Technical Support Document (TSD)

for the Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS

Docket ID No. EPA-HQ-OAR-2015-0500

# Ozone Transport Policy Analysis

# Final Rule TSD

U.S. Environmental Protection Agency

Office of Air and Radiation

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The analysis presented in this document supports the EPA's Final Cross-State Air Pollution Rule Update for the 2008 Ozone National Ambient Air Quality Standards (CSAPR Update). This TSD includes analysis to quantify upwind state emissions that significantly contribute to nonattainment or interfere with maintenance of the 2008 ozone NAAQS in downwind states and quantification of emission budgets (i.e., limits on emissions). The analysis is described in Section VI of the preamble to the final rule. This TSD also broadly describes how the EPA used the Integrated Planning Model (IPM) to inform air quality modeling, budget setting, and policy analysis aspects of this rule. This TSD is organized as follows:

A. Background on EPA's Analysis to Quantify Emissions that Significantly Contribute to Nonattainment or Interfere with Maintenance of the 2008 Ozone NAAQS
B. Using the Integrated Planning Model (IPM) to Assess Air Quality Modeling, Ozone-Season $NO_X$ Cost Thresholds, and Policy Impacts
C. Calculating Budgets From IPM Run and Historical Data
D. Analysis of Air Quality Responses to Emission Changes Using an Ozone Air Quality Assessment Tool (AQAT)
    1. Introduction: Development of the assessment tool
    2. Details on the construction of the assessment tool
    3. Description of analytical results
    4. Comparison between the air quality assessment tool estimates and CAMx air quality modeling estimates

## A. Background on EPA's Analysis to Quantify Emissions that Significantly Contribute to Nonattainment or Interfere with Maintenance of the 2008 Ozone NAAQS

In the preamble, we describe the four-step CSAPR framework that the EPA is applying to identify upwind states' emissions that significantly contribute to nonattainment or interfere with maintenance with respect to the 2008 ozone NAAQS in other states and to implement appropriate emission reductions. This framework was also used in the original CSAPR rulemaking to address interstate transport with respect to the 1997 ozone NAAQS and the 1997 and 2006 PM2.5 NAAQS. See section IV of the preamble for an overview of the CSAPR framework.

The first step of the CSAPR framework uses air quality analysis to identify nonattainment and maintenance receptors with respect to interstate transport for the 2008 ozone NAAQS. The second step of the framework uses further air quality analysis to identify upwind states whose ozone pollution contributions to these monitoring sites meet or exceed a specified threshold amount of 1% of the NAAQS and therefore merit further analysis. See section V of the preamble for details on applying these steps with respect to interstate emissions transport for the 2008 ozone NAAQS.

The third step in the framework quantifies upwind state emissions that significantly contribute to nonattainment or interfere with maintenance of the 2008 ozone NAAQS at the downwind receptors, and identifies the EGU $NO_X$ emission budgets for each state that represent the reduction of these emissions levels. See section VI of the preamble with respect to interstate emissions transport for the 2008 ozone NAAQS. Finally, the fourth step of the framework implements the emission budgets in each state via the CSAPR $NO_X$ ozone season allowance trading program. See section VII of the preamble for details on implementation of this CSAPR trading program.

This TSD primarily addresses step three of the CSAPR framework, which itself consists of several steps. In order to establish final EGU $NO_X$ emissions budgets for each linked upwind state, we first identify levels of uniform levels NOx control stringency based on available EGU $NO_X$ control strategies and represented by cost thresholds.[1] These levels of uniform $NO_X$ control stringency are modeled in IPM, as described in section B in this TSD for a discussion of this analysis. This data is then combined with historic data in order to quantify a series of potential EGU $NO_X$ emission budgets for each linked upwind state at each levels of uniform $NO_X$ control stringency. Next, we use the ozone Air Quality Assessment Tool (AQAT) to estimate the air quality impacts of the upwind state EGU $NO_X$ emission budgets on downwind ozone pollution levels for each of the assessed EGU $NO_X$ emission budget levels. Specifically, we look at the magnitude of air quality improvement at each receptor at each level of control, we examine whether receptors are "solved", and we look at the individual contributions of each state to each of its receptors. See section D in this TSD for discussion of the development and use of the ozone AQAT.

Finally, the EPA uses this air quality information in a multi-factor test, along with EGU $NO_X$ reductions and cost, to select a particular level of uniform EGU $NO_X$ control stringency that addresses each state's significant contribution to nonattainment and interference with maintenance (see Section VI of the preamble for additional information).

In this TSD, we assessed the EGU $NO_X$ mitigation potential for all states in the contiguous U.S. We also assessed the air quality impacts for all monitors in the contiguous U.S. However, in applying the multi-factor test for purposes of identifying the appropriate level of control, the EPA only evaluated EGU $NO_X$ reductions and air quality improvements from upwind states that were "linked" to downwind receptors in step two of the CSAPR framework. These states are listed in Table A-1 below.

[1] See the EGU NOx Mitigation Strategies Final Rule TSD

As described in preamble section VI, Delaware and the District of Columbia (D.C.) are “linked” to downwind ozone problems but are not included in the final rule.  Consequently, EPA did not include Delaware or D.C. in applying the multi-factor test.

| **Table A-1.  States Evaluated in the Multi-factor Test** | |
|---|---|
| Ozone Season $NO_X$ | |
| Alabama | Missouri |
| Arkansas | New Jersey |
| Illinois | New York |
| Indiana | Ohio |
| Iowa | Oklahoma |
| Kansas | Pennsylvania |
| Kentucky | Tennessee |
| Louisiana | Texas |
| Maryland | Virginia |
| Michigan | West Virginia |
| Mississippi | Wisconsin |

## B. Using the Integrated Planning Model (IPM) to Project Impact of Ozone-Season $NO_X$ Cost Thresholds, Budgets, and Policy Impacts

EPA used the Integrated Planning Model (IPM) v5.15 platform to inform air quality modeling for the final rule. IPM was also used to analyze the ozone season $NO_X$ emission reductions available from electric generating units (EGUs) at various uniform levels of $NO_X$ control stringency, represented by cost, in each upwind state. Finally, IPM was used to evaluate illustrative compliance with the rule's regulatory control alternatives (i.e., compliance with the finalized emission budgets, with a more stringent alternative, and with a less stringent alternative).

IPM is a multiregional, dynamic, deterministic linear programming model of the U.S. electric power sector that EPA uses to analyze cost and emissions impacts of environmental policies.[2] All IPM cases for this rule included representation of the Title IV $SO_2$ cap and trade program; the $NO_X$ SIP Call; the CSAPR regional cap and trade programs;[3] consent decrees and settlements; and state and federal rules as listed in the IPM documentation referenced above. The cases did not include the final Clean Power Plan (CPP), as explained in Preamble section IV.B.

Application of the CSAPR 4-step framework requires robust data collection, IPM modeling, and analysis and is in and of itself time consuming. Rather than freezing all IPM data sets at the outset of EPA's analysis for the final rule, the EPA allowed for ongoing improvement of the relied upon EGU data. As a result, each step of EPA's analysis for the final rule is informed by the best available data at the time the analysis was conducted. For example, after the EPA began its analysis for the final rule, Pennsylvania published its rule addressing requirements for Reasonable Available Control Technologies (RACT) that would result in $NO_X$ emissions reductions during 2017. Rather than ignore a significant new rule the EPA incorporated the rule into its analysis.[4] One factor that enabled the EPA to ensure that each step of its analysis is informed by the best available data is the agency's use of AQAT (as described in section D of this TSD). Within a short period of time, AQAT allows the agency to estimate the changes in air quality design values and air quality contributions as a result of the changes in emissions. For example, EPA was able to estimate the changes in air quality as a result of PA RACT and found that the 19 receptors identified in the final air quality modeling using CAMx

[2] See "Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model", "EPA Base Case v.5.14 Using IPM Incremental Documentation. March 25, 2015", and "EPA Base Case v.5.15 Using IPM Incremental Documentation. August, 2015," and "EPA v5.15 Supplemental Documentation for the Final CSAPR Update Rule" for further description of the IPM model, available at https://www.epa.gov/airmarkets/power-sector-modeling

[3] The D.C. Circuit issued its final decision in the litigation of CSAPR, remanding 11 states phase 2 NOx ozone season budgets for reconsideration, finding that the budgets over-controlled. *See EME Homer City Generation, L.P. v. EPA*, 795 F.3d 118, 138 (2015) (*EME Homer City II*). In light of this remand, the projected base case for the final rule accounts for compliance with the original CSAPR by including as constraints all original CSAPR emission budgets with the exception of remanded phase 2 $NO_X$ ozone season emission budgets for 11 states. The EPA has also excluded the phase 2 $NO_X$ ozone season emission budgets that were finalized in the original CSAPR supplemental rule for four additional states because those state budgets would over-control in the same manner as the remanded budgets. Specifically, to reflect original CSAPR ozone season $NO_X$ requirements, the modeling includes as constraints the original CSAPR $NO_X$ ozone season emission budgets for 10 states: Alabama, Arkansas, Georgia, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee.

[4] See the Memo to the Docket "Pennsylvania RACT memo to the docket for the final CSAPR Update" for details about this rule.

remained with design values greater than 76 ppb.[5] EPA also found that each state included in the rule maintained at least one linkage to one of those 19 receptors. EPA recognizes that AQAT is not the equivalent of photochemical air quality modeling using tools such as CAMx. However, AQAT is directly informed by robust CAMx data. Further, AQAT has evolved through iterative development under the original CSAPR, the CSAPR Update proposal, and the final CSAPR Update. One such evolution is its calibration to an emission reduction scenario that is very similar to the final rule $NO_X$ control stringency. As a result, the version of AQAT used for the final CSAPR Update is a reliable analytic tool that is specifically created and calibrated to the policy it is being used to evaluate. To confirm its reliability for these purposes, the EPA used both AQAT and CAMx to evaluate the illustrative policy analysis for the RIA, finding that AQAT provides results that are nearly identical to CAMx. This assessment can be found in section D-4, below.

In the body of power sector modeling done for this rule, the EPA needed to quantify emissions for three different analytic purposes. The first purpose was construct an Air Quality Modeling Base Case to identify nonattainment and maintenance receptors and perform contribution analysis. This base case was necessary given the long lead time required for air quality modeling. This base case incorporated the most important fleet changes and retrofits identified through comments on the August 4, 2015 Notice of Data Availability (NODA)[6] and EPA's continuous review of the power sector.

The second purpose was to construct an illustrative, and internally consistent, base case and control case to study the potential costs and benefits of this rulemaking, as described in the Regulatory Impact Analysis, or RIA, for this rule. This set of cases is referred to as the "Illustrative Cases." To allow time for air quality modeling and analysis of the policy, illustrative budgets were quantified from the Illustrative Cost Threshold Runs. These Illustrative Cases incorporated additional comments from the NODA and the proposal, as well as other modeling updates.

The third purpose was to quantify the final state emission budgets for the rule and to confirm that the results of the illustrative analysis are representative of the final CSAPR Update. This set of cases is referred to as the "Final Cases." For the Final Cases, the EPA conducted a new base case, cost threshold cases, and policy case. This final set of analysis allowed EPA to incorporate the most updated information possible for the calculation of emission budgets in the final regulation.

As a result, while EPA used the same budget quantification approach described in this document in both the Illustrative and Final sets of analysis cases, the quantified results for budgets in each track differ due to minor differences in the modeling projections within each track. Table B-1 below summarizes the various IPM runs conducted and Appendix A provides further details on each of these scenarios.

[5] For example, EPA was able to estimate the changes in air quality as a result of PA RACT and found that the 19 receptors identified in the final air quality modeling using CAMx remained with design values greater than 76 ppb.

[6] Notice of Availability of the Environmental Protection Agency's Updated Ozone Transport Modeling Data for the 2008 Ozone National Ambient Air Quality Standard (NAAQS), 80 FR 46271 (Aug. 4, 2015). available at http://www.epa.gov/airtransport/pdfs/FR_Version_Transport_NODA.pdf.

**Table B-1. Summary of Sets of Scenarios**

| | Air Quality Modeling Base Case | Illustrative Cases | Final Cases |
|---|---|---|---|
| **Scenarios Run** | Base Case | Base Case<br><br>Cost Threshold Cases<br><br>Policy Cases | Base Case<br><br>Cost Threshold Cases<br><br>Policy Cases |
| **What Analysis Each Set of Runs Inform** | Base Case air quality modeling (CAMx) to identify nonattainment and maintenance receptors | Budgets used for the Illustrative Policy Cases<br><br>Air quality analysis (CAMx and AQAT) of the Illustrative Policy Case<br><br>Illustrative Policy Analysis for the RIA | Final Budgets<br><br>AQAT Analysis<br><br>Appended analysis for the RIA |
| **Updates Captured In Each Set of Runs** | Unit retirements, additions and retrofits flagged In NODA comments<br><br>See "NEEDS v.5.15 AQM CSAPR Update" in the docket for full set of unit level characteristics | Additional comments on the NODA and Proposed Rule<br><br>Updated certain unit-specific $NO_X$ rates based on historical trends<br><br>Emission rate of units with SCRs is 0.081 lbs/mmBtu or lower<br><br>See "NEEDS v.5.15 Illustrative CSAPR Update" in the docket for full set of unit level characteristics | Updated additional $NO_X$ rates based on historical trends<br><br>Emission rate of units with SCRs is 0.1 lbs/mmBtu or lower<br><br>See "NEEDS v.5.15 Final CSAPR Update" in the docket for full set of unit level characteristics |

For the Illustrative and Final Cases, the EPA modeled the emissions that would occur within each state in a Base Case. The EPA then designed a series of IPM runs that imposed increasing cost thresholds representing uniform levels of $NO_X$ controls and tabulated those projected emissions for each state at each cost level.  The EPA has referred to these runs as "Cost Threshold Runs" and these tabulations as "cost curves".[7] The cost curves report the remaining emissions at each cost threshold after the state has made emission reductions that are available up to the particular cost threshold analyzed.

In each Cost Threshold run, the EPA applied ozone season cost thresholds to all fossil-fuel-fired EGUs with a capacity greater than 25 MW in all states. As described in the EGU $NO_X$ Mitigation Strategies Final Rule TSD, because of the time required to build advanced pollution controls, the model was prevented from building any new post-combustion controls, such as SCR or SNCR, before 2020, in response to the cost thresholds.[8] The modeling allows turning on idled existing SCR and SNCR, optimization of existing SCR, shifting generation to lower-$NO_X$ emitting EGUs, and adding or upgrading $NO_X$ combustion controls in 2017,[9] such as state-of-the-art low $NO_X$ burners (LNB).

In these scenarios, EPA imposed cost thresholds of $800, $1,400, $3,400, $5,000, and $6,400 per ton of ozone season $NO_X$. See Preamble Section VI for a discussion of how the cost thresholds were determined. Table B-2 below summarizes the reduction measures that are broadly available at various cost thresholds.

**Table B-2. Reduction strategies available to EGUs at each cost threshold.**

| **Cost Threshold ($ per ton Ozone-Season $NO_X$)** | **Reduction Options** |
|---:|---|
| **$800** | -Optimize extant operating SCRs<br>-generation shifting |
| **$1,400** | all above options and<br><br>- retrofitting state-of-the-art combustion controls<br>-Turning on and optimizing extant idled SCRs<br>-additional generation shifting |
| **$3,400** | all above options and<br><br>-Turning on extant idled SNCRs<br>-additional generation shifting |
| **$5,000** | all above options and additional generation shifting |
| **$6,400** | all above options and additional generation shifting |

[7] These projected state level emissions for each "cost threshold" run are presented in several formats. The IPM analysis outputs available in the docket contain a "state emissions" file for each analysis. The file contains two worksheets. The first is titled "all units" and shows aggregate emissions for all units in the state. The second is titled "all fossil > 25MW" and shows emissions for a subset of these units that have a capacity greater than 25 MW. The emissions in the "all fossil > 25 MW" worksheet are used to derive the budgets for each upwind state at the cost thresholds, in an average year.

[8] IPM results do include certain newly built post-combustion $NO_X$ control retrofits in base case modeling, cost curve runs, and remedy runs. These pre-2020 retrofits do not reflect any controls installed in response to the rule, but instead represent those that are already announced and/or under construction and expected to be online by 2018, or controls that were projected to be built in the base case in response to existing consent decree or state rule requirements.

[9] As described in Preamble Section IV.B, the EPA is aligning the analysis and implementation of this final rulemaking with the 2017 ozone season in order to assist downwind states with the timely attainment of the 2008 ozone NAAQS. As described in Preamble Section V.B.2., EPA adjusted the IPM v5.15 2018 run year results to account for differences between 2017 and 2018 in the power sector, because IPM v5.15 does not have an output year of 2017.

Within IPM, units with extant SCRs are defined as SCR equipped units with ozone season $NO_X$ emission rates less than 0.2 lbs/mmbtu in the Base Case. These units had their emission rates lowered to the lower of their mode 4 $NO_X$ rate in NEEDS[10] and the "widely achievable" optimized emissions rate of 0.081 lbs/mmbtu in the Illustrative Cost Threshold Cases and 0.10 lbs/mmBtu in the Final Cost Threshold Cases.

Units equipped with SCRs with an emissions rate exceeding 0.20 lbs/mmBtu were considered to have idled SCRs. These units had their emission rates lowered to the lower of their mode 4 $NO_X$ rate in NEEDS and the "widely achievable" optimized emissions rate of 0.081 lbs/mmbtu in the Illustrative Cost Threshold Cases of $1,400 per ton and higher, and 0.10 lbs/mmBtu in the Final Cost Threshold Cases of $1,400 per ton and higher.

