NO_X Emission Rates

Technical Support Document

New Source Performance Standards Review for Stationary Combustion Turbines

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1. Introduction

This document describes the EPA's approach to estimating achievable emission rates for combustion turbines using SCR. The EPA reviewed hourly Clean Air Market Program emissions data which includes information that allows emission rates to be calculated on either a lb NO_X/MMBtu or lb NO_X/MWh-gross basis. The EPA primarily reviewed NO_X emissions data for the highest efficiency simple and combined cycle turbines because these represent the specific combustion turbine models along with the operating and maintenance practices that are representative of the combustion turbines that would be constructed to comply with the EGU GHG NSPS, subpart TTTTa. This approach is necessary to account for potential higher NO_X emission rates associated with more efficient combustion turbines.

The EPA also evaluated the NO_X emissions from lower NO_X emitting, but higher GHG emitting, combustion turbines to identify the potential relationship between NO_X and GHG emission rates for combustion turbines. Finally, to determine the NO_X reduction potential of SCR, the EPA compared the long-term emission rates of combustion turbines with SCR to combustion turbines using combustion controls. This approach accounts for all periods of operation, including periods when the SCR would not be effective due to catalyst being below the operating temperature (e.g., periods of startup and shutdown).

The EPA also focused the hourly emissions data analysis on combustion turbines where the self-reported design maximum hourly heat input (*i.e.*, the base load rating) was within 10% of the maximum hourly heat input rating achieved in practice. There are multiple reasons why the design base load rating and the maximum heat input achieved in practice might not closely align. For example, while the design base load rating is determined at ISO conditions, high ambient temperature and/or high elevations can reduce the amount of fuel that can be burned in a combustion turbine—lowering the maximum hourly heat input achievable in practice. In addition, the reported base load ratings could include the potential heat input from duct burners, but the NSPS base load rating is based on the design heat input to the combustion turbine engine and does not include potential heat input from duct burners.

This approach is necessary because the proposed emission standards are subcategorized by high duty cycle hours (when the combustion turbine engine is operating at a high load for the entire hour) and low duty cycle hours (when the combustion turbine engine is not operated at high load for the entire hour). These hours are referred to as high load and part load hours, respectively. Combustion turbines not achieving the design base load rating in practice would be primarily reporting part load hours.

2. Part-Load Threshold

To determine the hourly capacity factor threshold for high duty cycle verses low duty cycle hours, the EPA determined the 99.5 percentile hourly emissions rate by load bin. This allows the Agency to determine when emissions rates begin to increase relative to the emission rates at higher loads. NO_X emissions increase at lower load because the combustion controls and/or SCR become less effective at reducing emissions of NO_X at those lower loads. The selection of this threshold is important because it impacts the achievability of the high hourly duty cycle emissions standard.

One challenge with determining an appropriate threshold is determining the base load rating of individual combustion turbines because the heat input capacity is self-reported and does not always match the actual maximum heat input achieved during operation. If the reported base load rating is 10% or greater than the maximum hourly heat input, the EPA did not use the combustion turbine for determining the load threshold when NO_X emissions begin to increase.

The EPA estimated when emissions increase by taking the average and standard deviation of the emission rates in load bins greater than 75% load (the subpart KKKK threshold) and using those values to calculate a threshold emissions rate: the average emissions rate plus a single standard deviation.[1] The EPA determined the hourly capacity factor threshold by identifying the load bin when emissions exceeded the threshold emissions rate value.

Using this approach, the average threshold value for simple cycle turbines and combined cycle turbines is 81% and 73%, respectively. These high threshold values are because the emissions rate of a combustion turbine tends to gradually increase as load is reduced, but the large inflection does not occur until significantly lower loads. Figure 1 shows the emissions rate of simple cycle unit 3 at the Ocotillo Power Plant. Emission rates are lowest near base load operation and gradually increase until approximately 50% of the base load rating, when emission rates start to increase significantly.

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[1] This approach is only valid if the data is normally distributed.

