	0.784	763.78
974	11.0	0.712	693.71
974	12.0	0.640	623.64
974	13.0	0.568	553.57
974	14.0	0.496	483.50
974	15.0	0.424	413.42
974	16.0	0.353	343.35
974	17.0	0.281	273.28
974	18.0	0.209	203.21
974	19.0	0.137	133.14
974	20.0	0.065	63.06
974	20.1	0.058	56.06
974	20.2	0.050	49.05
974	20.3	0.043	42.04
974	20.4	0.036	35.04
974	20.5	0.029	28.03
974	20.6	0.022	21.02
974	20.7	0.014	14.01
974	20.8	0.007	7.01

Using uncorrected NOx readings during preheat, startup and shutdown given a more realistic view of the actual emissions than numbers corrected to 7% since the stack oxygen content is considerably greater than 7% during those time periods.

Appendix B

Detailed Cost Analysis for Technically Feasible Control Options

Appendix A

Review of Available NOx Control Options

Good Combustion Practice (GCP)

Good combustion practice consists of low excess air/modified staged combustion controls which minimize NOx formation during waste combustion while maintaining good combustion efficiency to minimize CO emissions. GCP reduces NOx formation by limiting excess air (oxygen) (primary combustion air) in the primary combustion zone or pyrolysis zone at the grate level which reduces conversion of nitrogen in the waste to NOx. Secondary air is then injected above the grates to complete combustion of CO, hydrocarbons and other volatile combustible gases released from grate waste combustion. Secondary air also helps minimize peak flame temperature that reduces conversion of nitrogen in air to NOx. Generally total combustion air is split approximately 50/50 between primary and secondary air to achieve staged combustion. Secondary air also reduces peak flame temperature minimizing thermal NOx formation from nitrogen in the combustion air.

Feasibility: Feasible as GCP is already utilized on the Falls MWCs and all other Win-Waste MWCs.

Optimized/Enhanced SNCR (ESNCR):

As demonstrated, the existing SNCR system can consistently control NO_X to levels below 150 ppm on a 24-hour block average. To reduce NOx from the RACT II and Subpart Eb/PADEP BAT 180 ppm limit to the 150-ppm limit, the original SNCR systems were modified. The modifications included: installation of new larger reagent injectors wit variable geometry spray tips, new injector locations, modifications to injector control panels and additional NOx control system tuning. Further enhancements to the SNCR system can be made to cost effectively achieve a controlled NO_X level of 125-130 ppm on a 24-hour block average. Further enhancements would include installing additional 4 additional new injectors or each MWC, adding two (2) new injector control panels, upgrading the urea metering pumps, increasing dilution water capacity to enable use of more injectors and further tuning of the NOx controllers. Computational Fluid Dynamics (CFD) modeling of the furnaces would also be conducted to help select the locations of additional injectors, repositioning of existing injectors and optimum dilution water flow rates for injectors.

SNCR performance can be measured in many ways. The achievable NO_X reduction performance of any SNCR system will be limited by furnace design and operating conditions and ultimately the amount of ammonia slip generated. Excess ammonia slip (> 10 ppm) leads to highly visible detached plumes at the stack exit and an increase in condensable particulate emissions. Additionally excess ammonia and/or unreacted urea can increase furnace water wall and superheater corrosion. Maximizing urea utilization is critical to the SNCR system operating cost, as is the amount of dilution water and instrument air used for atomizing the urea solution in the injectors. Finally, any SNCR system needs to operate dynamically and effectively over a wide range of furnace temperatures, waste combustion conditions and boiler steam loads to maintain target NOx limit.

Feasibility: Technically Feasible.