Units with idled SNCRs were identified as units equipped with SNCR and mode 4 $NO_X$ rates in NEEDS greater than 0.30 lbs/mmbtu. These units were given $NO_X$ rates 25% lower to reflect reflect SNCR operation in Cost Threshold cases of $3,400 per ton and higher.

Finally, unit combustion control configurations listed in NEEDS were compared against Table 3-11 in the Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model IPM v.5.13, which lists state-of-the-art combustion control configurations based on unit firing type. This allowed EPA to identify units that would receive state-of-the-art combustion control upgrades in IPM. EPA then followed the procedure in Attachment 3-1 of the documentation to calculate the each of these unit's new $NO_X$ emission rate.

As described in preamble section VI, the EPA limited its assessment of shifting generation to other EGUs within the same state as a proxy for the amount of generation shifting that could occur for the 2017 ozone season. EPA did this by limiting state generation in each Cost Threshold case to the level in its respective Base Case.

Section C.2 of this TSD describes how budgets were calculated based on each Cost Threshold case. Once these budgets were calculated, EPA used the budgets for covered states to conduct IPM runs to investigate the impact of compliance with the budgets calculated from the $800, $1,400, and $3,400 per ton Cost Threshold Cases. These Cases are referred to as Policy Cases. Specifically, the budgets calculated from the Illustrative $1400 per ton Cost Threshold case were used for the Illustrative Policy Case, and the budgets calculated from the Illustrative $800 and $3400 per ton Cost Threshold cases informed the Illustrative Less- and More-Stringent Policy Cases. Lastly, the budgets calculated from the Final $1400 per ton Cost Threshold case were used for the Final Policy Case. These Policy Cases were used to inform air quality impact analysis of the rule and inform the RIA.

To model the policy cases in IPM, EPA used the calculated budget and assurance levels to set state and regional ozone-season $NO_X$ emissions. Additionally, EPA assumed a starting bank of allowances equal to 21% of the sum of the state budgets. States could individually emit up to their assurance levels in each run year, and collectively could not have emissions exceeding the sum of their budget and banked allowances in each run year. In all policy cases, units with extant operating SCRs were assumed to operate them at the lower of their mode 4 $NO_X$ rate in NEEDS and the "widely achievable" emissions rate, as EPA determined this was a cost-effective mitigation strategy. For all of the Policy Cases except the Illustrative Less Stringent Policy Case, all units with SCRs were assumed

[10] The mode 4 $NO_X$ rate, as described in Chapter 3 of the Documentation for EPA Base Case v.5.13 Using Integrated Planning Model, represents post-combustion controls operating and state-of-the-art combustion controls, where applicable. For units determined to be operating their SCR, the rate is typically equal to the unit's rate reported in the 2011 ETS data. For some units, as described in the EPA v.5.15 CSAPR Update Rule Base Cases Using IPM Incremental Documentation, this data was updated. For units not operating their SCRs, the mode 4 rate is calculated as described in Attachment 3-1 of the Documentation for EPA Base Case v.5.13 Using Integrated Planning Model.

to operate them at the "widely achievable" emissions rate and units that did not already have state-of-the-art combustion controls were assumed to retrofit them. In the Illustrative More Stringent Policy Case, units with idled SNCRs were assumed to operate them. Finally, no state-level generation constraints were imposed in the policy cases. While the EPA conservatively limited generation shifting in developing the budgets, through use of state-level generation constraints, the EPA believes that generation shifting may occur broadly among states and so removed that constraint for the IPM cases modeling the policy.

## C. Calculating Budgets From IPM Run and Historical Data

**1.** Overview of the State Budget Formula

As described in preamble section VI, EPA developed state EGU $NO_X$ emissions budgets for each of the cost thresholds. This section walks through the details of how each state emissions budget was calculated for each cost threshold. As described in Section B of this TSD, the same process was used to calculate two sets of budgets: an Illustrative for analysis of the rule and a Final set for quantifying the final CSAPR Update budgets

As described in Preamble Section VI, the EPA determined it was appropriate to calculate budgets by combining historical emissions and heat input data with projections from IPM. In the proposed rule, the EPA calculated state budgets with the following formula:

**State 2017 OS $NO_X$ Budget** =
2015 State OS Heat Input * State 2017 IPM OS $NO_X$ Emissions Rate

(note: "OS" stands for Ozone Season, and is equivalent to the "summer" label in some IPM outputs)

EPA intended this formula to root the state emissions budgets in historical data by tying them to state-level historic heat input as opposed to using emission projections that reflect interstate generation patterns that occur in IPM. However, commenters raised a related concern that notwithstanding this approach's use of state-level historic heat input, the model may still project a substantially cleaner generation profile within the state than might be possible to achieve in the relatively short timeframe of this rule. In other words, the proposal's application of an IPM-projected state-level emission rate to historical state-level heat input data could still yield potentially insufficient tons for a state budget if that state's EGUs were to maintain a similar total generation to 2015 but were unable to collectively achieve that projected emission rate by the 2017 ozone season. To address this concern, EPA updated the formula for the final rule to:

**State 2017 OS $NO_X$ Budget** = $\text{2015 State OS Heat Input} *$
$[2015\ State\ OS\ NO_X\ Emissions\ Rate -$
$(2017\ IPM\ Base\ Case\ OS\ NO_X\ Emissions\ Rate -\ \text{2017 IPM Cost Threshold}\ OS\ NO_X$ Emissions Rate)]

This formula subtracts the change in emissions rate between the IPM Base Case and a Cost Threshold Case from the actual 2015 emissions rate. This modified approach ensures that state budgets are informed by IPM projections of state-level emission rate *improvement* (change from base case to cost threshold case) while tying that improvement potential directly to observed emission rate performance in 2015.

This change in analytic approach means that unit retirements and retrofits known to occur after 2015 but before 2017, which were automatically captured in the proposal's use of IPM-projected emission rates, now need to be explicitly accounted for in the quantification of state budgets. In the proposal methodology, these fleet changes were captured in the State 2017 IPM Emissions Rate. In the formula above used to quantify budgets in this final rule, these fleet changes between 2015 and 2017 are reflected in both the IPM Base Case Rate and the Cost Threshold Case Rate, such that the effect of these fleet changes on the state-level emission rates cancels itself out. In other words, the degree of state-level IPM-projected emission rate improvement represented in this formula only captures what EGUs in that state can do to reduce emissions *beyond* the already-known retrofit and retirement changes expected in that state between 2015 and 2017. Accordingly, EPA determined it was necessary to adjust the 2015 State Emissions Rates to account for these known changes, so that the full degree of emission reductions expected in the state by 2017 is captured in the budget. Therefore, the final budget equation is:

$$\textbf{State 2017 Budget} = \text{2015 State OS Heat Input} * [\mathit{Adjusted}\ 2015\ \mathit{OS}\ \mathit{NO_X}\ \mathit{State\ Emissions\ Rate} - (2017\ \mathit{IPM\ Base\ Case\ OS}\ \mathit{NO_X}\ \mathit{Emissions\ Rate} - \text{2017 IPM Cost Threshold } \mathit{OS}\ \mathit{NO_X} \text{ Emissions Rate})]$$

Finally, EPA notes that in rare instances, it is possible for a state's emission rate to increase in a cost threshold case relative to its base case rate, even if a state's emissions decrease overall. This situation could yield a result greater than the state's 2015 (unadjusted) emissions. This outcome can be due to model-projected regional fuel prices and generation shifting among units. Therefore, EPA assigned state budgets as the lower of the calculated state budget or the state's 2015 (unadjusted) emissions.

**2.** Detailed Explanation of State Budget Calculations

Below is a detailed walk-through of how the formula for calculating state emissions budgets was applied to each cost threshold run to generate a corresponding budget for each state. For comparison and the purpose of AQAT modeling, this formula was also applied to the Base Case to generate base case "budgets" (alternatively, this could be considered a $0 per ton ozone season $NO_X$ cost threshold run). The budgets calculated from this process for the Final Cost Threshold cases appear in table C-1. The detailed calculations for all Cost Threshold cases appear in Appendix E (Excel spreadsheet).

First, the EPA tabulated each state's 2015 reported historical state-level ozone season heat input and $NO_X$ emissions from affected sources. To capture the emissions impact of committed fleet changes occurring before 2017, the EPA calculated an adjusted 2015 historical ozone-season $NO_X$ emissions level for each state. For units with planned new state-of-the-art SCR retrofits to be in place by the 2017 ozone season, heat input was assumed to match 2015 levels, but the units were given emission rates of 0.075 lbs/mmBtu[11] to reflect the control being in place for 2017 and in lieu of whatever emission rate the unit reported in 2015 (before its SCR was in place). For units with planned combustion control retrofits before 2017, the EPA recalculated emissions for the unit assuming heat input matched 2015 levels and the emission rate was improved to the Mode 4 $NO_X$ Emissions Rate for the unit listed in NEEDS.[12] For units with coal-to-gas conversions planned to occur by the 2017 ozone season, heat input was assumed to match 2015 levels, but the units were given an emissions rate equal to half of its 2015 rate[13] to reflect the $NO_X$ reductions associated with their conversion to gas for 2017.

[11] This is a conservative estimate, based on the floor rates for new SCRs in the IPM documentation, ranging from 0.05 to 0.07 lbs/mmBtu, depending on coal type. See "Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model," table 5-5.

[12] The Mode 4 $NO_X$ Emission Rate reflects the emission rate for a unit if state-of-the-art combustion controls were installed. See NEEDS v5.15 Final CSAPR Update

[13] This is consistent with $NO_X$ rate change used in IPM. See "Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model.", table 5-21.

Lastly, the heat input and emissions for units retiring before 2017 was changed to zero. However, the EPA assumed that the generation from the retiring unit would be replaced by other units. The displaced heat input, which EPA used as a proxy for generation, from these units was assumed to be replaced by generation within the state with an emission rate equal to the state's overall emission rate for the remaining units.[14] This heat input and associated emissions from replacement generation was then added to the state's total, yielding adjusted 2015 historical ozone season heat input and $NO_X$ emissions. With this data, EPA was also able to calculate each state's adjusted 2015 ozone season emissions rate.

Second, the EPA calculated each covered state's 2017 modeled ozone season $NO_X$ emission rate for the base case and each cost threshold. To do this, EPA started with the IPM projected 2018 ozone season heat input and $NO_X$ emissions from affected sources for each state. Next, EPA added an adjustment to account for differences in unit and SCR availability and operation between the IPM run year of 2018 and the expected conditions applicable to calendar year 2017.[15] Appendix C explains the 2017 adjustments and shows the adjustments made by model plant. Lastly, the state-level 2017 emissions rate was calculated as the total 2017 emissions from affected sources within the state, divided by the total 2017 heat input from these sources.

Third, the EPA calculated the change in emissions rate between the IPM base case and each cost threshold case.[16] The EPA then subtracted this change in emissions rate from the adjusted 2015 emissions rate. This yielded state-level historically based emission rates reflecting modeled $NO_X$ reduction potential.

Fourth, the EPA multiplied these rates by each state's adjusted 2015 heat input to yield emission budgets for each cost threshold. In instances where this calculated budget was greater than the state's 2015 (unadjusted) emissions, the state budget was set equal to the state's 2015 (unadjusted) emissions. However, for the budgets finalized in this rule, all states had calculated budgets lower or equal to their 2015 historical emissions. The state budgets for the Final Cost Threshold cases are displayed in table C-1. Note that budgets are calculated for all states for the purpose of AQAT analysis, as explained section D of this TSD, even if the state is not covered by the final CSAPR Update Rule.

Finally, the EPA calculated the variability limits and assurance levels for each state based on the calculated emission budgets. Each state's variability limit is 21% of its budget, and its assurance level is the sum of its budget and variability limit (or 121% of its budget), shown in Table C-2. Under the methodology established in the original CSAPR, the state-specific portion of the new unit set aside (NUSA) (including the Indian Country NUSA) is calculated as the percentage equal to the projected emissions from "planned units" divided by the state budget plus a base two percent. The calculated existing unit allocation and NUSA, including the Indian Country NUSA, for the Final budgets is

[14] Therefore, the 2015 adjusted heat input for each state is equal to its 2015 reported historical heat input.

[15] Unlike the manner in which the EPA calculated state budgets that were finalized in this rule, the EPA did not include the 2017 emissions and heat input adjustments in the calculating the budgets that were included in the IPM modeling of the Illustrative for Final Policy Cases. This is because the 2017 adjustments are done to account for emissions that are not captured in the IPM 2018 run year, emissions that the model would not need allowances to cover. Including these 2017 adjustments in the budgets modeled in IPM would artificially inflate the state budgets and assurance levels in the model. Therefore, analogous budgets without the 2017 adjustments were calculated for the purpose of modeling in IPM. For the Final Policy Case, this only resulted in a total regional budget difference of 907 tons. The state budgets and assurance levels used in IPM are shown in Appendix E.

[16] The Base Case can be considered equivalent to a $0 per ton cost threshold run, with a corresponding "budget." To calculate the equivalent "budget" for the Base Case using this process, the change in emissions rate for any state is zero. Applied through the rest of the budget calculation process, this means that the base case "budgets" are equal to the adjusted 2015 historical emissions.

shown in table C-3.[17] The variability limits, assurance levels, New Unit Set-Asides and Indian Country New Unit Set-Asides as further described in section VII of the preamble for the final CSAPR Update.

A complicating factor of this analysis was the Pennsylvania RACT (PA RACT) Rule that was finalized in April 2016. The PA RACT Rule will lead to reductions in ozone season $NO_X$ in Pennsylvania, but not have an impact until 2017, the first year the Final CSAPR Rule would be in effect. The EPA determined it was reasonable to not include it in its IPM modeling because it would lead to a budget for Pennsylvania that does not reflect achievable emission reductions by way of applying a regional uniform $NO_X$ control stringency for the 22 CSAPR Update states. In other words, if EPA included PA RACT in the IPM modeling, then Pennsylvania's resulting budget would not be commensurate with other state budgets for the final CSAPR Update. That is because the budget setting methodology uses the change in emissions rate between a Base Case and a Cost Threshold case, and 2015 historical emissions data. Including the PA RACT in the Base Case for this rule would lead to a small change in emissions rates between cases and apply that to historical data that does not reflect the PA RACT Rule. Mixing 2015 historical data that does not reflect the impact of the PA RACT with IPM cases that does reflect the PA RACT would yield budgets that were too large. However, as explained in the Memo to the Docket "The Pennsylvania Additional RACT Requirements for Major Sources of $NO_X$ and VOCs," the EPA found it reasonable to factor the PA RACT requirements into air quality modeling using AQAT, and reflect its costs and emissions reductions in the Illustrative and Final Base Cases and $800 per ton Cost Threshold Cases in the RIA.

As explained in the preamble, the EPA is promulgating EGU $NO_X$ ozone season emission budgets reflecting the uniform cost threshold of $1,400 per ton to reduce significant contribution to nonattainment and interference with maintenance. These budgets were calculated from the Final $1,400 per ton Cost Threshold run.

For the RIA analysis, budgets calculated from the Illustrative $1,400 per ton Cost Threshold run were used for the Illustrative Policy case. Additionally, the RIA includes analysis of the Illustrative Less Stringent policy option, using the budgets from the Illustrative $800 per ton Cost Threshold case, and an Illustrative More Stringent policy alternative, using the budgets from the Illustrative $3,400 per ton Cost Threshold case. The EPA also included additional analysis of the Final Policy case in Appendix 4-A of the RIA.

The IPM runs performed for the cost threshold analyses are listed in Appendix A of this TSD. Table Appendix A-1 lists the name of each IPM run next to a description of the run. The output files of these model runs can be found in the rulemaking docket. Detailed budget calculations for all Cost Threshold cases and the assurance levels used for Policy Cases can be found in Appendix E.

[17] See 'O3 NAAQS CSAPR Update -- NUSA Calculations' (Excel spreadsheet) in the docket.

