NERA
ECONOMIC CONSULTING

EPA Regulatory Impact Analysis of Proposed Federal Ozone Standard: Potential Concerns Related to EPA Compliance Cost Estimates

Prepared for:

National Association of Manufacturers

March 2015

Authors

David Harrison, Jr., Ph.D.
Anne E. Smith, Ph.D.
Scott J. Bloomberg
Conor Coughlin
Christopher D'Angelo
Julia Greenberger
Carl McPherson
Andrew Stuntz

NERA Economic Consulting

200 Clarendon St, 11th Floor
Boston, Massachusetts 02116
Tel: +1 617 927 4500
Fax: +1 617 927 4501

1255 23rd St, NW, Suite 600
Washington, D.C. 20037
Tel: +1 202 466 3510
Fax: +1 202 466 3605

www.nera.com

Report Qualifications/Assumptions and Limiting Conditions

Information furnished by others, upon which all or portions of this report are based, is believed to be reliable, but has not been independently verified, unless otherwise expressly indicated. Public information and industry and statistical data are from sources we deem to be reliable; however, we make no representation as to the accuracy or completeness of such information. The findings contained in this report may contain predictions based on current data and historical trends. Any such predictions are subject to inherent risks and uncertainties. NERA Economic Consulting accepts no responsibility for actual results or future events.

The opinions expressed in this report are valid only for the purpose stated herein and as of the date of this report. No obligation is assumed to revise this report to reflect changes, events or conditions, which occur subsequent to the date hereof. The opinions expressed in this report do not necessarily represent the views of NERA Economic Consulting, other NERA consultants, or NERA's clients.

All decisions in connection with the implementation or use of advice or recommendations contained in this report are the sole responsibility of the client. This report does not represent investment advice nor does it provide an opinion regarding the fairness of any transaction to any and all parties.

Contents

EXECUTIVE SUMMARY **E-1**

I. INTRODUCTION **1**
A. Background 1
B. Objectives of This Report 1
C. Report Organization 2

II. Overview of EPA'S Methodology for Estimating Emission Reductions and Compliance Costs **3**
A. EPA Baseline Projections of Ozone and Precursor Emissions 3
B. EPA Estimates of Required Precursor Emission Reductions and Known Controls 6
C. EPA Estimates of Compliance Costs 12

III. Concerns with EPA'S Emission and Compliance Cost Analysis **16**
A. Concerns Related to EPA's Determination of Compliance Emission Reductions 16
B. Concerns Related to EPA's Calculation of Unknown Control Costs 30
C. Summary of Concerns 38

IV. REFERENCES **40**

List of Figures

Figure E-1. Summary of Concerns with the EPA RIA Ozone Compliance Cost Estimates E-2

Figure 1. EPA 2025 “Base Case” Emissions by Source Category, Excluding California (1000s of tons)............ 4

Figure 2. Development of EPA Baseline NO_X Emissions by Source Category (tons).................. 6

Figure 3. EPA Air Quality Modeling Regions.................. 8

Figure 4. Regional Base Case NO_X Emissions and Amounts of Reduction Projected to Be Needed for Compliance with a 65 ppb Ozone Standard (Including Reductions EPA Has Assumed Will Be Part of Its Baseline) 10

Figure 5. EPA Known Control Technologies for a 65 ppb Ozone Standard (Incremental to the EPA Baseline).................. 11

Figure 6. U.S. Summary of EPA NO_X Control Strategy for a 65 ppb Ozone Standard 12

Figure 7. EPA Annualized Known Control Costs by Source Category for a 65 ppb Ozone Standard (millions of 2011 dollars) 13

Figure 8. EPA Annualized Unknown Control Costs by Region for a 65 ppb Ozone Standard.... 13

Figure 9. EPA Annualized Unknown Control Costs Sensitivity by Region for a 65 ppb Ozone Standard 14

Figure 10. EPA Annualized Control Costs by Region for a 65 ppb Ozone Standard (Excluding California).................. 15

Figure 11. EPA Area Classifications and Likely Attainment Dates.................. 17

