Combustion Turbine Inventory and NO_X Control Technology Baseline

Technical Support Document

New Source Performance Standards Review for Stationary Combustion Turbines

Docket ID No. EPA-HQ-OAR-2024-0419

U.S. Environmental Protection Agency

Office of Air and Radiation

November 2024

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1. Introduction

To determine the impacts of the proposed amendments to the criteria pollutant new source performance standards for combustion turbines, the EPA determined the NO_X controls technologies that are typically required for new combustion turbines. In general, combustion turbines are a highly regulated source category, and owners/operators of new combustion turbines are subject to multiple requirements that often result in emissions controls that achieve emission rates lower than the requirements in subpart KKKK. The EPA reviewed information on NO_X emissions control technology installed on combustion turbines that recently commenced operation to determine the typical level of emissions control. The EPA used this baseline when estimating the overall impacts—both costs and emissions.

2. Combustion Turbines > 250 MMBtu/h

Combustion turbines with base load ratings greater than 250 MMBtu/h and that are connected to a generator larger than 25 MW generally report emissions and control technology information to the EPA. The EPA reviewed the reported NO_X control technology from the Clean Air Markets Program Data (CAMPD) for combustion turbines that commenced operation between 2019 and 2023. Figure 1 shows the number of facilities that reported using SCR as a post-combustion control. Combustion turbines with heat recovery include both combined cycle facilities and combined heat and power (CHP) facilities without a steam turbine.

Figure 1: NO_X Control Technologies Reported to CAMPD—All Combustion Turbines

Reported Base Load Rating (MMBtu/h)	Number of Simple Cycle Turbines	Number of Simple Cycle Turbines with SCR	Number of Combustion Turbines with Heat Recovery	Number of Combustion Turbines with Heat Recovery with SCR
≤ 850	67	59	5	3
> 850	24	11	50	50

The 2 combustion turbines with base load ratings of less than 850 MMBtu/h with heat recovery that do not have SCR are CHP turbines where all the useful thermal output is used for non-electric generating applications (*i.e.*, the CHP facility does not have a steam turbine). The 3 other combustion turbines with base load ratings of less than 850 MMBtu/h with heat recovery that have SCR are combined cycle CHP facilities. All of the combustion turbines with heat recovery and that have base load ratings of greater then 850 MMBtu/h are combined cycle facilities. The EPA projects that all new combustion turbine with heat recovery will be base load EGUs and the proposed emission standards would result in 2 additional SCR installations. In addition, many of the combined cycle and CHP facilities built in the last 5 years are operating at emission rates higher than the proposed NSPS and would require either upgrades to the SCR system or improved operation and maintenance relative to the baseline to comply with he proposed NSPS.[1]

[1] If the emission rate reduction was greater than 0.0074 lb NO_X/MMBtu (2 ppm), the EPA used SCR upgrade costs to the combustion turbine to estimate impact. For smaller emission rate reductions, the EPA used increased operations and maintenance costs.

The EPA estimates that 11 SCR systems would need upgrades and 4 would need improved operations and maintenance procedures to comply with the proposed NSPS.

Based on the reported control technologies, 77% of recently installed simple cycle turbines have SCR. The EPA further reviewed the control technology of simple cycle turbines that have commenced operation since 2019 by technology—frame or aeroderivative turbine—and that operated at capacity factors of greater than 20% on a 12-operating month rolling average. Figure 2 shows the distribution of aeroderivative and frame type simple cycle turbines with SCR. SCR is often required for aeroderivative simple cycle turbines, it is often not required for large frame type simple cycle turbines.

Figure 2: NO_X Control Technologies Reported to CAMPD—Simple Cycle Combustion Turbines

Reported Base Load Rating (MMBtu/h)	Number of Aeroderivative Simple Cycle Turbines	Number of Aeroderivative Simple Cycle Turbines with SCR	Number of Frame Simple Cycle Turbines	Number of Frame Simple Cycle Turbines with SCR
≤ 850	62	55	5	4
> 850	7	7	17	4

The EPA estimates that the approximately 10 percent of new simple cycle turbines would be required to install SCR to comply with the proposed NSPS would have SCR in the base case. However, 30 percent of the SCR systems would require upgrades and 70% would require improved operation and maintenance practices to reduce emission rates to the proposed standards.

3. Non-CAPD Combustion Turbine EGUs

For combustion turbines with rated outputs of less than 250 MMBtu/h and direct mechanical drive combustion turbines, the EPA used 3 sources of information—the NEEDS database, Form EIA-860, and the NESHAP inventory.[2] The NEEDS database and EIA-860 include information on smaller combustion turbines connected to a generator. The combustion turbine NESHAP inventory includes information on combustion turbines at major sources of hazardous air pollutants which includes direct mechanical drive applications, so the EPA used the NESHAP information for recently installed direct mechanical drive applications as representative of typical NO_X controls for new direct mechanical drive combustion turbines.

The Form EIA-860 reported 6 small simple cycle turbines (none reported as having SCR), 19 small CHP combustion turbines without a steam turbine (2 reported as having SCR), and 5 small combined cycle CHP facilities (3 reported as having SCR). The EPA estimates that the simple cycle turbines would be non-base load combustion turbines with combustion controls consistent with the proposed BSER and would not be impacted by the proposed emission standards. The EPA estimates that 1 of the SCR systems would be upgraded to comply with the proposed emission standards and 19 additional SCR systems would be installed relative to the baseline.

[2] The Form EIA-860 was in general more comprehensive than the NEEDS database.