## Table C-1. Calculated Budgets for States for Final Cost Threshold Runs.

| State | State Covered by Final CSAPR Update Rule? | Final Base Case | Final $800/ton Cost Threshold | Final $1400/ton Cost Threshold | Final $3400/ton Cost Threshold | Final $5000/ton Cost Threshold | Final $6400/ton Cost Threshold |
|---|---|---|---|---|---|---|---|
| **Alabama** | Y | 15,179 | 14,332 | 13,211 | 12,620 | 11,928 | 11,573 |
| **Arkansas**[18] | Y | 12,560 | 12,048 | 9,210 | 9,048 | 8,518 | 8,050 |
| **Arizona** | | 10,710 | 10,680 | 9,810 | 9,788 | 9,710 | 9,486 |
| **California** | | 1,905 | 1,905 | 1,905 | 1,905 | 1,810 | 1,810 |
| **Colorado** | | 14,010 | 14,008 | 13,994 | 13,645 | 13,495 | 12,950 |
| **Connecticut** | | 605 | 584 | 558 | 558 | 554 | 554 |
| **Delaware** | | 497 | 497 | 497 | 494 | 494 | 494 |
| **Florida** | | 22,779 | 21,611 | 17,123 | 16,631 | 16,481 | 16,375 |
| **Georgia** | | 8,762 | 8,495 | 8,481 | 8,525 | 8,532 | 7,764 |
| **Iowa** | Y | 11,478 | 11,477 | 11,272 | 11,065 | 10,891 | 10,491 |
| **Idaho** | | 152 | 152 | 152 | 152 | 152 | 152 |
| **Illinois** | Y | 14,850 | 14,682 | 14,601 | 14,515 | 14,248 | 14,054 |
| **Indiana** | Y | 31,382 | 28,960 | 23,303 | 21,634 | 19,990 | 18,720 |
| **Kansas** | Y | 8,031 | 8,030 | 8,027 | 7,975 | 7,962 | 7,767 |
| **Kentucky** | Y | 26,318 | 24,052 | 21,115 | 21,007 | 20,273 | 19,496 |
| **Louisiana** | Y | 19,101 | 19,096 | 18,639 | 18,452 | 18,442 | 18,426 |
| **Massachusetts** | | 1,119 | 1,119 | 1,112 | 1,098 | 1,071 | 1,072 |
| **Maryland** | Y | 3,871 | 3,870 | 3,828 | 3,308 | 2,938 | 2,926 |
| **Maine** | | 109 | 109 | 109 | 109 | 109 | 109 |
| **Michigan** | Y | 19,811 | 19,558 | 16,545 | 15,298 | 12,616 | 12,115 |
| **Minnesota** | | 7,068 | 7,068 | 6,864 | 6,761 | 6,651 | 6,451 |
| **Missouri** | Y | 18,443 | 17,250 | 15,780 | 15,299 | 14,673 | 14,555 |
| **Mississippi** | Y | 6,438 | 6,438 | 6,315 | 6,243 | 6,203 | 6,205 |
| **Montana** | | 6,540 | 6,540 | 6,540 | 6,535 | 6,535 | 6,535 |
| **North Carolina** | | 17,419 | 14,424 | 14,326 | 13,189 | 12,460 | 12,207 |
| **North Dakota** | | 18,738 | 18,398 | 18,016 | 17,655 | 17,497 | 17,435 |
| **Nebraska** | | 9,737 | 9,678 | 8,970 | 7,197 | 6,467 | 6,448 |
| **New Hampshire** | | 416 | 416 | 416 | 416 | 415 | 415 |
| **New Jersey** | Y | 2,114 | 2,100 | 2,062 | 2,008 | 1,867 | 1,879 |
| **New Mexico** | | 9,443 | 9,443 | 9,055 | 8,921 | 8,746 | 8,650 |
| **Nevada** | | 2,405 | 2,301 | 2,241 | 2,112 | 1,559 | 886 |
| **New York** | Y | 5,531 | 5,220 | 5,135 | 5,006 | 4,746 | 4,594 |
| **Ohio** | Y | 27,382 | 23,659 | 19,522 | 19,165 | 18,561 | 18,348 |
| **Oklahoma** | Y | 13,747 | 13,746 | 11,641 | 9,174 | 8,790 | 8,439 |
| **Oregon** | | --- | --- | --- | --- | --- | --- |
| **Pennsylvania** | Y | 35,607 | 30,852 | 17,952 | 17,928 | 17,621 | 17,374 |
| **Rhode Island** | | 283 | 283 | 283 | 283 | 283 | 283 |
| **South Carolina** | | 5,486 | 5,288 | 5,288 | 5,293 | 5,300 | 5,318 |
| **South Dakota** | | 853 | 853 | 853 | 853 | 853 | 853 |
| **Tennessee** | Y | 7,779 | 7,736 | 7,736 | 7,735 | 7,724 | 7,729 |
| **Texas** | Y | 54,839 | 54,521 | 52,301 | 50,011 | 48,795 | 47,994 |
| **Utah** | | 16,949 | 16,949 | 14,149 | 13,592 | 11,356 | 11,324 |
| **Virginia** | Y | 9,367 | 9,365 | 9,223 | 8,754 | 8,619 | 8,416 |
| **Vermont** | | 52 | 52 | 52 | 52 | 52 | 52 |
| **Washington** | | 3,085 | 3,085 | 3,085 | 3,085 | 3,085 | 3,085 |
| **Wisconsin** | Y | 7,939 | 7,924 | 7,915 | 7,790 | 7,435 | 7,023 |
| **West Virginia** | Y | 26,874 | 25,984 | 17,815 | 17,380 | 17,388 | 17,373 |
| **Wyoming** | | 16,005 | 15,828 | 14,691 | 13,728 | 12,371 | 12,121 |
| **CSAPR State Total** | | **378,641** | **360,900** | **313,148** | **301,415** | **290,228** | **283,547** |

[18] The calculated budgets shown in this table for Arkansas correspond to its budget for 2018 and subsequent control periods. As discussed in Preamble Section VI.D, Arkansas's 2017 is 12,048 tons.

**Table C.2. State Budgets, Variability Limits, and Assurance Levels for the CSAPR Update Rule.**

| State | Budget | Variability Limit | Assurance Level |
|---|---|---|---|
| **Alabama** | 13,211 | 2,774 | 15,985 |
| **Arkansas**[19] | 12,048 (2017)<br>9,210 (2018+) | 2,530 (2017)<br>1,934 (2018+) | 11,144 (2017)<br>14, 478 (2018+) |
| **Iowa** | 11,272 | 2,367 | 13,639 |
| **Illinois** | 14,601 | 3,066 | 17,667 |
| **Indiana** | 23,303 | 4,894 | 28,197 |
| **Kansas** | 8,027 | 1,686 | 9,713 |
| **Kentucky** | 21,115 | 4,434 | 25,549 |
| **Louisiana** | 18,639 | 3,914 | 22,553 |
| **Maryland** | 3,828 | 804 | 4,632 |
| **Michigan** | 16,545 | 3,474 | 20,019 |
| **Missouri** | 15,780 | 3,314 | 19,094 |
| **Mississippi** | 6,315 | 1,326 | 7,641 |
| **New Jersey** | 2,062 | 433 | 2,495 |
| **New York** | 5,135 | 1,078 | 6,213 |
| **Ohio** | 19,522 | 4,100 | 23,622 |
| **Oklahoma** | 11,641 | 2,445 | 14,086 |
| **Pennsylvania** | 17,952 | 3,770 | 21,722 |
| **Tennessee** | 7,736 | 1,625 | 9,361 |
| **Texas** | 52,301 | 10,983 | 63,284 |
| **Virginia** | 9,223 | 1,937 | 11,160 |
| **Wisconsin** | 7,915 | 1,662 | 9,577 |
| **West Virginia** | 17,815 | 3,741 | 21,556 |
| **CSAPR Update Region Total** | **313,986 (2017)<br>313,148 (2018+)** | **N/A** | **N/A** |

[19] As discussed in Preamble Section VI.D, Arkansas's 2017 is 12,048 tons and 9,210 tons in 2018 and subsequent control periods.

**Table C-3. Existing unit allocation and NUSA, including the Indian Country NUSA, for the Final CSAPR Update Budgets.**

| State | Final 2017* EGU $NO_X$ Emission Budgets (tons) | New unit set-aside amount (percent) | New unit set-aside amount (tons)[1] | Indian country new unit set-aside amount (tons) |
|---|---|---|---|---|
| Alabama | 13,211 | 2 | 255 | 13 |
| Arkansas* | 12,048/9,210 | 2/2 | 240/185 | |
| Illinois | 14,601 | 2 | 302 | |
| Indiana | 23,303 | 2 | 468 | |
| Iowa | 11,272 | 3 | 324 | 11 |
| Kansas | 8,027 | 2 | 148 | 8 |
| Kentucky | 21,115 | 2 | 426 | |
| Louisiana | 18,639 | 2 | 352 | 19 |
| Maryland | 3,828 | 4 | 152 | |
| Michigan | 16,545 | 4 | 643 | 17 |
| Mississippi | 6,315 | 2 | 120 | 6 |
| Missouri | 15,780 | 2 | 324 | |
| New Jersey | 2,062 | 9 | 192 | |
| New York | 5,135 | 5 | 252 | 5 |
| Ohio | 19,522 | 2 | 401 | |
| Oklahoma | 11,641 | 2 | 221 | 12 |
| Pennsylvania | 17,952 | 3 | 541 | |
| Tennessee | 7,736 | 2 | 156 | |
| Texas | 52,301 | 2 | 998 | 52 |
| Virginia | 9,223 | 6 | 562 | |
| West Virginia | 17,815 | 2 | 356 | |
| Wisconsin | 7,915 | 2 | 151 | 8 |

[1] New-unit set-aside amount (tons) does not include the Indian country new unit set-aside amount (tons).
*The EPA is finalizing CSAPR EGU $NO_X$ ozone season emission budgets for Arkansas of 12,048 tons for 2017 and 9,210 tons for 2018 and subsequent control periods.

**3.** Assessing the Impact of Limiting Inter-State Generation Shifting

As described in preamble section VI, the EPA limited its assessment of shifting generation to other EGUs within the same state as a proxy for the amount of generation shifting that could occur for the 2017 ozone season. The amount of $NO_X$ reductions between the IPM cases that were used to quantify the emission budgets under this assumption can be found in Appendix F. To determine the impact of this assumption, the EPA conducted a separate analysis similar to the $1,400 per ton cost threshold scenario, except without limiting IPM's ability to shift generation between states. EPA calculated budgets from this alternative case and compared them to the final budgets, also shown in Appendix F. This analysis showed that budgets would only be 1,101 tons lower in the CSAPR region compared to the final budgets if the EPA assumed generation shifting was unrestricted between the states, or 0.35% of the sum of the final CSAPR state budgets.

At the state level, 19 of the 22 states had budgets less than 1% different and two additional states had changes of less than 2%, when comparing this alternative case to the approach used in the final rule. One state, Maryland, had an alternative budget 20% lower than its final budget. These results show two things. First, overall, this constraint had minimal impacts on state budgets. Second, in one case, the constraint did significantly impact a state budget, lowering Maryland's budget 20% as generation was shifted out of state. This evaluation supports EPA's determination that it was reasonable to use a conservative estimate of the potential for emissions reductions from generation shifting in the relatively short timeframe of this particular rule by limiting IPM's ability to shift generation among states in the modeling projections to inform state budget quantification.

**D. Analysis of Air Quality Responses to Emission Changes Using an Ozone Air Quality Assessment Tool (AQAT)**

EPA has defined each linked upwind state's significant contribution to nonattainment and interference with maintenance of downwind air quality using a multi-factor test (described in the preamble at section VI in step three of the CSAPR framework) which is based on cost, emissions, and air quality factors. A key quantitative input for determining the amount of each state's emission reduction obligation is the predicted downwind ambient air quality impacts of upwind EGU emission reductions under the budgets at various levels of $NO_X$ emission control (see in section C of this TSD). The emission reductions under the various levels of emission budgets can result in air quality improvements such that individual receptors drop below the level of the NAAQS based on the cumulative air quality improvement from the states, as well as decrease each upwind state's contributions such that they possibly drop below the 1% threshold that was used to identify the states for further analysis in step 2 of the CSAPR framework.

Direct simulation of air quality in CAMx would be the optimal way to examine these questions at each level of emission budgets. However, time and resource limitations (in particular the amount of time needed to set up, run the CAMx model, and analyze the results for a single model run) precluded the use of full air quality modeling for all but a few emissions scenarios. Therefore, in order to estimate the air quality impacts for the various levels of emission budgets and for the illustrative control alternative, EPA used a simplified air quality assessment tool (AQAT).[20] The simplified tool allows the Agency to analyze many more $NO_X$ emission budget levels than would otherwise be possible. The inputs and outputs of the tool can be found in the "AQAT_final_calibrated.xlsx" excel workbook.

The remainder of section D of this document will:

- Present an introduction and overview of the ozone AQAT;
- Describe the construction of the ozone AQAT; and
- Provide the results of the $NO_X$ emission budget level analyses.

1. Introduction: Development of the ozone AQAT

The ozone AQAT was developed for use in the rule's step three air quality analysis as part of the multi-factor test. Specifically, the AQAT was designed to evaluate air quality changes in response to emissions changes in order to quantify necessary emission reductions under the good neighbor provision and to evaluate potential budgets for over-control as to either the 1% threshold or the downwind receptor status. EPA described and used a similar tool in the original CSAPR to evaluate good neighbor obligations with respect to the fine particulate matter ($PM_{2.5}$) NAAQS and in the proposed CSAPR Update to evaluate good neighbor obligations with respect to ozone. For the CSAPR Update, EPA refined both the construction and application of the assessment tool for use in estimating changes in ozone concentrations in response to changes in $NO_X$ emissions. One important change

[20] EPA used CAMx to model both the base case (i.e., to determine the receptors and the contributions of each state to those receptors) and the final budget policy scenario. The air quality estimates in AQAT were comparable to design values in CAMx for the final illustrative control scenario, suggesting that the air quality estimates for alternative control scenarios performed using AQAT are also reasonable.

between the original CSAPR and this effort is to use AQAT to examine changes in ozone rather than $PM_{2.5}$. We followed the methodology developed in the original CSAPR rulemaking where we calibrate the response of a pollutant using two CAMx simulations at different emission levels.[21,22]

A critical factor in the assessment tool is the establishment of a relationship between ozone season $NO_X$ emission reductions and reductions in ozone. Within AQAT, we assume that the reduction of a ton of emissions of $NO_X$ from the upwind state results in a particular level of improvement in air quality downwind.[23] For the purposes of developing and using an assessment tool to compare the air quality impacts of $NO_X$ emission reductions under various emission budget levels, we determine the relationship between changes in emissions and changes in ozone contributions on a receptor-by-receptor basis. Specifically, EPA assumed that, within the range of total $NO_X$ emissions being considered (as defined by the emission budget levels), a change in ozone season $NO_X$ emissions leads to a proportional change in downwind ozone contributions.[24] This proportional relationship was then modified using calibration factors created using the 2017 base case contribution air quality modeling and the 2017 illustrative control case from the proposal to account for the majority of the nonlinearity between emissions and ozone concentrations.[25] For example, we assume that a 20% decrease in the upwind state's emissions leads to a 20% decrease in its downwind ozone contribution in the

[21] In CSAPR, we estimated changes in sulfate using changes in $SO_2$ emissions.

[22] In this rule, we used CAMx to calibrate the assessment tool's predicted change in ozone concentrations to changes in $NO_X$ emissions. This calibration is receptor-specific and is based on the changes in $NO_X$ emissions and resulting ozone concentrations between the 2017 base case and the modeled "illustrative control case" in 2017 from the modeling conducted for the proposed rule. This "illustrative control case" was created during the development of the assessment tool for the proposed rule and is an EGU $NO_X$ ozone-season emission budget sensitivity scenario at $1,300/ton for ozone-season $NO_X$, reflecting emission reductions from sources in the 23 eastern states that the EPA proposed to regulate under the rule. One intent of this control scenario was to create a calibration point within the range of all emission reductions for the geography examined by EPA using the AQAT. This calibration point was used to create site-specific calibration factors so that the response of ozone concentrations to upwind $NO_X$ emission changes would more-closely align with ozone estimates from CAMx.

[23] This downwind air quality improvement is assumed to be indifferent to the source sector or the location of the particular emission source within the state where the ton was reduced. For example, reducing one ton of $NO_X$ emissions from the power sector is assumed to have the same downwind ozone reduction as reducing one ton of $NO_X$ emissions from the mobile source sector. Because the emission reductions from base case to the 2017 illustrative control case at proposal and the resulting air quality improvements per ton of reduction occur exclusively from the power sector, the calibration factor and thereby calibrated ozone AQAT is tuned to changes in emissions in the power sector.

[24]As noted by EPA at proposal and as stated by commenters, the relationship between $NO_X$ emissions and ozone concentrations is known to be non-linear when examined over large ranges of $NO_X$ emissions (e.g., J.H. Seinfeld and S.N. Pandis, Atmospheric Chemistry and Physics From Air Pollution to Climate Change, 2nd Edition, John Wiley and Sons, 2006, Hoboken, NJ, pp 236-237). However, for some ranges of $NO_X$, VOC, and meteorological conditions, the relationship may be reasonably linear. In this assessment tool, we are assuming a linear relationship between $NO_X$ emissions and ozone concentrations calibrated between two CAMx simulations. To the extent that the changes in concentrations are the result of small changes in emissions, EPA disagrees with commenters assertions that these relationships are highly nonlinear. The nonlinearities are evident over tens of ppb of ozone changes with tens of percent changes in the overall emission inventories. For most states examined here, under the various control scenarios, most changes in the emission inventory are on the order of a few percent and most air quality changes are on the order of a fraction of a ppb. A significant portion of the nonlinearity is accounted for by using the calibration factor and having the air quality estimates occur at levels of emissions around the base case and the illustrative control case (which were both modeled in CAMx). In the EPA's air quality estimates using the calibrated AQAT, to the extent that uncertainties and non-linearities are present, they are more-likely to be the result of assuming uniform percent changes in statewide emissions, rather than changes in emissions at particular sources.

[25] *See* the Ozone Transport Policy Analysis TSD, EPA-HQ-OAR-2015-0500-0186 and the Ozone AQAT ,EPA-HQ-OAR-2015-0500-0069, both from the prosed rule, for the values and a description of the calibration factors from proposal.

“uncalibrated” ozone AQAT, while it may only decrease by 10% decrease in “calibrated” AQAT (where the calibration factor is 0.5).

The creation of the calibration factors is described in detail in section D.2.c (1).

In summary, because the tool is only being used over a fairly narrow emissions range (for which a calibration factor has been developed), and because other options such as using CAMx to model all scenarios is cost and time-prohibitive, EPA used ozone AQAT to estimate the downwind ozone reductions due to upwind $NO_X$ emission reductions for the air quality input to the multi-factor test for this rule. Other options, such as directly scaling the results (i.e., an “uncalibrated ozone AQAT”) will likely greatly overestimate the air quality impacts of emission reductions. The successful comparison of the AQAT estimates with the CAMx results for the $1,400/ton final illustrative control scenario demonstrates that, for the purposes here, the AQAT can sufficiently estimate the air quality impacts of relatively small emission changes.

