Attachment 3-2 NO_x Rate Development in EPA 2023 Reference Case

The following questions (Q) and answers (A) are intended to provide further background on the four NO_x rates found in the NEEDS database.

Q1: Why are four NO_x rates included in NEEDS?
A1: The four NO_x rates in NEEDS represent a menu of all the NO_x rates applicable to a specific electric generating unit given the current configuration of NO_x combustion and post-combustion controls installed at the unit. The menu also reflects installation of state-of-the-art combustion controls under all conceivable operating conditions involving NO_x controls that might be modeled in the future. By defining the menu of all the NO_x rates applicable up front for every generating unit, an IPM model run can then select among the rates on the menu the appropriate rate(s) for the unit based on the policy scenario being modeled.

Q2: What operational states do the four NO_x rates represent?
A2:
Mode 1 and mode 2 reflect a unit's emission rates with its existing configuration of combustion and post-combustion (i.e., SCR or SNCR) controls.

- For a unit with an existing post-combustion control, mode 1 reflects the existing post-combustion control not operating and mode 2 the existing post-combustion control operating. However:
    - If a unit has operated its post-combustion control year-round during the most recent of 2019, 2017, 2016, 2015, 2014, 2011, 2009, and 2007 years, then mode 1 = mode 2, which reflects that the control will likely continue to operate year-round.
    - If a unit has not operated its post-combustion control during the most recent of 2019, 2017, 2016, 2015, 2014, 2011, 2009, and 2007 years, mode 1 will be based on this data and mode 2 will be calculated using the method described under Question 3.
    - If a unit has operated its post-combustion control seasonally in recent years (i.e., either only in the summer or winter, but not both), mode 1 will be based on historic data from when the control was not operating, and mode 2 will be based on historic data from when the SCR or SNCR was operating.
- For a unit without an existing post-combustion control, mode 1 = mode 2 which reflects the unit's historic NO_x rates from a recent year.

See Figure 3-3 in Section 3.10.2 for an explanation of how the model selects the appropriate NO_x mode for each unit in the projection scenario.

Q3: How are emission rates calculated for each unit for each of the four NO_x modes?
A3: The calculation uses the emission data reported to EPA for a specific year under Title IV of the Clean Air Act Amendments of 1990 (Acid Rain Program) and Cross-State Air Pollution Rule (CSAPR). NO_x rates are derived from the data for the summer and winter seasons.

The illustration here is for coal units only, and with the assumption that the data were complete and consistent with engineering principles. Otherwise, additional screening steps are applied.

The procedure uses the following hierarchy of NO_x rate data sources:

1. 2019 ETS (referred to as 2019 NO_x rates in the discussion below)
2. Comments on NO_x rate
3. 2017/2016/2015/2014/2011/2009/2007 ETS
4. 2015 EIA Form 860
5. 2014 National Emissions Inventory (NEI)[1]

[1] National Emissions Inventory (NEI) is a comprehensive and detailed estimate of air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from air emissions sources. The NEI is released every three years.

6. 2016 California Air Resources Board (CARB) Database[2]
7. State Emissions Inventory in Florida, Michigan, New York, North Carolina, Ohio, Oklahoma, Texas and Virginia
8. Reasonably Available Control Technology (RACT) rate in New York, Connecticut and Pennsylvania
9. Defaults

The existing coal steam boilers in the United States are categorized into three groups depending on the configuration of NO_x combustion and post-combustion controls as summarized in NEEDS.

Group 1 - Coal boilers without post-combustion NO_x controls
Mode 1 = 2019 ETS Annual Average NO_x Rate
Mode 2 = Mode 1

Mode 3
Mode 3 calculation follows Steps 1-2:

Step 1: For units listed as having SOA combustion controls in NEEDS
Mode 3 = Mode 1

Step 2: For units listed as not having combustion controls in NEEDS

For non-wall fired dry bottom or tangential fired units.
Mode 3 = Mode 1

For wall fired dry bottom units[3]
If Mode 1 ≤ 0.1987 lb/mmBtu then the unit has SOA control and
Mode 3 = Mode 1
If Mode 1 > 0.1987 lb/mmBtu, then
Mode 3 = 0.1987 lb/mmBtu

For tangential fired units
If Mode 1 ≤ 0.1469 lb/mmBtu then the unit has SOA control and
Mode 3 = Mode 1
If Mode 1 > 0.1469 lb/mmBtu, then
Mode 3 = 0.1469 lb/mmBtu

Mode 4
Mode 4 =Mode 3

Group 2 - Coal boilers with SCR
Pre-screen coal boilers with 2019 ETS NO_x rates into the following four operating regimes. A coal boiler is assumed to be operating its SCR when the seasonal NO_x rate is less than 0.2 lbs/MMBtu.

The data is based primarily upon data provided by state, local, and tribal air agencies for sources in their jurisdictions. It is further supplemented by data developed by the U.S. EPA.