Advanced SNCR (ASNCR)

An Advanced-SNCR (ASNCR) system consists of multiple injectors and injection zones and utilizes an acoustic or infrared based real-time furnace temperature monitoring system to automatically control the location and manner of urea injection. In some cases, furnace temperature monitoring is the primary control signal for controlling urea and/or dilution water injection rates and selection of injection zones. Real time temperature monitoring can also be used to select different injectors within the same furnace injection zone. Typically, urea based SNCR systems have logic designed to control operations based on unit load, CEMS NO_X signal and the real time upper furnace temperature monitoring. The Advanced SNCR system utilizes not only CFD modeling but also Chemical Kinetic modeling (CKM) for determining injector locations, number of injectors, number of injection zones, furnace temperature monitoring system design and optimum injector spray patterns. In addition, CFD modeling and CKM can used in concert with real-time furnace temperature signals to select injection zones and/or individual injectors within a zone or to modulate urea and/or dilution water injection rates. The use of multiple injection zones and using real time furnace temperature monitoring system to automatically control urea injection locations allow for greater NOx reductions to be achieved compared to Optimized SNCR systems while still minimizing ammonia slip.

Urea based ASNCR systems have been recently installed at the Wheelabrator Baltimore MWC facility to achieve a 105 ppm/30 day rolling average limit by December 31, 2023. It has been demonstrated that the 105-ppm limit can be achieved but periods of excess ammonia slip with visible detached plumes are still periodically encountered so additional optimization is needed. As discussed below, there is uncertainty that ASNCR can achieve comparable performance at Wheelabrator Falls.

The Wheelabrator Falls MWCs have the same massburn reciprocating combustion grate, same waterwall furnace type and overall size as the Wheelabrator Baltimore MWCs. However, furnace temperatures on Falls MWCs are much higher because of the higher steam cycle in terms of both pressure and steam temperature with corresponding higher maximum steam flow rating and heat input. (See Table below.) The higher furnace temperature requires urea to be injected higher in the furnace reducing urea dispersion and SNCR reaction time. If urea is injected at too high a temperature, both reagents will oxidize to form additional NOx reducing SNCR performance and requiring significantly more reagent. In addition, the Baltimore MWCs have waterwall platens extending from furnace front walls which help absorb heat and reduce furnace temperatures. As such, the performance of the Baltimore ASNCR system cannot be directly extrapolated to Falls.

	Steam psig	Steam deg F	Maximum Steam Flow Rating (lbs/hr)	Furnace Type	Front Waterwall Platens	Maximum Heat Input MMBtu/hr	tpd boiler
Baltimore	850	825	195,000	Single pass	Yes	325	750
Falls	1,300	930	208,000	Single pass	No	344	800

<u>Feasibility:</u> Technically Feasible but there may be difficulties in achieving the presumptive limit given the higher steam cycle and higher heat input MWCs at Falls.

Covanta Low NOx (LN™)

Covanta's proprietary LN technology involves a third or tertiary level of combustion air staging within the furnace, along with the use of selective non-catalytic reduction (SNCR) to achieve lower NOx emissions. Covanta's LN technology is designed for specific Covanta MWC multi-pass furnace designs. As the OTC MWC Workgroup Report confirmed the Covanta LN is not applicable to all MWC configurations, including some that are owned or operated by Covanta, and its overall NOx reduction effectiveness may vary from unit to unit depending upon individual MWC characteristics. As such the OTC Report confirmed LN was not considered technically feasible for the Wheelabrator Baltimore facility and would not be viable for Wheelabrator Falls MWCs equipped with same combustion grate and single pass furnace design as Baltimore.

Feasibility: Not technically feasible as not compatible with Falls MWCs for reasons stated above.

Covanta VLN™ Technology

The Very Low NOx (VLN) system is another proprietary technology developed by Covanta in partnership with Martin GmBH. VLN employs a unique combustion air system design, which in addition to the conventional primary and secondary air 2-stage combustion air system, features an internal flue gas recirculation (FGR) system which injects recirculated flue gas as tertiary air above the secondary air injection. The combination of the internal FGR with tertiary air injection, and reduced secondary air extends the combustion zone in the furnace which inhibits the formation of NOx. However, this technology was developed for new MWC units but is not technically feasible for an existing unit as confirmed In the OTC MWC Workgroup Report.

Feasibility: Not technically feasible as not compatible with Falls MWCs for reasons stated above.