Section D.2, below, is a technical explanation of the construction of the ozone AQAT. Readers who prefer to access the results of the analysis using the ozone AQAT are directed to section D.3.

2. Details on the construction of the ozone AQAT

(a) Overview of the ozone AQAT

This section describes the step-by-step development process for the ozone AQAT. All of the input and output data can be found in the Excel worksheets described in Appendix B. In the ozone AQAT, EPA links state-by-state $NO_X$ emission reductions (derived from the IPM EGU modeling) with CAMx modeled ozone contributions in order to predict ozone concentrations at different levels of emission budgets at monitoring sites. The reduction in ozone contributions at each level of emissions budgets and the resulting air quality improvement at monitoring sites with projected nonattainment and/or maintenance problems in the 2017 base case were then considered in a multi-factor test for identifying the level of emissions reductions that define significant contribution to nonattainment and interference with maintenance.

In applying AQAT to analyze air quality improvements at a given receptor, emissions were reduced in only those upwind states that were “linked” to that receptor in step 2 of the CSAPR framework (i.e., those states that contributed an air quality impact at or above the 1 percent of the NAAQS). Emissions were also reduced in the state that contained that receptor (regardless of the level of that state’s contribution) at a level of control stringency consistent with the budget level applied in upwind states.

Specifically, the key estimates from the ozone AQAT for each receptor are:

- The ozone contribution as a function of emissions at each budget level, for each upwind state that is contributing above the 1 percent air quality threshold and the state containing the receptor.
- The ozone contribution under base case $NO_X$ emissions (i.e., the adjusted historic IPM 5.15 base case, or $0 per ton emission budget), for each upwind state that is not above the 1 percent air quality threshold for that receptor.

- The non-anthropogenic (i.e., background, boundary, biogenic, and wildfire) ozone concentrations. These are assumed to be constant and equal to the contributions from the 2017 final base case source apportionment modeling.

The results of the ozone AQAT analysis for each emission budget level can be found in section D.3 of this document.

(b) Data used to construct the ozone AQAT for this rule

Several air quality modeling and emissions inventory sources were used to construct the calibrated ozone AQAT for this rule. Several data sources from proposal provide the necessary information to construct the calibration factors.[26] Using the calibration factors, EPA modulated the final 2017 CAMx ozone season contributions for each upwind state to each downwind receptor. For each scenario, EPA multiplied each state's percent change in emissions at each emission budget level relative to the 2017 base case ozone season $NO_X$ emission inventories from all source sectors used in the source apportionment CAMx air quality modeling (this includes all anthropogenic sources and excludes biogenic sources and wildfires) by the receptor-specific calibration factor and the state's base case contribution. Note that the change in emissions for each emission budget level is compared with the IPM emission estimates from the base case that was modeled in CAMx. The base case emission inventories for the 2017 base case and the CAMx 2017 base case source apportionment air quality modeling results are discussed in the Air Quality Modeling Technical Support Document for the Final Cross-State Air Pollution Rule Update. The ozone season $NO_X$ EGU emissions for each emission budget level including the base case as modeled in AQAT, are listed in Table D-3 and described in section C of this TSD.

As described in the Air Quality Modeling Technical Support Document for the Final Cross-State Air Pollution Rule Update and the preamble at section V, the air quality contributions and emissions were modeled for all states in the contiguous United States and the District of Columbia. Thus, in the ozone AQAT, any emission differences between the air quality modeling base case and the base case emissions budget scenario or the emission budget cost levels (for linked states) would result in changes in air quality contributions and ozone concentrations at the downwind monitors.[27]

[26]EPA used the proposal calibration factors, rather than calibration factors based on the final modeling because we found them to have more-representative emission reductions throughout the 22 state geography. The final budget control scenario has smaller emission reductions compared with the proposal budget control scenarios. In addition, for the final modeling, the geographic distribution of emissions changed between the air quality modeling base and $1,400/ton illustrative control cases, leading to calibration factors that seemed to be unusually large or small. The datasets required to construct the calibration factors were: the proposed 2017 base case ozone-season $NO_X$ emission inventories from all source sectors used in the source apportionment CAMx air quality modeling (this includes all anthropogenic sources and excludes biogenic sources and wildfires); the proposed CAMx 2017 ozone-season contributions for each upwind state to each downwind receptor; and the proposed 2017 illustrative control case ozone-season $NO_X$ emissions inventories from all source sectors. An additional dataset, the proposed 2017 ozone concentrations from CAMx for the illustrative control case, was used to compare the ozone AQAT-estimated ozone concentrations for this scenario to the corresponding air quality modeling results, and develop calibration factors to align the response of ozone to changes in $NO_X$ emissions in the ozone AQAT with the response predicted by CAMx. See the Ozone AQAT ,EPA-HQ-OAR-2015-0500-0069 from the proposed rule for the data and results.

[27] Because the illustrative control case does not include emission changes in some upwind states (e.g., states in the western portion of the domain), calibration factors developed for monitors in these states, and any resulting changes in air quality projected by AQAT, may not be representative.

(c) Detailed outline of the process for constructing and utilizing the ozone AQAT

The ozone AQAT was created and used in a multi-step process. First, using the data sets and the AQAT from the proposed CSAPR Update, calibration factors were created. Next, a calibrated ozone AQAT was created using the contributions and emission inventory from the 2017 base case air quality modeling for the final rule. For each emissions budget scenario evaluated, for each state, EPA identified the percent change in anthropogenic $NO_X$ emissions relative to the 2017 base case and multiplied this by the receptor-specific calibration factor as well as by the state- and receptor-specific contribution. This resulted in a state- and receptor-specific "change in contribution" relative to the 2017 base case. Each state's change in contribution value was then added to its 2017 base case contribution and the results summed for all states for each receptor. To this total of each state's contribution to each receptor, the receptor-specific base case contributions from the other source-categories was added, resulting in an estimated design value for each receptor.[28] The calibrated ozone AQAT was used to project the ozone concentrations for each $NO_X$ emission budget level on a receptor-by-receptor basis for every monitor throughout the domain.

In order to facilitate understanding of the calibration process, EPA describes below a demonstrative example used at proposal: monitor number 240251001 in Harford County, Maryland, with a 2017 base case projected ozone average design value of 81.3 ppb and maximum design value of 84.0 ppb, at proposal.

(1) Create the calibration factors

The process for creating the calibration factors remains unchanged from the proposal. Furthermore, EPA used those data sets and retained the same calibration factors used at proposal (i.e., in the remainder of this subsection D.2.c.(1), we refer to data sets from the proposal). To create the calibration factors, EPA used emissions and contributions from proposal to estimate the change in predicted ozone due to $NO_X$ emission reductions under the proposed illustrative control case relative to the proposed 2017 base case.

First, EPA calculated ozone season state-level 2017 base case total $NO_X$ emissions from all source sectors from the proposal. These emissions estimates were used for the proposed rule's CAMx 2017 source apportionment modeling. This emissions data is divided into multiple source sectors for the purposes of air quality modeling: power sector point, non-power sector point, non-point, onroad, nonroad, C3 marine, alm, and fires (see the Emissions Inventory TSD from the proposed rule for additional details on the emissions inventories used in the CAMx air quality modeling).[29] The state-level total $NO_X$ emissions are the sum of emissions from all these source sectors. Next, EPA calculated the ozone season 2017 total $NO_X$ emissions across all source sectors for the illustrative control case. EPA calculated the ratio of the emissions for the illustrative control case to the total emissions for the base case for each state modeled in CAMx. More information on the emissions inventories can be found in the preamble to the proposed rule and in the August 4, 2015 Notice of Data

[28] Details on procedures for calculating average and maximum design values can be found in the Air Quality Modeling Technical Support Document for the Final Cross-State Air Pollution Rule Update.
[29] "Technical Support Document (TSD) Preparation of Emissions Inventories for the Version 6.2, 2011 Emissions Modeling Platform", available at www.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf

Availability, or NODA.[6] The total emissions data and resulting ratios from the proposal can be found in Table D-1.

For each monitor, the "uncalibrated" change in concentration from proposal was found by multiplying the 2017 base case ozone contribution by the difference in the ratio of emissions. The difference in the ratio of emissions was calculated as the difference in total ozone season $NO_X$ emissions between the illustrative control case and the 2017 base case scenario divided by the 2017 base case emission. Thus, when the illustrative control case had smaller emissions than the base case, the net result was a negative number. The change in concentrations summed across all states was the total "uncalibrated" change in concentration.

**Table D-1. From the Proposed Rule, the 2017 Base Case and 2017 Illustrative Control Case Ozone Contributions (ppb) for Monitor Number 240251001 in Harford County, Maryland, as well as Total $NO_X$ Emissions from all Source-Sectors (tons) for Each State.**

| State/Source | 2017 Base Case Ozone Contributions | 2017 Base Case $NO_X$ Emissions | 2017 Illustrative Control Case $NO_X$ Emissions | Ratio of Illustrative Control Case Emissions to Base Case Emissions | Difference between the Illustrative Control Case Emissions and Base Case Emissions as a Fraction of Base Case Emissions | Estimated 2017 Contribution of Ozone (Uncalibrated Ozone AQAT) |
|---|---|---|---|---|---|---|
| AL | 0.4053 | 88,805 | 85,721 | 0.97 | -0.03 | -0.01 |
| AZ | 0.0958 | 71,906 | 71,906 | 1.00 | 0.00 | 0.00 |
| AR | 0.2264 | 69,737 | 69,039 | 0.99 | -0.01 | 0.00 |
| CA | 0.1106 | 236,322 | 236,322 | 1.00 | 0.00 | 0.00 |
| CO | 0.1942 | 90,756 | 90,756 | 1.00 | 0.00 | 0.00 |
| CT | 0.011 | 17,672 | 17,672 | 1.00 | 0.00 | 0.00 |
| DE | 0.1559 | 7,786 | 7,786 | 1.00 | 0.00 | 0.00 |
| DC | 0.7334 | 2,252 | 2,252 | 1.00 | 0.00 | 0.00 |
| FL | 0.1141 | 177,514 | 177,513 | 1.00 | 0.00 | 0.00 |
| GA | 0.3035 | 103,536 | 103,526 | 1.00 | 0.00 | 0.00 |
| ID | 0.0349 | 27,893 | 27,893 | 1.00 | 0.00 | 0.00 |
| IL | 0.672 | 148,178 | 147,770 | 1.00 | 0.00 | 0.00 |
| IN | 1.8904 | 139,133 | 127,487 | 0.92 | -0.08 | -0.16 |
| IA | 0.1933 | 70,467 | 70,045 | 0.99 | -0.01 | 0.00 |
| KS | 0.285 | 79,939 | 79,513 | 0.99 | -0.01 | 0.00 |
| KY | 1.973 | 106,830 | 97,311 | 0.91 | -0.09 | -0.18 |
| LA | 0.2597 | 173,330 | 172,886 | 1.00 | 0.00 | 0.00 |
| ME | 0.0005 | 17,576 | 17,576 | 1.00 | 0.00 | 0.00 |
| MD | 24.619 | 46,029 | 45,312 | 0.98 | -0.02 | -0.38 |
| MA | 0.0037 | 35,369 | 35,369 | 1.00 | 0.00 | 0.00 |
| MI | 0.8339 | 131,486 | 124,374 | 0.95 | -0.05 | -0.05 |
| MN | 0.1142 | 89,328 | 89,332 | 1.00 | 0.00 | 0.00 |
| MS | 0.1596 | 54,832 | 54,706 | 1.00 | 0.00 | 0.00 |
| MO | 0.5299 | 101,035 | 99,736 | 0.99 | -0.01 | -0.01 |
| MT | 0.0688 | 38,504 | 38,504 | 1.00 | 0.00 | 0.00 |
| NE | 0.1569 | 70,005 | 70,005 | 1.00 | 0.00 | 0.00 |
| NV | 0.0279 | 28,192 | 28,192 | 1.00 | 0.00 | 0.00 |
| NH | 0.0009 | 8,932 | 8,932 | 1.00 | 0.00 | 0.00 |
| NJ | 0.4374 | 52,743 | 52,031 | 0.99 | -0.01 | -0.01 |
| NM | 0.1688 | 65,263 | 65,263 | 1.00 | 0.00 | 0.00 |
| NY | 0.4009 | 109,910 | 107,416 | 0.98 | -0.02 | -0.01 |
| NC | 0.4684 | 98,064 | 91,850 | 0.94 | -0.06 | -0.03 |
| ND | 0.0848 | 74,118 | 74,118 | 1.00 | 0.00 | 0.00 |
| OH | 4.0022 | 160,110 | 150,516 | 0.94 | -0.06 | -0.24 |
| OK | 0.4683 | 131,763 | 129,215 | 0.98 | -0.02 | -0.01 |
| OR | 0.0232 | 40,507 | 40,507 | 1.00 | 0.00 | 0.00 |
| PA | 6.0769 | 174,664 | 147,166 | 0.84 | -0.16 | -0.96 |
| RI | 0.0006 | 5,845 | 5,844 | 1.00 | 0.00 | 0.00 |
| SC | 0.1097 | 55,897 | 55,846 | 1.00 | 0.00 | 0.00 |
| SD | 0.0587 | 22,192 | 22,192 | 1.00 | 0.00 | 0.00 |
| TN | 0.7044 | 85,759 | 85,693 | 1.00 | 0.00 | 0.00 |
| TX | 1.0563 | 467,245 | 465,179 | 1.00 | 0.00 | 0.00 |
| UT | 0.0942 | 66,486 | 66,486 | 1.00 | 0.00 | 0.00 |
| VT | 0.0015 | 5,473 | 5,473 | 1.00 | 0.00 | 0.00 |
| VA | 5.3016 | 87,754 | 87,514 | 1.00 | 0.00 | -0.01 |
| WA | 0.0327 | 75,833 | 75,833 | 1.00 | 0.00 | 0.00 |
| WV | 2.9988 | 64,839 | 53,954 | 0.83 | -0.17 | -0.50 |
| WI | 0.2178 | 75,047 | 75,035 | 1.00 | 0.00 | 0.00 |
| WY | 0.2063 | 68,864 | 68,864 | 1.00 | 0.00 | 0.00 |
| TRIBAL | 0.0436 | 26,717 | 26,717 | 1.00 | 0.00 | 0.00 |
| CNMX | 0.7368 | | | 1.00 | 0.00 | 0.00 |
| OFFSHORE | 0.4494 | | | 1.00 | 0.00 | 0.00 |
| FIRE | 0.3074 | | | 1.00 | 0.00 | 0.00 |
| ICBC | 16.652 | | | 1.00 | 0.00 | 0.00 |
| BIOG | 6.0915 | | | 1.00 | 0.00 | 0.00 |

Next, the estimate of the monitor specific ozone responses under the illustrative control case was used to calibrate the ozone AQAT to CAMx and to derive the calibration factor. First, the changes in ozone predicted by the ozone AQAT and CAMx for the average design values were calculated for each monitor for the illustrative control case relative to the 2017 base case concentrations. The change in ozone predicted by CAMx was then divided by the change in ozone predicted by the uncalibrated AQAT, resulting in a monitor-specific calibration factor (see Table D-2 for an example calculation). The calculation of these monitor-specific calibration factors provided EPA with the ability to align the ozone response predicted by the ozone AQAT to the ozone response predicted by CAMx at a level of $NO_X$ reductions that EPA expected to be close to the range of all emission reductions examined by EPA for the final rule.

The ozone AQAT and CAMx concentration differences from proposal can be found in the "ozone_AQAT.xlsx" excel workbook on worksheet "2017 contributions uncalibrated" in columns BN and BO, respectively.[25] The resulting calibration factor from the proposal can be found in column BP of the aforementioned excel worksheet.

Following the completion of the AQAT analysis and modeling of the $1,400/ton level of the budget control scenario in CAMx, EPA was able to calculate updated calibration factors using the differences in concentrations and emissions between the base case and budget control cases. EPA examined all of the AQAT estimates for receptors using the final calibration factors and did not observe differences that would have resulted in substantive changes in the application of the multi-factor test (i.e., the status of receptors remained unchanged, either attainment, nonattainment, or maintenance at each emission budget level).

A comparison of the calibrations is shown in Figure 1, for the receptors in the rule (left panel) and overall, for all receptors in the eastern US (right panel). During the course of this analysis, EPA noticed, for some monitors (generally ones that were not nonattainment and/or maintenance receptors in the base case and often were located in the western US) that the final calibration factors led to nonintuitive results. In part, this may be a result of changes in the EGU emission estimates between the initial base case CAMx modeling and the final budget scenarios (particularly for states that are not in the geography of the final rule). Consequently, EPA elected to continue its use of the calibration factors from the proposal.[26] Using the calibration factors from the proposal in the creation of the final calibrated AQAT also enabled EPA to evaluate the AQAT estimates for the final rule by comparing them to the final air quality modeling of the illustrative budget control scenario since this air quality modeling was not used in the creation of AQAT (*see* section D.4 of this document for details of this comparison).