[2] California Air Resources Board (CARB) hosts an online database of facility-level criteria and toxic plus risk data (https://www.arb.ca.gov/app/emsinv/facinfo/facinfo.php).

[3] For EPA 2023 Reference Case, EPA identified coal steam units with firing types – wall fired dry bottom and tangential fired that had state-of-the-art combustion controls (SOA CC). EPA estimated the average 2019 ozone season NO_x emission rates for all such units by firing type. For dry bottom wall-fired coal boilers with "Low NO_x Burner" and "Overfire", there were 39 units averaging 0.1987 lb/mmBtu. For tangentially fired coal boilers with "Low NO_x Burner" and "Closed-coupled/Separated OFA", there were 54 units averaging 0.1469 lb/mmBtu. For units that had a mode 1 rate less than these average rates, mode 3 = mode 1. If the mode 1 rates are greater than these average rates, then mode 3 = average rates.

Group 2.1 SCR is not operating in both summer and winter seasons
Follow the NO_x rate rules summarized for Group 1 boilers. No state-of-the-art combustion controls are implemented.
Mode 1 = 2019 ETS Annual Average NO_x Rate
Mode 2 = maximum {(1-0.9) * Mode 1, 0.07}
Mode 3 = Mode 1
Mode 4 = Mode 2

Group 2.2 SCR is operating in summer only
Mode 1 = 2019 ETS Winter NO_x Rate
Mode 2 = 2019 ETS Summer NO_x Rate
Mode 3 = Mode 1
Mode 4 = Mode 2

Group 2.3 SCR is operating in winter only
Mode 1 = 2019ETS Summer NO_x Rate
Mode 2 = 2019 ETS Winter NO_x Rate
Mode 3 = Mode 1
Mode 4 = Mode 2

Group 2.4 SCR is operating year-round
Mode 1 = if (most recent of 2017/2016/2015/2014/2011/2009/2007 ETS Winter NO_x Rate > 0.2, most recent of 2017/2016/2015/2014/2011/2009/2007 ETS Winter NO_x Rate, 2019 ETS Annual Average NO_x Rate)[4]
Mode 2 = 2019 ETS Annual Average NO_x Rate
Mode 3 = Mode 1
Mode 4 = Mode 2

Group 3 - Coal boilers with SNCR
Step 1: Pre-screen coal boilers with 2019 ETS NO_x rates to verify if they have not operated their SNCR in both summer and winter seasons. A coal boiler is assumed to be not operating its SNCR when the NO_x rate is greater than 0.3 lbs/MMBtu in both summer and winter seasons.

Group 3.1 SNCR is not operating in both summer and winter seasons
Follow the NO_x rate rules summarized for Group 1 boilers
Mode 1 = 2019 ETS Annual Average NO_x Rate
Mode 2 = maximum {(1-removal efficiency[5]) * Mode 1, 0.1} for non FBC units
Mode 2 = maximum {(1-0.50) * Mode 1, 0.08} for FBC units
Mode 3 = same as Group 1 Mode 3
Mode 4 = maximum {(1-removal efficiency) * Mode 3, 0.1} for non FBC units
Mode 4 = maximum {(1-0.50) * Mode 3, 0.08} for FBC units

Step 2: Pre-screen coal boilers with 2019 ETS NO_x rates into the following three operating regimes. First estimate the implied removal for a coal boiler using the following equation:

Implied Removal (%) = ((Winter NO_x Rate – Summer NO_x Rate)/ Winter NO_x Rate) * 100

Second, assign the coal boiler to a specific operating regime based on the following logic.
If Implied Removal > 20% then SNCR is operating in summer season only,
Else if Implied Removal < -20% then SNCR is operating in winter season only,

[4] This equation implies that if a unit with a SCR operates year-round in ETS 2019 and in winter in ETS 2017/2016/2015/2014/2011/2009/2007, then Mode 1 NO_x rate will reflect SCR operation.

[5] SNCR removal efficiency for FBC units is 50%; and for non FBC coal units is 25%, 20%, and 15% for units < 200 MW, 200-400 MW, and > 400 MW respectively.

Else SNCR is operating year-round.

Second, assign the coal boiler to a specific operating regime based on the following logic.