FGR-SNCR

In FGR a portion of clean combustion flue gas is extracted downstream from the emission control system at the ID fan inlet duct. The clean gas is recirculated and re-injected back into the furnace through the secondary air (SA) system. The recirculated flue gas replaces a portion of the secondary air flow, reducing O_2 concentration in the combustion zone while maintaining the SA gas flow volume and velocity needed for good turbulence and mixing of SA and flue gas in the furnace to maximize combustion efficiency. The addition of FGR reduces NO_X generation by further lowering combustion zone O2 and peak flame temperature. An FGR retrofit would require the installation of new insulated ductwork, FGR fan, control dampers, additional electric power (for FGR fan), flue gas injection/mixing nozzles, system controls, and integration with the combustion controls and plant instrumentation. As explained in the Babcock NOx Control report the FGR-SNCR option was evaluated using a boiler heat transfer model. Based on the model, FGR rate was limited to 15% of the total combustion flue gas because of superheat attemperator spray flow rates considerations. The boiler model showed higher FGR rates would increase superheater heat transfer, so FGR rates must be limited to not increase superheater attemperator spray flow above the attemperator system capacity. Based on the Wheelabrator Baltimore NOx Control Study, predicted controlled NOx levels would be around 120 ppm/24-hour average which would not meet the RACT III limit. For the Falls MWCs with higher steam cycle, and higher maximum steam generation and heat input compared to the Baltimore MWCs there could be additional difficulty achieving 120 ppm as FGR contribution to lower NOx emissions could be further limited.

<u>Feasibility:</u> Not technically feasible as predicted controlled NOx levels of 120 ppm would not meet the 110-ppm presumptive RACT limit. Further, FGR may not be compatible with the Wheelabrator Falls higher steam cycle boilers. FGR increases superheater heat transfer requiring additional superheater attemperator spray that can exceed the existing attemperator system capacity. This would also limit FGR recirculation rate and reduce FGR's effectiveness in reducing uncontrolled NOx emissions.

<u>FGR-ASNCR</u>

FGR combined with ASNCR can meet the presumptive 110 ppm RACT limit. As described previously the implementation of ASNCR by adding additional independent zones of injection and real-time furnace temperature monitoring system additional NOX reduction can be achieved over enhanced SNCR while minimizing ammonia slip.

<u>Feasibility:</u> Technically feasible. However, FGR may not be compatible with the Wheelabrator Falls higher steam cycle boilers. FGR increases superheater heat transfer requiring additional superheater attemperator spray that can exceed the existing attemperator system capacity. This would also limit FGR recirculation rate and reduce its effectiveness in reducing uncontrolled NOx emissions. Additionally, FGR only a slight increase in NOx reduction performance over ASNCR. Further, the slight reduction in urea use provided by reduced uncontrolled NOx emissions with FGR does not offset the increased annualized capital cost over ASNCR alone.

<u>Baghouse with Catalytic Bags:</u>

A baghouse equipped with catalytic filter bags with ammonia or urea injection operates similarly to "traditional" Selective Catalytic Reduction (SCR) NOx control system. A catalytic filter bag is comprised of a PTFE membrane bag on the outside layer for particulate removal with SCR catalyst embedded fabric on the inside of the bag. As with SCR minimum operating temperatures for catalytic filter bags range from 356°F to 430°F but is highly dependent on flue gas constituents. The most significant challenge to applying catalytic bags on MWCs is the high operating temperature needed for the catalytic NOx reduction reaction to occur and the presence of SO2 in the flue gas.

The optimum temperature range for SO_2 and HCl removal is 150°C to 180°C (275°F to 350°F) for the spray dryer absorber (SDA) acid gas control technology installed at Falls which is too low for catalytic bags to be effective for NOx control. Further, at these lower SDA operating temperatures, catalyst activity will be reduced quickly from ammonium bisulfate deposition from flue gas SO2 combining with excess ammonia gradually blinding the catalyst in the bags and decreasing catalytic reactivity. Increasing SDA operating temperature to meet the desired catalytic filter bag temperature requirement (356°F to 430°F) greatly reduces SO_2/HCl removal capability and the ability to meet SO2/HCl limits. Additionally, as the USEPA has indicated in evaluating mercury control in MWCs, when flue gas temperatures exceed 350°F, the effectiveness of powdered activated carbon (PAC) is reduced rapidly. An increase in baghouse temperature from 300°F to 350°F during one study reduced mercury removal from approximately 90% to 10 to 20%.