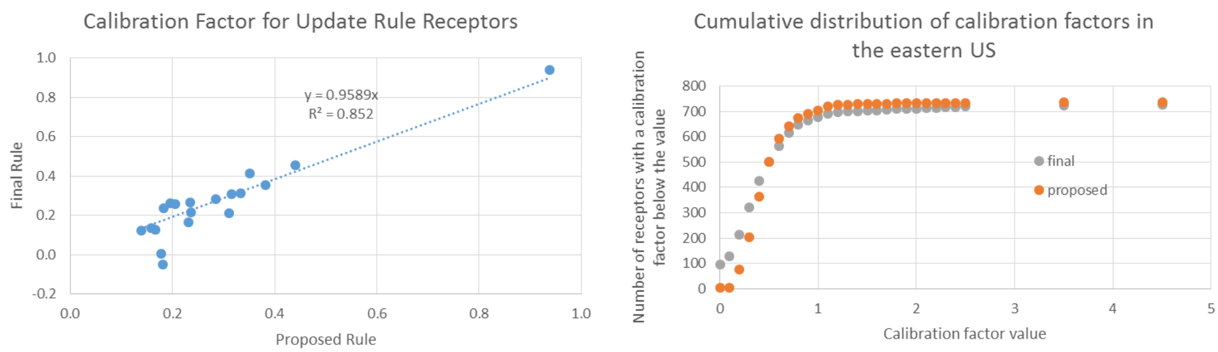


Figure 1. (left panel) A comparison of the calibration factors from the proposed and final rule. (left panel) A cumulative distribution, showing the number of monitors that have calibration factors below a particular value.

**Table D-2. From the Proposal, Ozone Contributions in the 2017 Base Case and 2017 Illustrative Control Case Calibration Scenario from CAMx and Uncalibrated Ozone AQAT for Monitor Number 240251001 in Harford County, Maryland (See Table D-1). These Values are then Used to Create a Calibration Factor.**

| | 2017 Base Case Ozone Concentration (ppb) | Estimated 2017 Illustrative Control Case Calibration Scenario Ozone Concentration (ppb) | Estimated Change in Concentration |
|---|---|---|---|
| CAMx | 81.369 | 80.469 | -0.900 |
| Ozone AQAT | 81.369 | 78.803 | -2.566 |
| Calibration Factor – Change in Concentration from CAMx Divided by Change in Concentration from the Ozone AQAT | | | 0.3508 |

<u>(2) Create a calibrated version of the ozone AQAT for emission budget analysis for the final rule</u>

Next, EPA used 2017 base case emissions and 2017 base case air quality ozone contributions from the final rule air quality modeling along with the calibration factors from the proposal to create a "calibrated" AQAT for the final rule. EPA examined the changes in the final rule contributions from changes in emissions relative to the final rule base case emissions (while using the calibration factor). This calibrated AQAT was then used to estimate the change in predicted ozone due to $NO_X$ emission reductions under each emission budget level evaluated.

First, as described above in section C of this TSD, EPA identified various levels of emissions budgets based on projected changes in emissions rates and adjusted historic data. For each state, the EGU emissions examined in AQAT are presented in Table D-3 (some additional columns as well as some minor differences in emissions can be found compared with the budgets in Tables C.1 and C.2). In all emission budget simulations, the contributions for all states were adjusted to the adjusted historic level or to an emission budget level using IPM.[30] For this assessment, because the emissions from all other sectors are constant, the EPA focused only on the differences in EGU emissions between each cost threshold[31] and the 2017 base case used in the modeling (see Table D-4 for the emission differences).[32] Finally, for each emission budget level, EPA calculated the ratio of the emission differences to the total $NO_X$ emissions for the 2017 base case used in the air quality modeling for each state modeled in CAMx (see Table D-5).[33]

[30] For Pennsylvania, this included an adjustment to reflect the estimated impact of the PA RACT Rule, as described in the Memo to the Docket "The Pennsylvania Additional RACT Requirements for Major Sources of $NO_X$ and VOCs."
[31] For Pennsylvania, the EPA used cost thresholds adjusted to reflect the PA RACT.
[32] We note that the total ozone-season $NO_X$ emissions from the IPM outputs used in the assessment tool air quality analysis and the EGU emissions used in the CAMx air quality modeling were slightly different (i.e., some EGU emissions are apportioned to different sectors in the emission inventory used in CAMx). However, within ozone AQAT, because the difference in emissions were consistently calculated using IPM's "all fossil >25 MW", the resulting air quality estimates are not affected.
[33] The total emissions from all anthropogenic sources (excluding Biogenics and Fires), coinciding with the emissions that were "tagged" in the source-apportionment modeling.

For each emission budget level analyzed, on a receptor-by-receptor basis, the emissions change for each upwind state is associated with one of two emission budget levels (either the adjusted historic base case emission level or the particular threshold cost level) depending on whether the upwind state is "linked" to that receptor or if the receptor is located within the state. States that are contributing above the air quality threshold (i.e., greater than or equal to 1 percent of the NAAQS) to the monitor, as well as the state containing the monitor, make $NO_X$ emission reductions available at the particular emission budget level. The emissions for all other states are adjusted to the adjusted historic base case level.

For the $1,400/ton final illustrative control alternative for the RIA, all states were adjusted to the emission levels in the illustrative control case, regardless of whether the state was "linked." These scenarios examine the emission results when budgets have been applied to the geography. This scenario was modeled in CAMx allowing a comparison with the AQAT estimates.

For each monitor, the predicted 2017 change in contribution of ozone from each state is calculated by multiplying the state-specific 2017 base case ozone contributions from the final air quality modeling by the calibration factor as well as by the ratio of the change in emissions (Table D-5, for either the emission budget level or the adjusted historic base case emission budget level adjusted for PA RACT depending on whether the state is linked, to the total 2017 base case emissions for all sectors used in the air quality modeling (*see* Table D-4 for the emission differences)).[34] This calibrated change in ozone is then added to the ozone contribution from the 2017 base case final air quality modeling. The result is the state and receptor specific "calibrated" total ozone contribution after implementation of the emission budgets at a particular level of control.

For each monitor, these state-level "calibrated" contributions are then summed to estimate total ozone contribution from the states to a particular receptor in the CAMx modeling domain. Finally, "other" modeled ozone contributions ("TRIBAL", "CNMX", "OFFSHORE", "FIRE", "ICBC", and "BIOG") are added from the 2017 base case final air quality modeling to the state contributions to account for other sources of ozone affecting the modeling domain. The total ozone from all the states and "other" contributions equals the average design values estimated in the assessment tool. The maximum design values were estimated by multiplying the estimated average design values by the ratio of the modeled 2017 base case maximum to average design values.

Generally, as the emission budget stringency increased, the estimated average and maximum design values at each receptor decreased. In the assessment tool, the estimated value of the average design value was used to estimate whether the location will be out of attainment, while the estimated maximum design value was used to estimate whether the location will have problems maintaining the NAAQS. The area was noted as having a nonattainment or maintenance issue if either estimated air quality level was greater than or equal to 76 ppb.

[34] The change in concentration can be positive or negative, depending on whether the state's emissions are larger or smaller than the 2017 air quality modeling base case emission level.

**Table D-3. 2017 Ozone Season EGU $NO_X$ Emissions (Tons) for Each State at Various Emission Budget Levels (Tons) as Modeled in AQAT.**

| | Air Quality Modeling Base Case | Final Base Case $0/ton Emission Budgets | Final Base Case $0/ton Emission Budgets with PA RACT | Final $800/ton Emission Budgets | Final $1400/ton Emission Budgets | Final $3400/ton Emission Budgets | Final $5000/ton Emission Budgets | Final $6400/ton Emission Budgets | Final $1,400/ton Illustrative Scenario AQ Model |
|---|---|---|---|---|---|---|---|---|---|
| **Alabama** | 10,902 | 15,179 | 15,179 | 14,332 | 13,211 | 12,620 | 11,928 | 11,573 | 8,521 |
| **Arkansas** | 9,890 | 12,560 | 12,560 | 12,048 | 9,210 | 9,048 | 8,518 | 8,050 | 6,862 |
| **Arizona** | 8,328 | 10,710 | 10,710 | 10,680 | 9,810 | 9,788 | 9,710 | 9,486 | 7,766 |
| **California** | 1,624 | 1,905 | 1,928 | 1,905 | 1,905 | 1,905 | 1,810 | 1,810 | 1,626 |
| **Colorado** | 13,426 | 14,010 | 14,010 | 14,008 | 13,994 | 13,645 | 13,495 | 12,950 | 13,434 |
| **Connecticut** | 387 | 605 | 605 | 584 | 558 | 558 | 554 | 554 | 386 |
| **Delaware** | 155 | 497 | 497 | 497 | 497 | 494 | 494 | 494 | 155 |
| **Florida** | 24,617 | 22,779 | 22,779 | 21,611 | 17,123 | 16,631 | 16,481 | 16,375 | 24,374 |
| **Georgia** | 11,120 | 8,762 | 8,762 | 8,495 | 8,481 | 8,525 | 8,532 | 7,764 | 8,840 |
| **Iowa** | 11,127 | 11,478 | 11,478 | 11,477 | 11,272 | 11,065 | 10,891 | 10,491 | 10,729 |
| **Idaho** | 15 | 152 | 152 | 152 | 152 | 152 | 152 | 152 | 16 |
| **Illinois** | 13,252 | 14,850 | 14,850 | 14,682 | 14,601 | 14,515 | 14,248 | 14,054 | 14,130 |
| **Indiana** | 40,223 | 31,382 | 31,382 | 28,960 | 23,303 | 21,634 | 19,990 | 18,720 | 26,047 |
| **Kansas** | 11,257 | 8,031 | 8,031 | 8,030 | 8,027 | 7,975 | 7,962 | 7,767 | 9,416 |
| **Kentucky** | 27,500 | 26,318 | 26,318 | 24,052 | 21,115 | 21,007 | 20,273 | 19,496 | 18,535 |
| **Louisiana** | 9,824 | 19,101 | 19,101 | 19,096 | 18,639 | 18,452 | 18,442 | 18,426 | 9,877 |
| **Massachusetts** | 939 | 1,119 | 1,119 | 1,119 | 1,112 | 1,098 | 1,071 | 1,072 | 961 |
| **Maryland** | 3,218 | 3,871 | 3,871 | 3,870 | 3,828 | 3,308 | 2,938 | 2,926 | 3,509 |
| **Maine** | 188 | 109 | 109 | 109 | 109 | 109 | 109 | 109 | 188 |
| **Michigan** | 21,415 | 19,811 | 19,811 | 19,558 | 17,023 | 15,782 | 13,110 | 12,612 | 17,524 |
| **Minnesota** | 9,710 | 7,068 | 7,068 | 7,068 | 6,864 | 6,761 | 6,651 | 6,451 | 8,596 |
| **Missouri** | 15,836 | 18,443 | 18,443 | 17,250 | 15,780 | 15,299 | 14,673 | 14,555 | 18,125 |
| **Mississippi** | 7,793 | 6,438 | 6,438 | 6,438 | 6,315 | 6,243 | 6,203 | 6,205 | 7,498 |
| **Montana** | 7,151 | 6,540 | 6,540 | 6,540 | 6,540 | 6,535 | 6,535 | 6,535 | 7,212 |
| **North Carolina** | 19,713 | 17,419 | 17,419 | 14,424 | 14,326 | 13,189 | 12,460 | 12,207 | 19,469 |
| **North Dakota** | 14,392 | 18,738 | 18,738 | 18,398 | 18,016 | 17,655 | 17,497 | 17,435 | 11,557 |
| **Nebraska** | 12,196 | 9,737 | 9,737 | 9,678 | 8,970 | 7,197 | 6,467 | 6,448 | 12,195 |
| **New Hampshire** | 140 | 416 | 416 | 416 | 416 | 416 | 415 | 415 | 140 |
| **New Jersey** | 1,776 | 2,114 | 2,114 | 2,100 | 2,062 | 2,008 | 1,867 | 1,879 | 1,731 |
| **New Mexico** | 5,626 | 9,443 | 9,443 | 9,443 | 8,834 | 8,633 | 8,367 | 8,219 | 5,735 |
| **Nevada** | 3,597 | 2,405 | 2,405 | 2,301 | 2,241 | 2,112 | 1,559 | 886 | 3,339 |
| **New York** | 4,275 | 5,531 | 5,531 | 5,220 | 5,135 | 5,006 | 4,746 | 4,594 | 3,783 |
| **Ohio** | 27,038 | 27,382 | 27,384 | 23,659 | 19,522 | 19,165 | 18,561 | 18,348 | 18,434 |
| **Oklahoma** | 16,718 | 13,747 | 13,747 | 13,746 | 11,641 | 9,174 | 8,790 | 8,439 | 14,642 |
| **Oregon** | - | --- | 0 | --- | --- | --- | --- | --- | - |
| **Pennsylvania** | 39,987 | 35,607 | 20,200 | 17,514 | 15,452 | 15,428 | 15,121 | 14,874 | 14,461 |
| **Rhode Island** | 180 | 283 | 283 | 283 | 283 | 283 | 283 | 283 | 180 |
| **South Carolina** | 5,839 | 5,486 | 5,486 | 5,288 | 5,288 | 5,293 | 5,300 | 5,318 | 5,824 |
| **South Dakota** | 537 | 853 | 853 | 853 | 853 | 853 | 853 | 853 | 537 |
| **Tennessee** | 6,944 | 7,779 | 7,779 | 7,736 | 7,736 | 7,735 | 7,724 | 7,729 | 7,129 |
| **Texas** | 56,331 | 54,839 | 54,839 | 54,521 | 52,301 | 50,011 | 48,795 | 47,994 | 54,345 |
| **Utah** | 21,618 | 16,949 | 16,949 | 16,949 | 14,149 | 13,592 | 11,356 | 11,324 | 21,616 |
| **Virginia** | 2,586 | 9,367 | 9,367 | 9,365 | 9,223 | 8,754 | 8,619 | 8,416 | 2,858 |
| **Vermont** | 0 | 52 | 52 | 52 | 52 | 52 | 52 | 52 | 0 |
| **Washington** | 136 | 3,085 | 3,085 | 3,085 | 3,085 | 3,085 | 3,085 | 3,085 | 136 |
| **Wisconsin** | 6,488 | 7,939 | 7,939 | 7,924 | 7,915 | 7,790 | 7,435 | 7,023 | 6,548 |
| **West Virginia** | 26,110 | 26,874 | 26,874 | 25,984 | 17,815 | 17,380 | 17,388 | 17,373 | 16,298 |
| **Wyoming** | 11,216 | 16,005 | 16,005 | 15,828 | 14,691 | 13,728 | 12,371 | 12,121 | 11,290 |

* EPA analyzed all segments of the PA RACT Rule. For the EGU sector, this was primarily a cap on emission rates at coal EGUs with SCRs (12,848 tons), but also included a number of less impactful provisions on EGU emission rates (59 tons). This results in 12,907 tons of reduction from EGU PA RACT. These EGU PA Ract reductions are only included in the PA estimates for the final base case $0/ton emission budgets with PA RACT and the final $800/ton emissions budgets cases. A separate 2,500 tons of reductions from non-EGU PA RACT is included in the PA estimates for all cases except the air quality modeling base case, the final base case, and the final $1,400/ton illustrative scenario AQ model.

**Table D-4. 2017 Ozone Season EGU $NO_X$ Emission Differences (Thousand Tons) for Each State Relative to the Air Quality Modeling Base Case Emission Level as Modeled in AQAT.**