Group 3.2 SNCR is operating in summer only
Mode 1 = 2019 ETS Winter NO_x Rate
Mode 2 = 2019 ETS Summer NO_x Rate
Mode 3 = same as Group 1 Mode 3
Mode 4 = maximum {(1-removal efficiency) * Mode 3, 0.1} for non FBC units
Mode 4 = maximum {(1-0.50) * Mode 3, 0.08} for FBC units

Group 3.3 SNCR is operating in winter only
Mode 1 = 2019 ETS Summer NO_x Rate
Mode 2 = 2019 ETS Winter NO_x Rate
Mode 3 = same as Group 3.2 Mode 3
Mode 4 = same as Group 3.2 Mode 4

Group 3.4 SNCR is operating year-round
If (most recent of 2017/2016/2015/2014/2011/2009/2007 ETS Winter NO_x Rate > 0.3) then

Mode 1 = most recent of 2017/2016/2015/2014/2011/2009/2007 ETS Winter NO_x Rate
Mode 2 = 2019 ETS Annual Average NO_x Rate
Mode 3 = same as Group 3.2 Mode 3
Mode 4 = maximum {(1-removal efficiency) * Mode 3, 0.1} for non FBC units
Mode 4 = maximum {(1-0.50) * Mode 3, 0.08} for FBC units

Else

Mode 1 = 2019 ETS Annual Average NO_x Rate
Mode 2 = 2019 ETS Annual Average NO_x Rate
Mode 3 = same as Group 3.2 Mode 3
Mode 4 = Mode 3

Other things worth noting are:

(a) In general, winter NO_x rates reported in EPA's Emission Tracking System were used as proxies for assigning emission rates to Mode 1.

(b) **NO_x Emission Rates for Units with Common Stacks -** The reported ETS NO_x emissions and emissions rate data for units that share a common stack typically reflect an average of emissions and emission rates across all units that share the common stack. This can include instances where one or more units sharing a common stack are equipped with a SCR and one or more units are not. Because the emissions are measured at the stack, the emission rate for the SCR and non-SCR equipped units are typically reported as being similar, even if at the unit level they are not. This can create the appearance of SCRs being operated at reduced efficiencies, even if they are not. In instances where SCRs were retrofit on one of the units after 2019, the non-SCR equipped unit was represented with a NO_x emissions rate equal to the 2019 emissions rate and the SCR equipped unit was represented with a 0.05 lbs/MMBtu emissions rate, matching IPM's assumption for emission rates achieved with recent SCR retrofits. This represents no change from how these units were previously represented in NEEDS.

For units with SCRs built in 2019 or earlier and share a common stack with a non-SCR equipped unit, there is no reliable data to determine the emission rates of the individual units. Therefore, EPA 2023 Reference Case assumed that SCR-equipped units sharing a common stack with non-SCR equipped units would have emission rates equal to 0.075 lbs/MMBtu. This is a conservatively low rate which implies that these units cannot achieve any additional reductions. The NO_x emission rate for the non-SCR equipped unit is then recalculated such that the capacity weighted emissions rate of the units

sharing the common stack would be equal to the capacity weighted emissions rate calculated from the ETS data.

(c) The NEI, CARB, and other state datasets where NO_x emissions dataset are available, were used to reduce the number of default NO_x rates in instances where the 2019 ETS did not report any NO_x rates.

The NEI dataset contained NO_x emission and fuel use data presented at the facility ID, point ID, process ID, and source classification code (SCC) level. EPA matched NEI facility ID and point ID's with NEEDS units to create a crosswalk that was then used to map the NEI NO_x emission and fuel use data to the NEEDS units that were without reported ETS NO_x rates. Unit-level NO_x emission rates were then calculated for the units. The calculated unit-level NO_x rates were further evaluated to remove outliers. Calculated unit-level NO_x rates that were outside the rate range of the 2019 ETS NO_x rates for the relevant plant type were not adopted.

Also, the NEI dataset is the primary data source for internal combustion (IC) engine NO_x rates. These NO_x rates varied between 0.011 lbs/MMBtu and 28.11 lbs/MMBtu and have a median value of 3.12 lbs/MMBtu. The cut-off rate was assumed to be 4.80 lbs/MMBtu, which was the 85 percentile. For IC engines, if the NEI NO_x rate was higher than 4.80 lbs/MMBtu, then the NEI rate was not adopted.

The CARB and other state NO_x emissions dataset contained NO_x emissions information but no fuel use information. To obtain fuel use information, EPA mapped the facilities to those in the 2019 EIA Form 923 data and used the fuel use from the 2019 EIA Form 923 data, together with the NO_x emissions to calculate facility-level NO_x emission rates. If a facility in NEEDS had only one plant type, the calculated facility-level NO_x rate was adopted for all NEEDS units located at the facility. If a facility in NEEDS had multiple plant types, the calculated facility-level NO_x rate was not adopted. The calculated facility-level NO_x rates were further evaluated to remove outliers. If a NEEDS unit had a calculated facility-level NO_x rate that was higher than the average NO_x rate based on the 2019 ETS, the calculated facility-level NO_x rate was not adopted.

(d) The state and national-level default NO_x rates account for the units that were assigned NO_x rates from the NEI, CARB and other states dataset described above. For units located in Connecticut, Pennsylvania, and New York, the revised state-level default NO_x rates were further compared with RACT rates. If the revised state-level default NO_x rates were higher than the RACT rates, the revised state-level default rates were not adopted, and the RACT rates were used instead.