<u>Feasibility</u>: Not technically feasible as explained above.

Hybrid SNCR-SCR

The Hybrid SNCR-SCR option utilizes two treatment stages: an SNCR treatment stage followed by an SCR treatment stage. The first SNCR stage allows for over injection of urea or ammonia reagent in the furnace that both lower NOx and generates excess ammonia slip. In the second stage, the excess ammonia further reacts with NOx in a SCR type catalyst located downstream in the flue gas path in the appropriate temperature range, generally between 550°F and 750°F, which lies in the boiler convection section between the generator and economizer. The combination of over injection of reagent in the furnace with excess ammonia and NOx reacting in the catalyst will result in lower NOx emissions that SNCR by itself. Since the SCR catalyst is before the emission controls and is exposed to a very high flue gas dust levels rapid deactivation or "poisoning' of the catalyst occurs from lead and other trace metals present in the flyash. Catalytic poisoning is through either chemical reaction, or by the introduction of a barrier between the gas phase and the active catalyst sites. Babcock in preparing the Baltimore NOx Study Report was unable to locate references of any full-scale Hybrid SNCR-SCR systems installed in the United States in the MSW combustion industry. Due to the high catalyst deactivation rates, lack of reference installations, the Hybrid SNCR-SCR option is not considered technically feasible as was concluded in the Babcock NOx Study report.

Feasibility: Not technically feasible as explained above.

Tail End SCR System

A Tail-End SCR system positions the SCR downstream of all other air pollution control equipment (APCE) at the fabric filter exit to provide a clean flue gas to the SCR reactor. Positioning the SCR downstream of the APCE removes many of the flue gas constituents that would be damaging to the SCR catalyst. Further, SCR installation downstream of the APCE results in flue gas temperatures in the 300-325 deg F range well below the required SCR operating temperature for catalytic reduction. As such the clean flue gas must be reheated via a combination of a steam coil air heater and air to air heat exchanger to increase flue gas temperature to the minimum SCR operating temperature of 465 deg F. The addition of the SCR reactor and steam coil air heater and gas to gas heat exchanger adds considerable pressure drop requires increasing the size of the ID fan and motor. Additionally, clean flue gas entering the SCR reactor still contains some SO_2, depending on uncontrolled SO2 levels and degree of reduction in the acid gas control system. A portion of this residual SO2 will be catalytically oxidized to SO_3 which then forms ammonium bisulfate (ABS) which over time will blind the catalyst and reduce catalyst activity and NOx removal efficiency. Catalyst activity can be periodically restored by heating flue gas to 608-662 deg F using natural gas fired duct burners where the ABS is decomposed back to NH3 and SO2.

As the OTC MWC Report recognizes, SCR is a potentially retrofittable NOx control technology for existing MWCs. However, the RACT analyses prepared by Trinity Consultants for Covanta's Virginia MWCs included in the OTC report concluded that SCR was not RACT for existing MWCs due to both technical feasibility and cost considerations where cost effectiveness was in the \$16,000/ton to \$31,000/ton range well beyond what would be considered RACT. (See Appendix B for cost analysis) Additionally, in Pennsylvania's 2021 RACT III rule proposal, the PA Department of Environmental Protection determined that the addition of SCR to existing units would likely not be considered RACT because of its technical infeasibility (RACT III Technical Support Document).

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Feasibility: Not technically feasible as explained above.

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Feasibility: SCR would be extremely difficult to retrofit on an existing MWC but could be considered marginally technically feasible. However, multiple cost effectiveness estimates range from $16,000 - $31,000/ton which is well beyond what would be considered RACT as confirmed in the OTC MWC Work Group report and PADEP RACT III Technical Support Document (TSD).