| | Total Antro-pogenic $NO_X$ | Final Base Case | Final Base Case $0/ton Emission Budgets | Final Base Case $0/ton Emission Budgets with PA RACT | Final $800/ton Emission Budgets | Final $1400/ton Emission Budgets | Final $3400/ton Emission Budgets | Final $5000/ton Emission Budgets | Final $6400/ton Emission Budgets | Final $1,400/ton Illustrative Scenario AQ Model |
|---|---|---|---|---|---|---|---|---|---|---|
| Alabama | 88.3 | -0.5 | 4.3 | 4.3 | 3.4 | 2.3 | 1.7 | 1.0 | 0.7 | -2.4 |
| Arizona | 67.3 | -2.4 | 2.4 | 2.4 | 2.4 | 1.5 | 1.5 | 1.4 | 1.2 | -0.6 |
| Arkansas | 68.1 | 0.0 | 2.7 | 2.7 | 2.2 | -0.7 | -0.8 | -1.4 | -1.8 | -3.0 |
| California | 210.4 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.0 |
| Colorado | 89.3 | 0.0 | 0.6 | 0.6 | 0.6 | 0.6 | 0.2 | 0.1 | -0.5 | 0.0 |
| Connecticut | 17.5 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.0 |
| Delaware | 7.7 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 |
| District of Columbia | 2.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Florida | 173.9 | -0.2 | -1.8 | -1.8 | -3.0 | -7.5 | -8.0 | -8.1 | -8.2 | -0.2 |
| Georgia | 105.2 | -2.3 | -2.4 | -2.4 | -2.6 | -2.6 | -2.6 | -2.6 | -3.4 | -2.3 |
| Idaho | 28.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| Illinois | 146.0 | 1.3 | 1.6 | 1.6 | 1.4 | 1.3 | 1.3 | 1.0 | 0.8 | 0.9 |
| Indiana | 136.8 | 2.0 | -8.8 | -8.8 | -11.3 | -16.9 | -18.6 | -20.2 | -21.5 | -14.2 |
| Iowa | 73.4 | -0.2 | 0.4 | 0.4 | 0.3 | 0.1 | -0.1 | -0.2 | -0.6 | -0.4 |
| Kansas | 109.0 | -0.4 | -3.2 | -3.2 | -3.2 | -3.2 | -3.3 | -3.3 | -3.5 | -1.8 |
| Kentucky | 95.9 | -4.2 | -1.2 | -1.2 | -3.4 | -6.4 | -6.5 | -7.2 | -8.0 | -9.0 |
| Louisiana | 168.9 | 0.2 | 9.3 | 9.3 | 9.3 | 8.8 | 8.6 | 8.6 | 8.6 | 0.1 |
| Maine | 17.8 | 0.0 | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | -0.1 | 0.0 |
| Maryland | 44.7 | 0.4 | 0.7 | 0.7 | 0.7 | 0.6 | 0.1 | -0.3 | -0.3 | 0.3 |
| Massachusetts | 35.4 | 0.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 |
| Michigan | 121.9 | -0.9 | -1.6 | -1.6 | -1.9 | -4.4 | -5.6 | -8.3 | -8.8 | -3.9 |
| Minnesota | 89.5 | -1.1 | -2.6 | -2.6 | -2.6 | -2.8 | -2.9 | -3.1 | -3.3 | -1.1 |
| Mississippi | 54.4 | -0.2 | -1.4 | -1.4 | -1.4 | -1.5 | -1.6 | -1.6 | -1.6 | -0.3 |
| Missouri | 100.9 | 4.8 | 2.6 | 2.6 | 1.4 | -0.1 | -0.5 | -1.2 | -1.3 | 2.3 |
| Montana | 37.4 | 0.0 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 | -0.6 | 0.1 |
| Nebraska | 68.2 | 0.0 | -2.5 | -2.5 | -2.5 | -3.2 | -5.0 | -5.7 | -5.7 | 0.0 |
| Nevada | 27.9 | -0.2 | -1.2 | -1.2 | -1.3 | -1.4 | -1.5 | -2.0 | -2.7 | -0.3 |
| New Hampshire | 8.9 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 |
| New Jersey | 49.8 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.1 | 0.1 | 0.0 |
| New Mexico | 66.2 | 0.0 | 3.8 | 3.8 | 3.8 | 3.2 | 3.0 | 2.7 | 2.6 | 0.1 |
| New York | 106.3 | -0.1 | 1.3 | 1.3 | 0.9 | 0.9 | 0.7 | 0.5 | 0.3 | -0.5 |
| North Carolina | 97.0 | 0.7 | -2.3 | -2.3 | -5.3 | -5.4 | -6.5 | -7.3 | -7.5 | -0.2 |
| North Dakota | 65.8 | -2.8 | 4.3 | 4.3 | 4.0 | 3.6 | 3.3 | 3.1 | 3.0 | -2.8 |
| Ohio | 148.7 | 3.1 | 0.3 | 0.3 | -3.4 | -7.5 | -7.9 | -8.5 | -8.7 | -8.6 |
| Oklahoma | 124.7 | -0.2 | -3.0 | -3.0 | -3.0 | -5.1 | -7.5 | -7.9 | -8.3 | -2.1 |
| Oregon | 40.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pennsylvania | 165.2 | -5.0 | -4.4 | -19.8 | -22.5 | -24.5 | -24.6 | -24.9 | -25.1 | -25.5 |
| Rhode Island | 5.9 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| South Carolina | 56.4 | -0.1 | -0.4 | -0.4 | -0.6 | -0.6 | -0.5 | -0.5 | -0.5 | 0.0 |
| South Dakota | 22.3 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.0 |
| Tennessee | 87.5 | 0.4 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.2 |
| Texas | 435.5 | -0.4 | -1.5 | -1.5 | -1.8 | -4.0 | -6.3 | -7.5 | -8.3 | -2.0 |
| Utah | 62.8 | 0.0 | -4.7 | -4.7 | -4.7 | -7.5 | -8.0 | -10.3 | -10.3 | 0.0 |
| Vermont | 5.4 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 |
| Virginia | 81.6 | 0.2 | 6.8 | 6.8 | 6.8 | 6.6 | 6.2 | 6.0 | 5.8 | 0.3 |
| Washington | 76.1 | 0.0 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 2.9 | 0.0 |
| West Virginia | 65.9 | 0.3 | 0.8 | 0.8 | -0.1 | -8.3 | -8.7 | -8.7 | -8.7 | -9.8 |
| Wisconsin | 74.2 | 0.1 | 1.5 | 1.5 | 1.4 | 1.4 | 1.3 | 0.9 | 0.5 | 0.1 |
| Wyoming | 65.8 | 0.1 | 4.8 | 4.8 | 4.6 | 3.5 | 2.5 | 1.2 | 0.9 | 0.1 |

* EPA analyzed all segments of the PA RACT Rule. For the EGU sector, this was primarily a cap on emission rates at coal EGUs with SCRs (12,848 tons), but also included a number of less impactful provisions on EGU emission rates (59 tons). This results in 12,907 tons of reduction from EGU PA RACT. These EGU PA Ract reductions are only included in the PA estimates for the final base case $0/ton emission budgets with PA RACT and the final $800/ton emissions budgets cases. A separate 2,500 tons of reductions from non-EGU PA RACT is included in the PA estimates for all cases except the air quality modeling base case, the final base case, and the final $1,400/ton illustrative scenario AQ model.

**Table D-5. 2017 Ozone Season EGU $NO_X$ Emission Fractions for Each State Relative to the Air Quality Modeling Base Case Emission Level as Modeled in AQAT.**

| | Final Base Case | Final Base Case $0/ton Emission Budgets | Final Base Case $0/ton Emission Budgets with PA RACT | Final $800/ton Emission Budgets | Final $1400/ton Emission Budgets | Final $3400/ton Emission Budgets | Final $5000/ton Emission Budgets | Final $6400/ton Emission Budgets | Final $1,400/ton Illustrative Scenario AQ Model |
|---|---|---|---|---|---|---|---|---|---|
| Alabama | -0.0056 | 0.0485 | 0.0485 | 0.0389 | 0.0262 | 0.0195 | 0.0116 | 0.0076 | -0.0270 |
| Arizona | -0.0351 | 0.0354 | 0.0354 | 0.0349 | 0.0220 | 0.0217 | 0.0205 | 0.0172 | -0.0084 |
| Arkansas | 0.0000 | 0.0392 | 0.0392 | 0.0317 | -0.0100 | -0.0124 | -0.0201 | -0.0270 | -0.0445 |
| California | 0.0000 | 0.0013 | 0.0014 | 0.0013 | 0.0013 | 0.0013 | 0.0009 | 0.0009 | 0.0000 |
| Colorado | 0.0001 | 0.0065 | 0.0065 | 0.0065 | 0.0064 | 0.0024 | 0.0008 | -0.0053 | 0.0001 |
| Connecticut | 0.0000 | 0.0125 | 0.0125 | 0.0113 | 0.0098 | 0.0098 | 0.0096 | 0.0096 | 0.0000 |
| Delaware | 0.0000 | 0.0445 | 0.0445 | 0.0445 | 0.0445 | 0.0441 | 0.0441 | 0.0441 | 0.0000 |
| District of Columbia | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Florida | -0.0013 | -0.0106 | -0.0106 | -0.0173 | -0.0431 | -0.0459 | -0.0468 | -0.0474 | -0.0014 |
| Georgia | -0.0214 | -0.0224 | -0.0224 | -0.0250 | -0.0251 | -0.0247 | -0.0246 | -0.0319 | -0.0217 |
| Idaho | 0.0000 | 0.0049 | 0.0049 | 0.0049 | 0.0049 | 0.0049 | 0.0049 | 0.0049 | 0.0000 |
| Illinois | 0.0089 | 0.0109 | 0.0109 | 0.0098 | 0.0092 | 0.0087 | 0.0068 | 0.0055 | 0.0060 |
| Indiana | 0.0143 | -0.0646 | -0.0646 | -0.0824 | -0.1237 | -0.1359 | -0.1479 | -0.1572 | -0.1036 |
| Iowa | -0.0025 | 0.0048 | 0.0048 | 0.0048 | 0.0020 | -0.0008 | -0.0032 | -0.0087 | -0.0054 |
| Kansas | -0.0032 | -0.0296 | -0.0296 | -0.0296 | -0.0296 | -0.0301 | -0.0302 | -0.0320 | -0.0169 |
| Kentucky | -0.0440 | -0.0123 | -0.0123 | -0.0360 | -0.0666 | -0.0677 | -0.0754 | -0.0835 | -0.0935 |
| Louisiana | 0.0011 | 0.0549 | 0.0549 | 0.0549 | 0.0522 | 0.0511 | 0.0510 | 0.0509 | 0.0003 |
| Maine | 0.0000 | -0.0044 | -0.0044 | -0.0044 | -0.0044 | -0.0044 | -0.0044 | -0.0044 | 0.0000 |
| Maryland | 0.0081 | 0.0146 | 0.0146 | 0.0146 | 0.0136 | 0.0020 | -0.0063 | -0.0065 | 0.0065 |
| Massachusetts | 0.0005 | 0.0051 | 0.0051 | 0.0051 | 0.0049 | 0.0045 | 0.0037 | 0.0038 | 0.0006 |
| Michigan | -0.0075 | -0.0132 | -0.0132 | -0.0152 | -0.0360 | -0.0462 | -0.0681 | -0.0722 | -0.0319 |
| Minnesota | -0.0124 | -0.0295 | -0.0295 | -0.0295 | -0.0318 | -0.0329 | -0.0342 | -0.0364 | -0.0124 |
| Mississippi | -0.0031 | -0.0249 | -0.0249 | -0.0249 | -0.0272 | -0.0285 | -0.0292 | -0.0292 | -0.0054 |
| Missouri | 0.0472 | 0.0258 | 0.0258 | 0.0140 | -0.0006 | -0.0053 | -0.0115 | -0.0127 | 0.0227 |
| Montana | 0.0006 | -0.0164 | -0.0164 | -0.0164 | -0.0164 | -0.0165 | -0.0165 | -0.0165 | 0.0016 |
| Nebraska | 0.0000 | -0.0361 | -0.0361 | -0.0369 | -0.0473 | -0.0733 | -0.0840 | -0.0843 | 0.0000 |
| Nevada | -0.0072 | -0.0428 | -0.0428 | -0.0465 | -0.0487 | -0.0533 | -0.0732 | -0.0973 | -0.0092 |
| New Hampshire | 0.0000 | 0.0309 | 0.0309 | 0.0309 | 0.0309 | 0.0309 | 0.0308 | 0.0308 | 0.0000 |
| New Jersey | -0.0001 | 0.0068 | 0.0068 | 0.0065 | 0.0057 | 0.0047 | 0.0018 | 0.0021 | -0.0009 |
| New Mexico | 0.0004 | 0.0576 | 0.0576 | 0.0576 | 0.0484 | 0.0454 | 0.0414 | 0.0392 | 0.0016 |
| New York | -0.0011 | 0.0118 | 0.0118 | 0.0089 | 0.0081 | 0.0069 | 0.0044 | 0.0030 | -0.0046 |
| North Carolina | 0.0072 | -0.0236 | -0.0236 | -0.0545 | -0.0555 | -0.0672 | -0.0748 | -0.0774 | -0.0025 |
| North Dakota | -0.0422 | 0.0660 | 0.0660 | 0.0609 | 0.0551 | 0.0496 | 0.0472 | 0.0462 | -0.0431 |
| Ohio | 0.0210 | 0.0023 | 0.0023 | -0.0227 | -0.0505 | -0.0529 | -0.0570 | -0.0584 | -0.0579 |
| Oklahoma | -0.0017 | -0.0238 | -0.0238 | -0.0238 | -0.0407 | -0.0605 | -0.0636 | -0.0664 | -0.0167 |
| Oregon | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Pennsylvania | -0.0306 | -0.0265 | -0.1198 | -0.1360 | -0.1485 | -0.1486 | -0.1505 | -0.1520 | -0.1545 |
| Rhode Island | 0.0000 | 0.0174 | 0.0174 | 0.0174 | 0.0174 | 0.0174 | 0.0174 | 0.0174 | 0.0000 |
| South Carolina | -0.0016 | -0.0063 | -0.0063 | -0.0098 | -0.0098 | -0.0097 | -0.0096 | -0.0092 | -0.0003 |
| South Dakota | 0.0000 | 0.0142 | 0.0142 | 0.0142 | 0.0142 | 0.0142 | 0.0142 | 0.0142 | 0.0000 |
| Tennessee | 0.0050 | 0.0095 | 0.0095 | 0.0091 | 0.0091 | 0.0090 | 0.0089 | 0.0090 | 0.0021 |
| Texas | -0.0009 | -0.0034 | -0.0034 | -0.0042 | -0.0093 | -0.0145 | -0.0173 | -0.0191 | -0.0046 |
| Utah | 0.0000 | -0.0744 | -0.0744 | -0.0744 | -0.1190 | -0.1279 | -0.1635 | -0.1640 | 0.0000 |
| Vermont | 0.0000 | 0.0096 | 0.0095 | 0.0096 | 0.0096 | 0.0096 | 0.0096 | 0.0096 | 0.0000 |
| Virginia | 0.0026 | 0.0831 | 0.0831 | 0.0831 | 0.0813 | 0.0756 | 0.0739 | 0.0715 | 0.0033 |
| Washington | 0.0000 | 0.0388 | 0.0388 | 0.0388 | 0.0388 | 0.0388 | 0.0388 | 0.0388 | 0.0000 |
| West Virginia | 0.0048 | 0.0116 | 0.0116 | -0.0019 | -0.1259 | -0.1325 | -0.1324 | -0.1327 | -0.1490 |
| Wisconsin | 0.0009 | 0.0195 | 0.0195 | 0.0193 | 0.0192 | 0.0175 | 0.0128 | 0.0072 | 0.0008 |
| Wyoming | 0.0009 | 0.0728 | 0.0728 | 0.0701 | 0.0528 | 0.0382 | 0.0176 | 0.0138 | 0.0011 |

* EPA analyzed all segments of the PA RACT Rule. For the EGU sector, this was primarily a cap on emission rates at coal EGUs with SCRs (12,848 tons), but also included a number of less impactful provisions on EGU emission rates (59 tons). This results in 12,907 tons of reduction from EGU PA RACT. These EGU PA Ract reductions are only included in the PA estimates for the final base case $0/ton emission budgets with PA RACT and the final $800/ton emissions budgets cases. A separate 2,500 tons of reductions from non-EGU PA RACT is included in the PA estimates for all cases except the air quality modeling base case, the final base case, and the final $1,400/ton illustrative scenario AQ model.

3. Description of the results of the analysis using the assessment tool for the approach.

EPA used the ozone AQAT to estimate improvements in downwind air quality at base case levels, then $800 per ton and, then, at higher emission budget levels . At each emission budget level, using AQAT, EPA examined whether the average and maximum design values for each of the receptors decreased to values below 76 ppb at which point their nonattainment and maintenance issues would be considered resolved. EPA also examined each states' air quality contributions at each emission budget level, assessing whether a state maintained at least one linkage to a receptor that was estimated to remain in nonattainment and/or maintenance. EPA examined emission budget levels of $0/ton, $0/ton including adjustments due to PA RACT, $800/ton, $1,400/ton, $3,400/ton, $5,000/ton, and $6,400/ton. PA RACT was included in all of the scenarios that were more stringent than the $0/ton including adjustments due to PA RACT scenario. The preamble explains at section VI.D how EPA considered the results of the air quality analyses described in this TSD to determine the appropriate set of emission budgets for reducing significant contribution to nonattainment and interference with maintenance.

The average and maximum design values (ppb) estimated using the assessment tool for each identified receptor for each emission budget level have been truncated to a tenth of a ppb and can be found in Tables D-6 and D-7, respectively. The monitors are in alphabetical order by state. Notably, no monitors are projected to have either their average or maximum design values drop below 76 ppb in the transition from the air quality modeling base case to the adjusted historic base cases (i.e., $0/ton emissions budget with or without PA RACT). At each of the $NO_X$ emission budget levels examined, we found that only one additional monitor is projected to have resolved its average design value problems (i.e., nonattainment). We project that monitor 211110067 in Kentucky is resolved at the $1,400/ton threshold, meaning that we estimate its average design value will drop below 76 ppb.

Many monitors are projected to have maintenance issues at all emission budget levels. However, three monitors have their maintenance issues solved at various emission budget levels. At the $800/ton emission budget level, we estimate that the maintenance problems at monitor 421010024 in Pennsylvania to be resolved (when PA RACT is also considered). Delaware is solely linked to this receptor (*see* the discussion of Delaware in preamble section VI). At the $1,400/ton emission budget level, two additional monitors are projected to have their maintenance concerns resolved. These are monitors 211110067 in Kentucky and 390610006 in Ohio. Tennessee is uniquely linked to the latter receptor in Ohio following the resolution of its other linkage (monitor 421010024 in Pennsylvania) which is projected to occur at the less stringent $800/ton emission budget. *See* the discussion of Tennessee in preamble section VI for additional details.

We observe no additional change in receptor status between the $3,400/ton and $6,400/ton emission budget levels.

In the assessment of air quality using the calibrated assessment tool, we are able to estimate the change in the air quality contributions of each upwind state to each receptor (see the description of the state and receptor-specific contributions in section D.2.c.(2)) in order to determine whether any state's contribution is below the 1 percent threshold used in step 2 of the CSAPR framework to identify "linked" upwind states. For this over-control assessment, we compared each state's adjusted ozone concentration against the 1% air quality threshold at each of the emission budgets levels up to $6,400/ton at each remaining receptor, using AQAT (see the "links" worksheets in the AQAT workbook, referred to in Appendix B). For Delaware at $800/ton and Tennessee at $1,400/ton, where their final monitors have all of their nonattainment and maintenance issues resolved, the reductions required by the emissions budgets would not reduce their contributions below the 1% threshold. For all other linked states, we did not see instances where a state's contributions dropped below 1% of the NAAQS for all of its linkages to downwind receptors. This is not a surprising result because, for a linkage to be resolved by emission reductions of just a few percent, the contribution would need to be within a few percent of the threshold. As a hypothetical example, if the state is making a 6% emission reduction in its overall anthropogenic ozone season $NO_X$ emissions, and the calibration factor was 0.5, its base case maximum contribution to a remaining unresolved nonattainment and/or maintenance receptor would need to be just under 1.03% of the NAAQS or 0.77 ppb, to drop below the 0.75 ppb linkage threshold.