Figure 12. “Base Case” vs. 65 ppb Compliance NO_X Emissions, 2018 – 2025 (States Requiring Reductions for 65 ppb, Excluding California).................. 20

Figure 13. Percentage NO_X Reduction Required by State and Counties with Nonattaining Monitors in the 2025 Baseline (65 ppb Standard) 22

Figure 14. Regional NO_X Reductions and Costs by Nonattainment Status for 65 ppb (Incremental to the EPA Baseline).................. 23

Figure 15. EPA “Base Case” NO_X Emissions in 2018 and 2025 (Excluding California)............ 25

Figure 16. NO_X Reductions from Baseline for a 65 ppb Ozone Standard (Excluding CA)......... 28

Figure 17. U.S. NO_X Reductions and Cost per Ton for EPA 65 ppb Control Strategy, Incremental to EPA Baseline (Excluding California).................. 31

Figure 18. Marginal Cost Curve Example of EPA Average ("Fixed") and Hybrid Approach 33

Figure 19. Unknown Control Costs for 65 ppb Using EPA Average ("Fixed") and Hybrid Approaches, Excluding California 33

Figure 20. State Marginal Cost Curve Illustrations of EPA's 65 ppb Analysis 34

Figure 21. NO_X Emissions Remaining After Known Controls for 65 ppb by Source Category by 2025 (Excluding California) 36

EXECUTIVE SUMMARY

This report reviews the data and methodology the U.S. Environmental Protection Agency (EPA) used to develop estimates of the compliance costs of a more stringent national ambient air quality standard (NAAQS) for ozone. Our assessment is supported by numerical examples based on emission reductions and costs of a tightening of the ozone standard to 65 parts per billion (ppb), relative to the current standard of 75 ppb; however, the data and methodological issues we discuss would apply to any of the alternative standards in the EPA ozone NAAQS Proposed Rule. In its Regulatory Impact Analysis (RIA),[1] EPA estimated that the additional annualized costs of achieving a 65 ppb standard beyond costs of attaining the current standard of 75 ppb, for areas other than California, would be about $15.4 billion per year, of which about $4.2 billion would be "known" controls and about $11.3 billion would be "unknown" controls[2] —very substantial costs by any criterion. However, as summarized below and explained in more detail in our report, we find that EPA's estimate understates likely compliance costs.

Figure E-1 summarizes our assessments of the most substantial concerns we identified with EPA's emission reductions and cost information, divided into those affecting emission reductions and those affecting the estimated cost per ton for emission reductions.

[1] U.S. EPA, *Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone,* EPA-452/P-14-006, Office of Air and Radiation, Research Triangle Park, NC, November 2014. Available: http://www.epa.gov/ttnecas1/regdata/RIAs/20141125ria.pdf.

[2] We exclude California costs in our assessments because EPA used a different methodology and presented costs for California separately. The EPA RIA listed $1.6 billion in unknown control costs in California.

Figure E-1. Summary of Concerns with the EPA RIA Ozone Compliance Cost Estimates

	Concern	Implication for EPA's Compliance Cost Estimate
Concerns Related to Calculation of Compliance Emission Reductions		
1	EPA used a 2025 "snapshot" to estimate incremental attainment needs, but nonattainment designations and attainment deadlines are earlier	
	(a) Number of areas that will be in nonattainment	Major Understatement
	(b) Number of tons needing to be reduced compared to Baseline emissions, and timing of the spending	Understatement
2	EPA assumed controls for multistate regions rather than for individual states	Understatement
3	EPA projected large reductions in onroad mobile source "Base Case" emissions from 2018 to 2025	Understatement
4	EPA included the proposed Clean Power Plan in the Baseline	Major Understatement
5	EPA's analysis used a different EGU "Base Case" emissions projection than in EPA's Clean Power Plan analysis	Understatement
Concerns Related to Calculation of Unknown Control Costs		
6	EPA assumed an average value of $15,000 per ton in its unknown control cost estimates	Major Understatement
7	EPA's sensitivity analysis on the average cost per ton for emission reductions from unknown controls assumed a low of $10,000 per ton and a high of $20,000 per ton	Major Understatement