Table 1 Tail End SCR Cost Analysis

SCR Cost Based on Babcock Report for Wheelabrator Baltimore									
NOx Control (3 MWC Unit)	Babcock Captial Costs (2019)*	Adjusted Captial Costs (2022)**	Annualized Capital Cost (20 years) 7.5% Interest	Direct Annual Operating Cost***	Total Annualized Cost (2022)	2020 annual NOx (tons) at 142 ppm7%	2020 annual NOx (tons) at 50 ppm7%	NOx Reduction (tons)	Cost Effect. ($/ton)
SCR	$ 63,603,015	$ 73,628,440	$ 7,222,950	$ 2,543,167	$ 9,766,117	882.4	310.7	571.7	$ 17,083
Notes:									
*1) Babock cost ($60,574,340) adjusted by 5% to include Wheelabrator internal costs.									
*2) Includes Babcock Installation estimate at 1-1.25 times equipment pricing									
** Escalated for 3 years at 5% annual increase.									
*** 1) Does not include maintenance costs 2) includes catalyst replacement									
Wheelabrator Falls SCR Cost Based on Babcock Report Adjusted from 3 to 2 MWC Units and Falls NOx Baseline Emissions									
NOx Control (2 MWC Units)	Babcock Captial Costs (2019)*	Adjusted Captial Costs (2022)	Annualized Capital Cost (20 years) 7.5% Interest	Direct Annual Operating Cost**	Total Annualized Cost (2022)	Falls annual NOx (tons) at 146 ppm7%	Falls annual NOx (tons) at 50ppm7%	NOx Reduction (tons)	Cost Effect. ($/ton)
SCR	$ 42,402,010	$ 49,085,627	$ 4,815,300	$ 1,695,445	$ 6,510,745	587.9	201.3	386.6	$ 16,843
Notes:									
* Captial cost taken at 2/3 of Baltimore costs									
** Based on 2/3 Baltimore costs									
Capital Recovery Factor		0.0981							
Lifetime of Equipment (yr)		20							
Interest Rate		7.5%							

Table 2 FGR-ASNCR Cost Analysis

FGR-SNCR Cost Analysis Based on Babcock Report for Wheelabrator Baltimore

NOx Control (3 MWC Unit)	Captial Costs (2019)*	Adusted Captial Costs (2022)**	Annualized Capital Cost** (20 years) 7.5% Interest	Direct Annual operating Cost *** (Urea at $2.39/gal)	Total Annualized Cost (2022)	2020 annual NOx (tons) at 142 ppm7%	2020 annual NOx (tons) at 110 ppm7%	NOx Reduction (tons)	Cost Effect. ($/ton)
FGR-ASNCR	$ 13,643,200	$ 15,793,710	$ 1,549,363	$ 1,189,229	$ 2,738,592	882.4	683.5	198.9	$ 13,772

Notes:
*1) Babock cost ($12,993,524) adjusted by 5% to include Wheelabrator internal costs.
*2) Includes Babcock Installation estimate at 1-1.25 times equipment pricing
** Escalated for 3 years at 5% annual increase,
***Does not include maintenance costs. .

Wheelabrator Falls FGR-ASNCR Cost Based on Babcock Report Adjusted from 3 to 2 MWC Units and Falls NOx Baseline Emissions

NOx Control (2 MWC Units)	Captial Costs (2019)*	Adusted Captial Costs (2022)*	Annualized Capital Cost** (20 years) 7.5% Interest	Direct Annual operating Cost (Urea at $2.39/gal)	Total Annualized Cost (2022)	Falls annual NOx (tons) at 146 ppm7%	Falls annual NOx (tons) at 110 ppm7%	NOx Reduction (tons)	Cost Effect. ($/ton)
FGR-ASNCR	$ 9,095,467	$ 10,529,140	$ 1,032,909	$ 923,334	$ 1,956,243	587.9	443.4	144.5	$ 13,537

Notes
* Captial cost taken at 2/3 of Baltimore costs,

Capital Recovery	0.0981	CRF x TCI
Expected Lifetime of Equipment	20	years
at	7.5%	interest

Table 3 ASNCR Option (Fuel Tech Complete)

Facility Capital and Annualized Costs for Installation and Operation of an Advanced Selective Non-Catalytic Reduction (ASNCR) System