Lastly, once the budgets for the rule were established (based on the results of the multi-factor test) and IPM was used to model compliance with the rule, it was possible to estimate air quality concentrations at each downwind receptor using the ozone AQAT for the $1,400 final illustrative control air quality case. This scenario was directly modeled in CAMx. The average and maximum design value estimates from AQAT and CAMx can be found in Table D-8. The results are described in the following section (D.4). The design value results from AQAT (i.e., which receptors are estimated to have nonattainment and/or maintenance problems) for the final emissions budgets scenario are similar to that of the $1,400/ton emission budget level.

**Table D-6. Average Ozone DVs (ppb) for $NO_X$ Emissions Budget Levels ($/ton) Assessed Using the Ozone AQAT for all Nineteen Nonattainment and Maintenance Receptors.**

| Monitor Identification Number | State | County | CAMx 2017 Base Case (ppb) | Assessment Tool Average Ozone Design Values (ppb). | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Adjusted Historic Base Case | Adjusted Historic Base Case w/ PA RACT | $800 | $1,400 | $3,400 | $5,000 | $6,400 |
| 90010017 | Connecticut | Fairfield | 74.1 | 74.1 | 73.9 | 73.9 | 73.8 | 73.8 | 73.8 | 73.8 |
| 90013007 | Connecticut | Fairfield | 75.5 | 75.5 | 75.3 | 75.3 | 75.2 | 75.2 | 75.2 | 75.2 |
| 90019003 | Connecticut | Fairfield | 76.5 | 76.5 | 76.3 | 76.3 | 76.2 | 76.2 | 76.2 | 76.2 |
| 90099002 | Connecticut | New Haven | 76.2 | 76.2 | 76.1 | 76.1 | 76.0 | 76.0 | 76.0 | 76.0 |
| 211110067 | Kentucky | Jefferson | 76.9 | 76.4 | 76.4 | 76.0 | 75.4 | 75.3 | 75.1 | 75.0 |
| 240251001 | Maryland | Harford | 78.8 | 79.0 | 78.8 | 78.7 | 78.4 | 78.3 | 78.2 | 78.2 |
| 260050003 | Michigan | Allegan | 74.7 | 74.6 | 74.6 | 74.6 | 74.4 | 74.4 | 74.3 | 74.3 |
| 360850067 | New York | Richmond | 75.8 | 75.7 | 75.3 | 75.2 | 75.0 | 74.9 | 74.9 | 74.9 |
| 361030002 | New York | Suffolk | 76.8 | 76.8 | 76.6 | 76.6 | 76.5 | 76.5 | 76.5 | 76.5 |
| 390610006 | Ohio | Hamilton | 74.6 | 74.1 | 74.1 | 73.3 | 72.1 | 71.9 | 71.7 | 71.5 |
| 421010024 | Pennsylvania | Philadelphia | 73.6 | 73.4 | 72.7 | 72.5 | 72.2 | 72.1 | 72.1 | 72.0 |
| 480391004 | Texas | Brazoria | 79.9 | 79.9 | 79.9 | 79.9 | 79.8 | 79.7 | 79.7 | 79.7 |
| 481210034 | Texas | Denton | 75.0 | 74.9 | 74.9 | 74.9 | 74.9 | 74.8 | 74.8 | 74.8 |
| 482010024 | Texas | Harris | 75.4 | 75.4 | 75.4 | 75.3 | 75.3 | 75.3 | 75.3 | 75.3 |
| 482011034 | Texas | Harris | 75.7 | 75.7 | 75.7 | 75.7 | 75.6 | 75.6 | 75.6 | 75.5 |
| 482011039 | Texas | Harris | 76.9 | 76.9 | 76.9 | 76.9 | 76.8 | 76.8 | 76.8 | 76.7 |
| 484392003 | Texas | Tarrant | 77.3 | 77.2 | 77.2 | 77.2 | 77.2 | 77.1 | 77.1 | 77.0 |
| 484393009 | Texas | Tarrant | 76.4 | 76.3 | 76.3 | 76.3 | 76.3 | 76.2 | 76.2 | 76.2 |
| 551170006 | Wisconsin | Sheboygan | 76.2 | 76.2 | 76.2 | 76.1 | 76.1 | 76.0 | 76.0 | 76.0 |

**Table D-7. Maximum Ozone DVs (ppb) for $NO_X$ Emissions Budget Levels ($/ton) Assessed Using the Ozone AQAT for all Nineteen Nonattainment and Maintenance Receptors.**

| Monitor Identification Number | State | County | CAMx 2017 Base Case (ppb) | Assessment Tool Maximum Ozone Design Values (ppb). | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Adjusted Historic Base Case | Adjusted Historic Base Case w/ PA RACT | $800 | $1,400 | $3,400 | $5,000 | $6,400 |
| 90010017 | Connecticut | Fairfield | 76.6 | 76.6 | 76.4 | 76.4 | 76.3 | 76.3 | 76.3 | 76.3 |
| 90013007 | Connecticut | Fairfield | 79.7 | 79.7 | 79.5 | 79.5 | 79.4 | 79.4 | 79.4 | 79.3 |
| 90019003 | Connecticut | Fairfield | 79.5 | 79.5 | 79.3 | 79.3 | 79.2 | 79.2 | 79.2 | 79.2 |
| 90099002 | Connecticut | New Haven | 79.2 | 79.1 | 79.0 | 79.0 | 79.0 | 79.0 | 78.9 | 78.9 |
| 211110067 | Kentucky | Jefferson | 76.9 | 76.4 | 76.4 | 76.0 | 75.4 | 75.3 | 75.1 | 75.0 |
| 240251001 | Maryland | Harford | 81.4 | 81.6 | 81.4 | 81.3 | 81.0 | 80.9 | 80.8 | 80.8 |
| 260050003 | Michigan | Allegan | 77.7 | 77.6 | 77.6 | 77.5 | 77.4 | 77.3 | 77.3 | 77.2 |
| 360850067 | New York | Richmond | 77.4 | 77.3 | 76.9 | 76.7 | 76.5 | 76.5 | 76.5 | 76.4 |
| 361030002 | New York | Suffolk | 78.4 | 78.3 | 78.2 | 78.2 | 78.1 | 78.1 | 78.1 | 78.1 |
| 390610006 | Ohio | Hamilton | 77.4 | 76.8 | 76.8 | 76.0 | 74.7 | 74.6 | 74.3 | 74.1 |
| 421010024 | Pennsylvania | Philadelphia | 76.9 | 76.7 | 76.0 | 75.7 | 75.4 | 75.3 | 75.3 | 75.2 |
| 480391004 | Texas | Brazoria | 80.8 | 80.8 | 80.8 | 80.8 | 80.7 | 80.7 | 80.6 | 80.6 |
| 481210034 | Texas | Denton | 77.4 | 77.3 | 77.3 | 77.3 | 77.3 | 77.2 | 77.2 | 77.2 |
| 482010024 | Texas | Harris | 77.9 | 77.9 | 77.9 | 77.9 | 77.9 | 77.8 | 77.8 | 77.8 |
| 482011034 | Texas | Harris | 76.6 | 76.6 | 76.6 | 76.6 | 76.5 | 76.5 | 76.5 | 76.5 |
| 482011039 | Texas | Harris | 78.8 | 78.7 | 78.7 | 78.7 | 78.7 | 78.7 | 78.6 | 78.6 |
| 484392003 | Texas | Tarrant | 79.7 | 79.6 | 79.6 | 79.6 | 79.5 | 79.5 | 79.4 | 79.4 |
| 484393009 | Texas | Tarrant | 76.4 | 76.3 | 76.3 | 76.3 | 76.3 | 76.2 | 76.2 | 76.2 |
| 551170006 | Wisconsin | Sheboygan | 78.7 | 78.6 | 78.6 | 78.6 | 78.5 | 78.5 | 78.4 | 78.4 |

4. Comparison between the air quality assessment tool estimates and CAMx air quality modeling estimates.

As described earlier, because the AQAT was calibrated using data from the proposal, it was possible to evaluate the estimates from the tool with the independent model design value predictions from CAMx for the final modeling 2017 illustrative control scenario. The average and maximum design values from AQAT and CAMx, as well as the differences, are shown in Table D-8. The AQAT values and the differences in the table have been truncated to a tenth of a ppb.

Strong correlations are observed (nearly one to one) between the estimated average and maximum design values from AQAT and CAMx (Figure 2). The slopes of the least-squares linear regression lines are almost exactly equal to 1, and the regression coefficients are also nearly 1. The differences in estimates are also small, averaging less than 0.1 ppb and reaching a maximum of about 0.2 ppb for several receptors. These small differences suggest that each of the state contributions are being reasonably approximated. The results of this demonstrate that, considering the constraints faced by the EPA, the AQAT provides reasonable estimates of air quality concentrations for each receptor, can provide reasonable inputs for the multi-factor assessment, and can serve as a method to test for linkages dropping below the threshold.

**Table D-8. Average and Maximum DVs (ppb) in the 2017 Budget Control Scenario as Modeled in CAMx and as Estimated in Calibrated AQAT, for Receptors with Maximum DVs Greater than or Equal to 76 ppb in the 2017 Base Case Modeled in CAMx.**

| Monitor Identification Numbe | State | County | 2017 Budget Control Scenario | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | CAMx Avg. DV | CAMx Max. DV | AQAT Avg. DV | AQAT Max. DV | Difference, Avg. DV (CAMx-AQAT) | Difference, Max. DV (CAMx-AQAT) |
| 90010017 | Connecticut | Fairfield | 73.7 | 76.2 | 73.7 | 76.1 | 0.0 | 0.1 |
| 90013007 | Connecticut | Fairfield | 75.0 | 79.2 | 75.1 | 79.3 | -0.1 | -0.1 |
| 90019003 | Connecticut | Fairfield | 76.0 | 79.0 | 76.1 | 79.1 | -0.1 | -0.1 |
| 90099002 | Connecticut | New Haven | 76.0 | 78.9 | 75.9 | 78.9 | 0.1 | 0.0 |
| 211110067 | Kentucky | Jefferson | 75.1 | 75.1 | 75.1 | 75.1 | 0.0 | 0.0 |
| 240251001 | Maryland | Harford | 78.0 | 80.6 | 78.1 | 80.8 | -0.1 | -0.2 |
| 260050003 | Michigan | Allegan | 74.4 | 77.4 | 74.4 | 77.4 | 0.0 | 0.0 |
| 360850067 | New York | Richmond | 74.8 | 76.4 | 74.8 | 76.3 | 0.0 | 0.1 |
| 361030002 | New York | Suffolk | 76.5 | 78.0 | 76.4 | 78.0 | 0.1 | 0.0 |
| 390610006 | Ohio | Hamilton | 71.7 | 74.3 | 71.7 | 74.3 | 0.0 | 0.0 |
| 421010024 | Pennsylvania | Philadelphia | 72.1 | 75.3 | 71.9 | 75.1 | 0.2 | 0.2 |
| 480391004 | Texas | Brazoria | 79.8 | 80.7 | 79.8 | 80.7 | 0.0 | 0.0 |
| 481210034 | Texas | Denton | 74.9 | 77.3 | 74.9 | 77.3 | 0.0 | 0.0 |
| 482010024 | Texas | Harris | 75.4 | 77.9 | 75.3 | 77.8 | 0.1 | 0.1 |
| 482011034 | Texas | Harris | 75.6 | 76.5 | 75.6 | 76.5 | 0.0 | 0.0 |
| 482011039 | Texas | Harris | 76.8 | 78.7 | 76.8 | 78.7 | 0.0 | 0.0 |
| 484392003 | Texas | Tarrant | 77.1 | 79.5 | 77.1 | 79.5 | 0.0 | 0.0 |
| 484393009 | Texas | Tarrant | 76.3 | 76.3 | 76.3 | 76.3 | 0.0 | 0.0 |
| 551170006 | Wisconsin | Sheboygan | 76.0 | 78.5 | 76.0 | 78.4 | 0.0 | 0.1 |

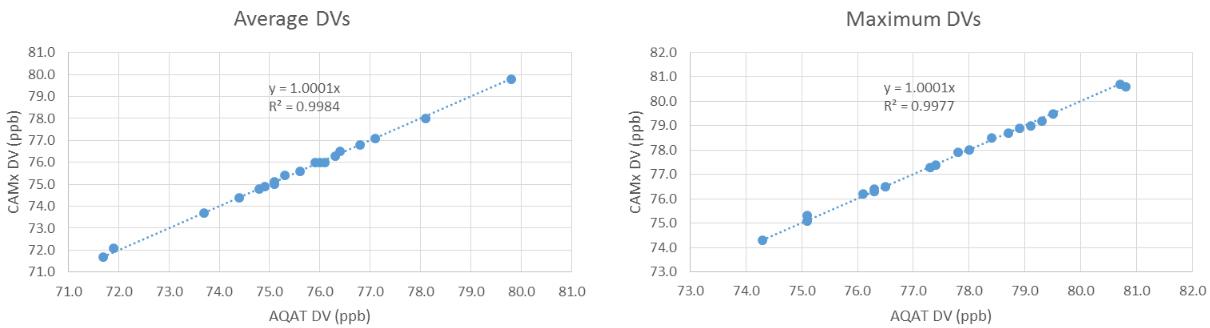


Figure 2. Least squares linear regression plots showing correlations between CAMx and calibrated AQAT for the 2017 illustrative budget control scenario base case for estimated average and maximum design values (ppb) in the left and right panels, respectively.

# Appendix A: IPM Runs Used in Transport Rule Significant Contribution Analysis

Table A-1 lists IPM runs used in analysis for this rule. The IPM runs can be found in the docket for this rulemaking under the IPM File Name listed in square brackets in the table below

**Table Appendix A-1. IPM Runs Used in Transport Rule Significant Contribution Analysis**

| **Run Name<br>[IPM File Name]** | **Description** |
|---|---|
| **Air Quality Modeling Base Case**<br><br>[5.15_OS_NOx_AQM_Base_Case] | Model run used for the air quality modeling base case, which includes the national Title IV SO2 cap-and-trade program; $NO_X$ SIP Call; the Cross-State Air Pollution trading programs, and settlements and state rules. This is based on AEO estimates from 2015 and excludes the final Clean Power Plan. It also includes key fleet updates regarding new units, retired units, and control retrofits, particularly those raised in comments to the agency on the August 4, 2015 NODA[6]. |
| **Illustrative Base Case**<br><br>[5.15_OS_NOx_Illustrative_Base_Case] | Model run used as the base case for the Illustrative Analysis of the final rule. Based upon the 5.15_OS_NOx_AQM_Base_Case case, but incorporating comments the agency received on the model, particularly those that affect $NO_X$ emissions and $NO_X$ rates. |
| **Illustrative $800 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Illustrative_800_CT] | Imposes a marginal cost of $800 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation". |
| **Illustrative $1,400 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Illustrative_1400_CT] | Imposes a marginal cost of $1,400 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. |
| **Illustrative $3,400 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Illustrative_3400_CT] | Imposes a marginal cost of $3,400 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. |
| **Illustrative $5,000 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Illustrative_5000_CT] | Imposes a marginal cost of $5,000 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. |
| **Illustrative $6,400 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Illustrative_6400_CT] | Imposes a marginal cost of $6,400 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. |
| **Illustrative Less Stringent Policy Case**<br><br>[5.15_OS_NOx_Illustrative_Less_Stringent] | Imposes the budgets with variability limits derived from the $800 per ton of $NO_X$ case were applied to states covered by the final rule. Units in covered states with extant and operating SCRs operate them at "full operation." This run is also called the "Illustrative Less Stringent Case" |

| | |
|---|---|
| **Illustrative Policy Case**<br><br>[5.15_OS_NOx_Illustrative_Policy] | Imposes the budgets with variability limits derived from the $1,400 per ton of $NO_X$ case were applied to states covered by the final rule. Units in covered states with SCRs operate them at "full operation" and units with SCRs that are not operating return them to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. This run is also called the "Illustrative Policy Case". This case was used for the Illustrative Policy Air Quality Modeling analysis. |
| **Illustrative More Stringent Policy Case**<br><br>[5.15_OS_NOx_Illustrative_More_Stringent] | Imposes the budgets with variability limits derived from the $3,400 per ton of $NO_X$ case were applied to states covered by the final rule. Unit in covered states with SCRs operate them at "full operation" and units with SCRs that are not operating return them to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. This run is also called the "Illustrative More Stringent Case" |
| **Final Base Case**<br><br>[5.15_OS_NOx_Final_Base_Case] | Model run used as the base case for setting the final state budgets for this rule. Based upon the 5.15_OS_NOx_Illustrative_Base_Case case, incorporates updated $NO_X$ rates for units that altered behavior significantly in 2015 as compared to 2011. |
| **Final $800 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Final_800_CT] | Imposes a marginal cost of $800 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation". |
| **Final $1,400 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Final_1400_CT] | Imposes a marginal cost of $1,400 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. |
| **Final $3,400 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Final_3400_CT] | Imposes a marginal cost of $3,400 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. |
| **Final $5,000 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Final_5000_CT] | Imposes a marginal cost of $5,000 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. |
| **Final $6,400 per ton Cost Threshold**<br><br>[5.15_OS_NOx_Final_6400_CT] | Imposes a marginal cost of $6,400 per ton of ozone season $NO_X$ in all states starting in 2017. Also forces all extant and currently operating SCR to operate at "full operation" and all non-operating SCR are returned to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. Units with SNCR "fully operate" those controls. |

| | |
|---|---|
| **Final Policy Case**<br><br>[5.15_OS_NOx_Final_Policy] | Imposes the budgets with variability limits derived from the $1,400 per ton of $NO_X$ case were applied to states covered by the final rule. Units in covered states with SCRs operate them at "full operation" and units with SCRs that are not operating return them to "full operation". Units without SOA combustion controls upgraded to SOA combustion controls. This run is also called the "Final Policy Case". This case was used for the Illustrative Policy Air Quality Modeling analysis. |
| **Final $1,400 per ton Cost Threshold With No State Generation Limits**<br><br>[5.15_OS_NOx_Final_1400_CT] | Similar to the 5.15_OS-NOx_Finfal_1400_CT run, but without limits on state generation levels |

Notes:
1. For the "Illustrative" cases, "fully operating" SCRs means units achieve an emission rate of 0.081 lbs/mmBtu or lower. For the "Final" cases, it means these units achieve an emission rate of 0.10 lbs/mmBtu or lower.
2. Delaware was included as a covered state and given a budget in the Illustrative Policy Case and the Less and More Stringent Policy Cases. This budget did not limit Delaware's emissions in those cases and therefore did not impact the model results. Delaware is not covered by this final rule.