The information in Form EIA-860 also included 4 medium and 3 large CHP combustion turbines that are not in the CAPD database. Three of the medium CHP combustion turbines are simple cycle CHP units (*i.e.*, do not have an associated steam turbine) and do not have SCR. The other medium CHP combustion turbine is a combined cycle turbine and has SCR. The 3 large CHP combustion turbines (2 combined cycle and 1 simple cycle) all have SCR. The EPA estimates that the 3 combustion turbines would have to install SCR to comply with the NSPS.

4. Estimating the Number of Direct Mechanical Combustion Turbines

To estimate the number of new direct mechanical drive combustion turbines that will be subject to this proposed NSPS, the EPA used the NESHAP database as the basis for this analysis. A unit from that database was deemed a direct mechanical drive combustion turbine if the unit description or plant type contained "compressor". As before, the EPA assumed that the number of new direct mechanical drive combustion turbines that will commence operation over the next 5 years will roughly mirror the number of like units that commenced operation in the previous 5 years. It should be noted, however, that the NESHAP database only reports the permit construction date as opposed to the actual commencement date, so the EPA corrected for this by assuming a 1-year lag between construction and operation. In other words, the EPA used the number of direct mechanical drive combustion turbines that have a permit construction date between 2018 and 2022 to estimate the number of like turbines that will commence operation within the next 5 years.

Within the NESHAP database, however, there are several direct mechanical drive turbines that are identified as new subpart YYYY facilities but have an unknown permit construction date. To incorporate these combustion turbines with an unknown date into the analysis, the EPA estimated their operation dates by assuming that the populations of known and unknown dates are similar (i.e., there is no correlation between whether a date was reported and what the date is). Thus, the EPA determined that the ratio of recent combustion turbines within the total number of combustion turbines that have a permit construction date can be applied to the total number of combustion turbines that did not have a known permit construction date. The EPA found that there are 53 recent direct mechanical units that had dates—10 of which had a permit construction date between 2018-2022. Applying this ratio (10/53) to the 86 recent direct mechanical drive units (identified as new subpart YYYY facilities) without dates gives an estimated 16 extra direct mechanical units to consider.

Therefore, the EPA projects that there will be 26 newly constructed, major source direct mechanical drive turbines subject to this proposed NSPS within the next 5 years. All 26 of these direct mechanical drive turbines are expected to be driven by simple cycle combustion turbines and fall within the high-load category.

The EPA reviewed permits for 6 the 10 recent compressor stations and none of these units required SCR.[3] Based on this, the EPA did not include SCR in the baseline for direct mechanical drive applications. Of the 10 units that have a permit construction date, only 1 of them has a capacity > 250 MMBtu/h. Applying this ratio to the 26 new turbines gives an estimated 3 large, direct

[3] The EPA was not able to find permits for the 4 other facilities.

mechanical drive combustion turbines. In addition, the NESHAP database only contains combustion turbines major sources and the EPA estimated that an equal number of combustion turbines will be constructed at area sources. In total the EPA estimates that 52 direct mechanical units will be subject to the proposed NSPS. The EPA estimates that all new mechanical drive applications would be base load combustion turbines with a BSER based on the use of SCR—52 additional SCR installations relative to the baseline.

Figure 3 shows the estimated impacts, relative to the historical baseline, for the different categories of combustion turbines.[4]

[4] The Impacts for the CAPD and non-CAPD EGUs being in year 4 and the impacts for the small EGUs and compressors begin in year 3. The annual numbers begin in year 4 and 3 respectively and for years prior to 2032.

Figure 3: Annual Impacts of the Proposed NSPS Relative to the Historical Baseline

Category	Additional SCR Installations	SCR Upgrades	Improved SCR O&M	Annualized Costs (million $)	Reductions in NO_X (tons)	Cost Effectiveness ($/ton NO_X reduced)	Increase in NH_3 (tons)	Increase in CO_2 (tons)
CAPD EGUs	0.4	2.8	2.2	$1.8	260	$3,000	18	1,400
Non-CAPD EGUs	0.6	-	-	$1.5	60	$5,500	4	320
Small EGUs	3.8	0.2	-	$1.3	50	$27,000	6	430
Mechanical Drive/Compressors	10.4	-	-	$5.1	136	$38,000	14	1,100

5. Ammonia Slip in Relation to NOx Emissions Controls

Ammonia slip is the emission of ammonia that, in this case, does not react with NO_X and is emitted for the SCR system. Ammonia slip is a combination of unreacted ammonia (which increases when more ammonia than is needed is injected into the SCR) passes through the catalyst bed and ammonia that leaks around and bypasses the catalyst bed. In fact, NO_X emissions are effectively controlled when there is an 80% stoichiometric ratio between the NO_X produced and the ammonia used to control it.[5] Above that 80% threshold, however, ammonia slip increases.

To determine an approximate level of ammonia slip the EPA reviewed ammonia slip levels in permits. Figures 4 and 5 summarize the EPA's findings for small and large combustion turbines, respectively.

Figure 4: Permitted Ammonia Slip Emissions from Turbines in Small Subcategory (≤ 250 MMBtu/h)

Category	Ammonia Emissions Range (ppm)
Combined Cycle Facilities/CHP Facilities	3-10
Simple Cycle Facilities	2-10

Figure 5: Permitted Ammonia Slip for Large Combustion Turbine> 250 MMBtu/h)

Category	Simple Cycle	Combined Cycle/CHP
Nameplate Capacity Range (MMBtu/h)	167-2,655	1,024-1,911
Ammonia Slip Emissions Range (ppm)	5-10	5-10
Ammonia Slip Emissions Average (ppm)	8.75	6.61
Total Sites	8	11

[5] See slide 3 of http://www.aqmd.gov/docs/default-source/Agendas/aqmp/control-strategy-symposium/pm2-5-miller.pdf?sfvrsn=2