Wheelabrator Falls, Inc. - Morrisville, PA

CAPITAL COSTS

COST ITEM	FACTOR			COST ($)
Direct Capital Costs[a]				
Purchased Equipment Costs				
ASNCR Ammonia-Based System (Fuel Tech 2022)			A	$2,017,500
Air Compressors (2 x 200 hp/850 cfm)				$400,000
Freight	5%	A		$125,919
Spare Parts	5%			$100,875
Total Purchased Equipment Cost			**B**	**$2,644,294**
Direct Installation Costs[b]				
Handling and Erection				Included below
Electrical				Included below
Piping				Included below
Total Direct Installation Cost	Fuel Tech	85%		**$2,054,875**
Total Direct Capital Cost				**$4,699,169**
Indirect Capital Costs[a]				
Indirect Installation Costs				
General Facilities	5%	DC		$234,958
Engineering and Home Office Fees	5%	DC		$234,958
Process Contingency	5%	DC		$234,958
Total Indirect Installation Cost				**$704,875**
Project Contingency	15%	(DC+IC)		$810,607
Total Plant Cost		DC+IC+ Proj. Cont.		$6,214,651
Preproduction Cost	2%	(Total Plant Cost)		$124,293
Total Capital Investment (TCI)				**$6,338,944**

ANNUALIZED COSTS

COST ITEM	FACTOR		UNIT COST		COST ($)
Direct Annual Costs					
Maintenance					
Maintenance Labor and Materials	1.5%	of TCI			$95,084
Urea Reagent[c, d] (Increase only)	264,492	gallons/yr	$2.39	per gallon	$632,136
Utilities					
Electricity[e]	298.28	kilowatts	$0.0818	per kWh	$179,265
Water[f, g] (Increase only)	8,816,400	gallons/yr	$0.009643	per gallon	$85,017
Total Direct Annual Costs					**$991,501**
Indirect Annual Costs[a]					
Capital Recovery	0.0981	CRF x TCI			$621,801
Expected Lifetime of Equipment:	20	years			
at	7.5%	interest			
Total Indirect Annual Costs					**$621,801**
Total Annualized Costs					**$1,613,302**

Cost Effectiveness ($/ton)

NOx reduction	25%			
Base Emissions Rate[h]:	587.9	tons NO_X/yr	**Annual Cost/Ton NO_X Removed:**	**$11,176**
Potential Controlled Emissions:	443.5	tons NO_X/yr		
NOx reduction	144.4	tons NO_X/yr		

(a) Direct and indirect capital and annual costs were estimated based upon the U.S. EPA Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual, Seventh Edition November 2017), Section 1 Chapter 2 and Section 4 Chapter 1. While an SNCR already exists, the ASNCR is more aptly described as a retrofit. Therefore, based on U.S. EPA Guidance in the OAQPS Manual, indirect installation costs are representative of a reasonable retrofit factor.

(b) Direct installation costs calculated using installation factors evaluated for similar control methods, as presented in the U.S. EPA OAQPS Air Pollution Control Manual, 6th Edition, January 2002.

(c) Inventory capital is based on the storage tank capacity and the vendor-specific reagent price for a 50% urea solution.

Storage Tank Capacity	12,000	gallons
Price of Urea Reagent	$2.39	$/per gallon

(d) Annual reagent consumption based on the expected 50% urea solution.

Expected Consumption Increase (2 Units)	36.0	gallons/hr
Operating Schedule (Average 2021-2022)	7,347	hrs/yr

(e) Price of electricity (industrial) for August 2022 data in Pennsylvania: https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

(f) Annual water consumption based on dilution water flow rate with four SNCR injectors.