All seven of these concerns point to a conclusion that the EPA RIA understated the potential costs—including the range of potential costs—of meeting a more stringent ozone standard.[3] Four of the concerns listed in Figure E-1 seem in our judgment likely to lead to a major understatement:

[3] We also identified a number of concerns with EPA's known control costs. Given the relatively small magnitude of those components as part of the total cost estimate, however, we do not expect that concerns with these estimates would have as substantial an effect as the concerns we identify in Figure E-1. We therefore did not focus any attention in this report on issues affecting the known control cost estimates.

1. *EPA used a 2025 "snapshot" to estimate incremental attainment needs, but nonattainment designations and attainment deadlines are earlier.* This assumption understates the number of areas that will be in nonattainment as well as the number of tons needed to be reduced compared to Baseline emissions and timing of the spending. Areas designated as marginal or moderate would likely have attainment dates around the end of 2020 and 2023, respectively, and would incur costs before 2025—costs that are disregarded (by assumption) in EPA's analysis. (Our assessment does not consider the complications of potential reclassifications of individual non-attainment areas.)

4. *EPA included the proposed Clean Power Plan (CPP) in the Baseline.* EPA's inclusion of CPP emission reductions is not only inconsistent with its standard practice of only including promulgated regulations, but such a deviation from standard procedure is particularly unjustified given the enormous uncertainty in what carbon limits may actually be applied and how states would comply, and hence what NO_X emission reductions might actually occur as a result of EPA regulation of carbon emissions from existing electricity generating units. Without the proposed CPP in the Baseline, at least an additional 300,000 tons of NO_X reductions would be required for the 65 ppb standard, leading to a substantial increase in the estimated compliance costs.

6. *EPA assumed a constant value of $15,000 per ton for all unknown emission reductions*. Controls that EPA refers to as unknown (*i.e*., for which no compliance controls are identified) represent about 40% of EPA's estimated tons and about 73% of EPA's estimated costs to attain a 65 ppb ozone standard (excluding California). As one indication of the importance of this single assumption, we calculated that unknown control costs would have increased by about $3.7 billion per year (*i.e.*, from $11.3 billion to $15.0 billion, excluding California) if EPA had used an alternative methodology presented in its own most recent prior ozone NAAQS cost assessment in 2010, as described in the body of this report. Changing just this one aspect of the EPA methodology would lead to a total cost estimate of $19.2 billion to achieve a 65 ppb ozone standard (excluding California).

7. *EPA assumed an uncertainty band for unknown costs of $10,000 to $20,000 per ton*. This arbitrary range seems likely to understate substantially the potential compliance costs. Given that unknown controls would have to reduce emissions from many diffuse area or mobile sources—since point sources are already highly controlled—the cost per ton could be substantial (*e.g.*, requiring early turnover of still productive capital stock such as motor vehicles and residential or commercial heating equipment).

The other three concerns listed in Figure E-1 also suggest that the EPA RIA understated the compliance costs of meeting a more stringent ozone standard.

2. *EPA allowed for multistate controls rather than for state-by-state compliance plans*. Although the Clean Air Act requires states to develop plans to achieve the ozone

standard—absent specific multi-state agreements that seem unlikely to be put in place by the time that states would be required to submit their State Implementation Plans (SIPs)—EPA's modeling approach allows controls in other states to "count" toward a state's compliance. Since EPA's control strategy first implemented relatively inexpensive known controls throughout a region before moving to more expensive unknown controls, requiring state-by-state compliance would lead to greater dependence on unknown controls in some states and thus greater compliance costs.