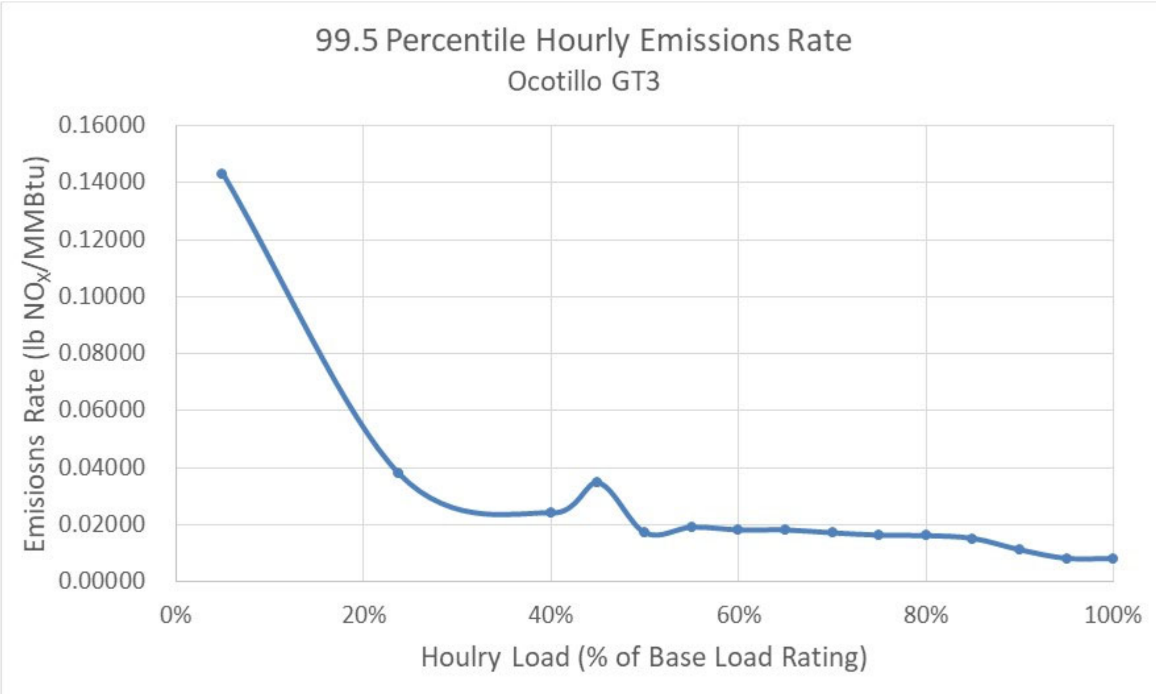

Figure 1. Hourly Emissions Rate vs. Load

Since there is not an inflection point for the emissions rate, selection of the high load/part load threshold is a balance between a numerically more stringent high load standard and the amount of data in the high load subcategory. At the same level of stringency, a lower threshold results in a numerically higher high load emissions standard.

For this proposal, the EPA selected a high load/low load threshold of 70% of the base load rating. At this threshold, approximately 80%of the heat input from simple cycle turbines and 90% of the heat input for combined cycle turbines respectively would be high load hours, which would make them subject to the high duty cycle emissions rate. The remaining heat input for each type of combustion turbine would be subject to the part load standard.

3. Emission Rates of Highly Efficient Combustion Turbines

Figures 2 and 3 show the theoretical compliance rates for highest efficiency simple and combined cycle combustion turbines. These combustion turbines have maintained emission rates consistent with the GHG emission standards in subpart TTTTa.

Facility	Turbine Model	Online Year	Base Load Rating (MMBtu/h)	Theoretical NO_X 4-Hour Rolling Compliance Rate Part Load Standard = 0.37 ln NO_X/MMBtu Part Load Threshold = 70% Hourly Capacity Factor			Overall NO_X Emissions Rate (lb/MMBtu)
				High Load Standard = 0.018 lb NO_X/MMBtu	High Load Standard = 0.011 lb NO_X/MMBtu	High Load Standard = 0.00074 lb NO_X/MMBtu	
Agua Fria Generating Station	GE LM6000	2022	439	96.9%	91.7%	72.71%	0.0174
Bayonne Energy Center	Rolls Royce Trent 60 WLE ISI	2012	603	100.0%	100%	91.82%	0.0074
Clayville	Rolls Royce Trent 60 WLE ISI	2015	628	99.43%	93.58%	48.41%	0.0123
Montana Power Station	GE LMS100	2015	858	99.93%	77.35%	53.41%	0.0111
Scattergood Generating Station	GE LMS100PA-SAC (Water)	2015	903	99.94%	99.23%	91.73%	0.0081
Panoche Energy Center	GE LMS100PB-DLE2	2009	970	99.93%	97.63%	72.88%	0.0100
Ocotillo Power Plant	GE LMS100	2019	1,000	99.98%	99.84%	66.02%	0.0082
Desert Basin Generating Station	Siemens SGT6-5000F	2022	435	89.40%	86.65%	67.76%	0.0225

Figure 2. Emission Rates of the Highest Efficiency Simple Cycle Turbines

Facility	Turbine Model	Online Year	Base Load Rating (MMBtu/h)	Theoretical NO_X 4-Hour Rolling Compliance Rate Part Load Standard = 0.37 ln NOx/MMBtu Part Load Threshold = 70% Hourly Capacity Factor		Overall NO_X Emissions Rate (lb/MMBtu)
				High Load Standard = 0.011 lb NO_X/MMBtu	High Load Standard = 0.00074 lb NO_X/MMBtu	
Dresden Energy Facility	GE7FA	2011	2,250	67.72%	19.72%	0.0111
Okeechobee Clean Energy Center	GE 7HA.02	2018	3,681	100%	99.80%	0.0071
CPV Fairview, LLC	GE 7HA.02	2019	3,763	100%	99.99%	0.0058
IPL - Eagle Valley Generating Station	GE 7FA.05	2017	2,542	100%	99.90%	0.0060
Port Everglades	Siemens SGT6-8000H	2015	2,700	99.97%	99.73%	0.0073

Figure 3. Emission Rates of the Highest Efficiency Combined Cycle Turbines