Expected Water Consumption Increase	1,200	gallons/hr	16 injectors/MWC unit	1.25 gpm injector, vs 8 injectors
Operating Schedule (Average 2021-2022)	7,347	hrs/yr		

(g) https://www.amwater.com/paaw/customer-service-billing/your-water-and-wastewater-rates

(h) Base emissions rate is calculated using 146 ppm7% Annual NO_X average

Table 4 Enhanced SNCR (Revised)

Facility Capital and Annualized Costs for Installation and Operation of an Advanced Selective Non-Catalytic Reduction (ASNCR) System

Wheelabrator Falls, Inc. - Morrisville, PA

CAPITAL COSTS COST ITEM	FACTOR		COST ($)
Direct Capital Costs[a]			
Purchased Equipment Costs			
Additional Equipement Upgrades (Fuel Tech 2023)		A	$133,850
New Injectors (8 x $2610/each) and wall ports			$67,152
Air Compressor (1 x 200 hp/850 cfm)			$200,000
Freight	5% A		$17,027
Spare Parts	5%		$6,693
Total Purchased Equipment Cost		**B**	**$424,722**
Direct Installation Costs[b]			
Handling and Erection			Included below
Electrical			Included below
Piping			Included below
Total Direct Installation Cost	Fuel Tech	85%	**$283,773**
Total Direct Capital Cost			**$708,494**
Indirect Capital Costs[a]			
Indirect Installation Costs			
General Facilities	2% DC		$14,170
Engineering and Home Office Fees	2% DC		$14,170
Process Contingency	5% DC		$35,425
Total Indirect Installation Cost			**$63,764**
Project Contingency	15% (DC+IC)		$115,839
Total Plant Cost	DC+IC+ Proj. Cont.		$888,097
Preproduction Cost	2% (Total Plant Cost)		$17,762
Total Capital Investment (TCI)			**$905,859**

ANNUALIZED COSTS COST ITEM	FACTOR		UNIT COST		COST ($)
Direct Annual Costs					
Maintenance					
Maintenance Labor and Materials	1.5%	of TCI			$13,588
Urea Reagent[c, d] (Increase only)	146,940	gallons/yr	$2.39	per gallon	$351,187
Utilities					
Electricity[e]	0.00	kilowatts	$0.0818	per kWh	$0
Water[f, g] (Increase only)	2,204,100	gallons/yr	$0.009643	per gallon	$21,254
Total Direct Annual Costs					**$386,029**
Indirect Annual Costs[a]					
Capital Recovery	0.0981	CRF x TCI			$88,858
Expected Lifetime of Equipment:	20	years			
at	7.5%	interest			
Total Indirect Annual Costs					**$88,858**
Total Annualized Costs					**$474,886**
Cost Effectiveness ($/ton)					
NOx reduction	11%				
Base Emissions Rate[h]:	587.9	tons NO_x/yr	**Annual Cost/Ton NO_X Removed:**		**$7,454**
Potential Controlled Emissions:	524.2	tons NO_x/yr			
NOx reduction	63.7	tons NO_x/yr			

(a) Direct and indirect capital and annual costs were estimated based upon the U.S. EPA Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual, Seventh Edition November 2017), Section 1 Chapter 2 and Section 4 Chapter 1. While an SNCR already exists, the ASNCR is more aptly described as a retrofit. Therefore, based on U.S. EPA Guidance in the OAQPS Manual, indirect installation costs are representative of a reasonable retrofit factor.

(b) Direct installation costs calculated using installation factors evaluated for similar control methods, as presented in the U.S. EPA OAQPS Air Pollution Control Manual, 6th Edition, January 2002.

(c) Inventory capital is based on the storage tank capacity and the vendor-specific reagent price for a 50% urea solution.

Storage Tank Capacity	12,000	gallons
Price of Urea Reagent	$2.39	$/per gallon

(d) Annual reagent consumption based on the expected 50% urea solution.

Expected Consumption Increase (2 Units)	20.0	gallons/hr
Operating Schedule (Average 2021-2022)	7,347	hrs/yr

(e) Price of electricity (industrial) for August 2022 data in Pennsylvania: https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

(f) Annual water consumption based on dilution water flow rate with four SNCR injectors.

Expected Water Consumption Increase	300	gallons/hr	10 injectors/MWC unit	1.25 gpm injector, vs 8 injectors
Operating Schedule (Average 2021-2022)	7,347	hrs/yr		

(g) https://www.amwater.com/paaw/customer-service-billing/your-water-and-wastewater-rates

(h) Base emissions rate is calculated using 146 ppm7% Annual NO_X average