# Appendix B: Description of Excel Spreadsheet Data Files Used in the AQAT

EPA placed the AQAT_final_calibrated.xlsx Excel workbook file in the Transport Rule docket that contains all of the emission and CAMx air quality modeling inputs and resulting air quality estimates from the AQAT. The following bullets describe the contents of various worksheets within the AQAT workbook:

State-level emission totals

- "2017ek (base)" contains state and source-sector specific ozone-season $NO_X$ emission totals for the 5.15 base case modeled in CAMx. Column D, "TOTAL w/o beis, fires" is an input in the AQAT.
- "2011ek (base)" contains state and source-sector specific ozone-season $NO_X$ emission totals for the 5.15 base case for 2011. This is not used in the AQAT.
- "state_sector_summer" contains the emissions used to create the "2017ek (base)" and "2011ek (base)" worksheets.
- "IPM TBtu and $NO_X$_policy case" contains the IPM 5.15 estimates for each of the cases in the air quality modeling.
- "Budget Calcs (2017)" contains each emission budget level.
- "State Level Emissions" are the total ozone-season $NO_X$ emissions for the various base, emissions budgets (EB), and $1,400/ton illustrative control scenario. The results reflect emissions from all fossil units greater than 25 MW for 2017. This sheet also includes the calculations to transform the emission estimates to emission differences as fractions of each state's 2017 base case emission inventory used in the CAMx source apportionment modeling.

Air quality modeling design values from CAMx

- "2017ek-ctrl-ozone-DV-3x3 - Ozon" contains design values for three scenarios (the 2011 case, the 2017 final air quality modeling base case, and the 2017 $1,400 final illustrative control case. The average and maximum design values in 2017 are shown using one decimal place and to four decimal places.

State-level ozone contributions

- "2017 contributions (orig)" includes the original contributions with five decimal places of resolution. The truncated shortened version of these contributions equal the truncated base case average design value. See the Air Quality Modeling Technical Support Document for the Final Cross-State Air Pollution Rule Update and the preamble for details about the contributions.
- "2017 contributions" is a second copy of the contributions. In column BK, the contributions are summed.

Air quality estimates

- "Summary DVs" contains the average and maximum design value estimates (truncated to one decimal place) for receptors that were nonattainment or maintenance in the 2017 base case air quality modeling. Monitors that are at or above 76.0 ppb are shaded.
- "2017 calibration". Contains the unadjusted estimated change in concentration resulting from the difference in emissions between the 2017 base case and the 2017 final budget control scenario case. The calibration factor from the proposal is found in columns BN and BQ. The calibration factor from the final rule modeling is calculated in column CA. The calibration factor used is in column CB. The ratio of the maximum to average design value for the base case is used on all worksheets to estimate the maximum design value.

- "0 IPM" contains the contributions and design values for the $0/ton final base case. These are the emission estimates directly from IPM.
- "0 eng EB" contains the contributions and design values for the $0/ton final emissions budgets base case) cost threshold analysis (where non-linked states were adjusted to the final emissions budgets base case level). These are the emission estimates after the final base case emission estimates from IPM have been converted using the adjusted historical emission values.
- "0 eng EBwith PA" contains the contributions and design values for the $0/ton final emissions budgets base case including PA RACT) cost threshold analysis (where non-linked states were also adjusted to the final emissions budgets base case including PA RACT emission level).
- "800 eng EB" contains the contributions and design values for the $800/ton emissions budgets analysis (where non-linked states were adjusted to the final emissions budgets base case including PA RACT emission level).
- "1400 eng EB" contains the contributions and design values for the $1,400/ton emissions budgets analysis (where non-linked states were adjusted to the final emissions budgets base case including PA RACT emission level).
- "3400 eng EB" contains the contributions and design values for the $3,400/ton emissions budgets analysis (where non-linked states were adjusted to the final emissions budgets base case including PA RACT emission level).
- "5000 eng EB" contains the contributions and design values for the $5,000/ton emissions budgets analysis (where non-linked states were adjusted to the final emissions budgets base case including PA RACT emission level).
- "6400 eng EB" contains the contributions and design values for the $6,400/ton emissions budgets analysis (where non-linked states were adjusted to the final emissions budgets base case including PA RACT emission level).
- "1400_control" contains the estimated state-by-state and receptor-by-receptor air quality contributions and design values for the $1,400/ton illustrative policy case emissions. All states are adjusted to this emission level regardless of whether they are "linked" to a specific monitor. These values can be compared to the CAMx values.
- The "6400 eng EB links", "5000 eng EB links", "3400 eng EB links", "1400 eng EB links", "800 eng EB links", "0 eng EB links", "0 eng EB with PA links", "0 IPM links", "0 eng EB w PA links all", and "1400_control links" worksheets assess the linkages for the 1% threshold. A contribution is set to zero if the maximum design value at that monitor is less than 76.0 ppb or if it is a contribution from the state containing the monitor (i.e., "home" state). Compare rows 4 and 5 to look for linkages that affect whether a state is no longer linked to a monitor that continues to have air quality issues. A value of 1 indicates that the state is "linked". Note that, for the over-control assessment, we are particularly interested in states where there is a value of 1 in row 4 and no value in row 5.

# Appendix C: Description of 2017 Adjustments to 2018 IPM EGU Ozone-Season $NO_X$ Emissions Data

As described in Preamble Section IV.B, the EPA is aligning the analysis and implementation of this final rulemaking with the 2017 ozone season in order to assist downwind states with the timely attainment of the 2008 ozone NAAQS. As described in Preamble Section V.B.2., adjusted the IPM v5.15 2018 run year results to account for differences between 2017 and 2018 in the power sector, because IPM v5.15 does not have an output year of 2017.

To calculate the 2017 emissions for the base case, uniform $NO_X$ cost threshold cases, proposed remedy and alternative cases, and produce a flat files for air quality modeling, EPA started with the 2018 Base Case results and made modifications to emissions of units in three categories as described in the table below.

**Table Appendix C-1. Description of 2017 ozone-season $NO_X$ Adjustment Calculation**

| **2017 ozone-season $NO_X$ Adjustment Case** | **How 2017 Adjustments Were Calculated** |
|---|---|
| SCR Operation/Installation | For units that had an SCR in 2018 but were assumed to not operate (or be installed) in 2017, EPA recalculated the $NO_X$ emissions for the unit with the 2018 heat input and the 2016 emissions rate |
| Retirement | For units projected to retire in 2018, emissions from the 2016 run year were included in the 2017 emissions<br><br>For uniform $NO_X$ cost threshold cases and policy alternative cases, emissions from units with SCRs were determined by multiplying their heat input in the 2016 run year by their optimized $NO_X$ removal rate. |
| Coal-To-Gas | For units that had implemented coal-to-gas retrofit options in 2018 and had not dispatched, emissions from the 2016 run year were incorporated. However, if the coal-to-gas retrofit options had dispatched in 2018, then the $NO_X$ emissions were calculated based on the 2018 fuel use and 2016 $NO_X$ rate. |

Note: 2017 adjustment calculations are based on data from the retrofitted or retired model plant, and therefore may not match unit data in the parsed file, which is not a direct IPM output but rather a post-processed file

The Excel workbook, “Appendix C-2: Incremental ozone season $NO_X$ emissions and heat input for 2017 Adjustments” show the units that were affected by these changes. The workbook lists by unit the reason for the change, the incremental ozone season $NO_X$ and the incremental heat input for 2017 that was calculated. Units may not have added emissions and heat input in every case. These adjustments are summarized at the state level in Appendix E.

# Appendix D:  Ozone-Season $NO_X$ Emissions Budgets for IPM Modeling

To best model the three regulatory control alternatives in IPM, EPA did not include the 2017 budget adjustments in the state budgets, as those adjustments are accounting for things not reflected in the model. Table Appendix D-1 shows the proposed 2017 state budgets and the equivalent 2018 transport region and state emission constraints used for IPM analysis in the IPM v5.15 model platform. The calculations of these numbers are included in Appendix E.

**Table Appendix D-1. Ozone-Season $NO_X$ Emissions Budgets For IPM v5.15 Modeling**

| | Illustrative Policy Case | | Less Stringent Policy Case | | More Stringent Policy Case | | Final Policy Case | |
|---|---|---|---|---|---|---|---|---|
| | Budget | Assurance Level | Budget | Assurance Level | Budget | Assurance Level | Budget | Assurance Level |
| **Alabama** | 12,599 | 15,245 | 13,548 | 16,393 | 11,406 | 13,801 | 13,210 | 15,984 |
| **Arkansas** | 9,211 | 11,145 | 12,060 | 14,593 | 9,041 | 10,940 | 9,210 | 11,144 |
| **Delaware** | 497 | 601 | 497 | 601 | 494 | 598 | N/A | N/A |
| **Iowa** | 11,272 | 13,639 | 11,477 | 13,887 | 11,065 | 13,389 | 11,272 | 13,639 |
| **Illinois** | 14,588 | 17,651 | 14,632 | 17,705 | 14,464 | 17,501 | 14,587 | 17,650 |
| **Indiana** | 21,527 | 26,048 | 26,419 | 31,967 | 19,804 | 23,963 | 23,303 | 28,197 |
| **Kansas** | 7,782 | 9,416 | 7,785 | 9,420 | 7,730 | 9,353 | 8,027 | 9,713 |
| **Kentucky** | 19,675 | 23,807 | 23,030 | 27,866 | 19,475 | 23,565 | 20,782 | 25,146 |
| **Louisiana** | 18,636 | 22,550 | 19,087 | 23,095 | 18,470 | 22,349 | 18,639 | 22,553 |
| **Maryland** | 3,457 | 4,183 | 3,795 | 4,592 | 2,838 | 3,434 | 3,820 | 4,622 |
| **Michigan** | 16,483 | 19,944 | 18,630 | 22,542 | 15,222 | 18,419 | 16,545 | 20,019 |
| **Missouri** | 15,085 | 18,253 | 16,628 | 20,120 | 14,604 | 17,671 | 15,780 | 19,094 |
| **Mississippi** | 6,315 | 7,641 | 6,350 | 7,684 | 6,191 | 7,491 | 6,315 | 7,641 |
| **New Jersey** | 2,057 | 2,489 | 2,063 | 2,496 | 2,061 | 2,494 | 2,061 | 2,494 |
| **New York** | 5,050 | 6,111 | 5,129 | 6,206 | 4,928 | 5,963 | 5,135 | 6,213 |
| **Ohio** | 18,763 | 22,703 | 22,372 | 27,070 | 18,599 | 22,505 | 19,522 | 23,622 |
| **Oklahoma** | 11,742 | 14,208 | 13,871 | 16,784 | 9,254 | 11,197 | 11,619 | 14,059 |
| **Pennsylvania** | 19,554 | 23,660 | 29,875 | 36,149 | 19,479 | 23,570 | 17,946 | 21,715 |
| **Tennessee** | 9,115 | 11,029 | 9,115 | 11,029 | 9,115 | 11,029 | 7,693 | 9,309 |
| **Texas** | 51,931 | 62,837 | 54,544 | 65,998 | 50,022 | 60,527 | 52,300 | 63,283 |
| **Virginia** | 9,224 | 11,161 | 9,357 | 11,322 | 8,758 | 10,597 | 9,223 | 11,160 |
| **Wisconsin** | 7,862 | 9,513 | 7,922 | 9,586 | 7,791 | 9,427 | 7,915 | 9,577 |
| **West Virginia** | 18,152 | 21,964 | 25,730 | 31,133 | 17,706 | 21,424 | 17,815 | 21,556 |
| **CSAPR Update Region Total** | **310,577** | **N/A** | **353,916** | **N/A** | **298,517** | **N/A** | **312,719** | **N/A** |

# Appendix E: Detailed Budget Calculations

See the spreadsheet “Ozone Transport Policy Analysis Final Rule TSD Appendix E” for detailed calculations of state budgets and assurance levels.

# Appendix F: State Generation Constraint Analysis

**Table F-1. Tons of EGU $NO_X$ reduction potential from shifting generation (with state level generation constraints), compared to adjusted historic emissions.[35]**

| Row Labels | 2015 Adjusted Historical Emissions | Reductions from Generation Shifting between the Final Base Case and the Final $1,400 per ton Cost Threshold Case | Reductions From Generation Shifting as a Percentage of 2015 Adjusted Historical Emissions |
|---|---|---|---|
| Alabama | 15,179 | -474 | -3% |
| Arkansas | 12,560 | -348 | -3% |
| Illinois | 14,850 | -241 | -2% |
| Indiana | 31,382 | -1,205 | -4% |
| Iowa | 11,478 | -10 | 0% |
| Kansas | 8,031 | -8 | 0% |
| Kentucky | 26,318 | -690 | -3% |
| Louisiana | 19,101 | -318 | -2% |
| Maryland | 3,871 | -45 | -1% |
| Michigan | 19,811 | -357 | -2% |
| Mississippi | 6,438 | -29 | 0% |
| Missouri | 18,443 | -430 | -2% |
| New Jersey | 2,114 | -34 | -2% |
| New York | 5,531 | -295 | -5% |
| Ohio | 27,382 | -252 | -1% |
| Oklahoma | 13,747 | -457 | -3% |
| Pennsylvania | 35,607 | -353 | -1% |
| Tennessee | 7,779 | -34 | 0% |
| Texas | 54,839 | -441 | -1% |
| Virginia | 9,367 | -83 | -1% |
| West Virginia | 26,874 | 33 | 0% |
| Wisconsin | 7,939 | -34 | 0% |
| **TOTAL** | 378,641 | -6,107 | -2% |

[35] See "Reductions From Generation Shifting in the Final $1400 Per Ton Cost Threshold Case" in the docket for this rule

**Table F-2. Comparison of state level ozone season $NO_X$ emission reductions from affected sources and resulting state budgets between the $1,400 per ton cost threshold cases with and without state level generation constraints.**[36] Note that the change in budget in the table would be additional reductions (negative numbers) of fewer reductions (positive numbers) due to allowing generation to shift among states. This change would be incremental to $NO_X$ reductions from generation shifting identified in table F-1.

| State | Final Budget (with state generation limits) (tons) | Budget without state generation limits (tons) | Change in Budget (tons) | Percent Change |
|---|---|---|---|---|
| **Alabama** | 13,211 | 13,097 | -114 | -1% |
| **Arkansas** | 9,210 | 9,290 | 80 | 1% |
| **Iowa** | 11,272 | 11,230 | -42 | 0% |
| **Illinois** | 14,601 | 14,608 | 7 | 0% |
| **Indiana** | 23,303 | 23,399 | 96 | 0% |
| **Kansas** | 8,027 | 7,969 | -58 | -1% |
| **Kentucky** | 21,115 | 20,931 | -184 | -1% |
| **Louisiana** | 18,639 | 18,572 | -67 | 0% |
| **Maryland** | 3,828 | 3,066 | -762 | -20% |
| **Michigan** | 16,545 | 16,615 | 70 | 0% |
| **Missouri** | 15,780 | 15,776 | -4 | 0% |
| **Mississippi** | 6,315 | 6,438 | 123 | 2% |
| **New Jersey** | 2,062 | 2,074 | 12 | 1% |
| **New York** | 5,135 | 5,146 | 11 | 0% |
| **Ohio** | 19,522 | 19,516 | -6 | 0% |
| **Oklahoma** | 11,641 | 11,450 | -191 | -2% |
| **Pennsylvania** | 17,952 | 18,038 | 86 | 0% |
| **Tennessee** | 7,736 | 7,736 | 0 | 0% |
| **Texas** | 52,301 | 52,098 | -203 | 0% |
| **Virginia** | 9,223 | 9,169 | -54 | -1% |
| **Wisconsin** | 7,915 | 7,889 | -26 | 0% |
| **West Virginia** | 17,815 | 17,849 | 34 | 0% |
| **Total** | 313,148 | 312,047 | -1,192 | 0% |

[36] See "Budget Calculations for Final $1400 per ton Cost Threshold Case with No State Generation Limits" in the docket for calculations.