3. *EPA projected large reductions from 2018 to 2025 in onroad mobile sources in the Baseline.* We have identified several concerns that these Baseline reductions may be overstated, which would have the effect of understating the emissions that need to be reduced and thus the overall cost of a more stringent ozone standard. One corollary of EPA's disregard of the need for some states to achieve compliance before 2025 is that the large reductions in mobile source emissions after actual compliance dates (the end of 2020 and 2023) would not "count" toward compliance, and hence there will be costs for either speeding up the pace of those reductions, or making up for their absence by attainment deadlines. An additional concern is related to the lack of documentation by EPA of its assumptions regarding fleet turnover; fleet turnover is important because more stringent emission standards apply to new vehicles and the actual emission reductions thus depend in part upon the extent to which older vehicles are replaced by the lower-emitting new vehicles. Also, the tighter CAFE standard will be reviewed in 2018 and could be reduced if found to be too costly (as discussed in the report). If CAFE standards were to be relaxed, the rate of NO_X reductions from onroad vehicles could be less than EPA has assumed in the Baseline. For all of these reasons, we are concerned that the Baseline NO_X reductions achievable by 2025 from this source category may be overstated, with little likelihood that they are understated.

5. *EPA used different EGU emissions in the Baseline for its ozone analysis than in the Clean Power Plan analysis*. EPA's analysis of the CPP indicates fewer EGU NO_X emissions in the Baseline than assumed in the ozone RIA. Although we could not determine the reasons for this difference between two recent analyses, a lower Baseline EGU NO_X level would likely imply fewer NO_X reductions from the CPP than EPA assumes in the ozone RIA, leading to an increase in the compliance costs to achieve a more stringent ozone standard.

In summary, our evaluation suggests that EPA has understated the potential compliance costs—including their likely range—of meeting a more stringent ozone standard. Achieving a more stringent ozone standard could be substantially more costly than even the very substantial costs EPA has estimated.

I. INTRODUCTION

This report provides an assessment of the compliance cost estimates provided in the Regulatory Impact Analysis (RIA) prepared by the U.S. Environmental Protection Agency (EPA) for its proposed revision to the federal national ambient air quality standard (NAAQS) for ozone. We focus on the EPA estimates of the incremental emission reductions and costs that would be required to achieve compliance with a potential 65 parts per billion (ppb) ozone standard. As in the RIA, all of these estimated reductions and costs are incremental to the effort needed to attain the existing standard of 75 ppb.

A. Background

1. EPA Ozone Proposal

EPA released its ozone proposal on November 26, 2014 and published the proposal in the *Federal Register* on December 17, 2014. The current ozone standard is 75 ppb, established by EPA in 2008. In its proposal, EPA proposed a range for revised primary and secondary ozone standards of 65 to 70 ppb. The Agency also indicated it would take comment on a 60 ppb standard and that it also would take comment on the option to retain the current standard.

2. EPA Regulatory Impact Analysis

EPA released its RIA on November 26, 2014.[4] The RIA provides EPA's estimates of the potential societal benefits and costs for the proposed ozone standards. Costs and benefits were estimated relative to first achieving full attainment of the current standard of 75 ppb.

B. Objectives of This Report

The objectives of this report are to summarize the emission and cost information developed by EPA in its RIA and to identify potential concerns with its accuracy. In particular, we concentrate on EPA's estimates of reductions in ozone precursor emissions (nitrogen oxides, or NO_X, and volatile organic compounds, or VOCs) necessary to achieve a revised ozone standard and on EPA's estimates of the compliance costs that would be incurred.

As noted, we limit our examples to the 65 ppb proposed standard. The issues we raise would be relevant to other potential ozone standards, although the numerical magnitude would vary.

[4] USEPA, *Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone*, EPA-452/P-14-006, Office of Air and Radiation, Research Triangle Park, NC, November 2014. Available: http://www.epa.gov/ttnecas1/regdata/RIAs/20141125ria.pdf.

C. Report Organization

The remainder of this report is divided into two sections. Section II provides an overview of EPA's methodology and results. As noted, we focus on EPA's estimates of emission reductions and compliance costs related to a 65 ppb standard. Section III discusses concerns with the EPA's estimates, prioritizing the concerns as "major" concerns and "additional" concerns.

II. OVERVIEW OF EPA'S METHODOLOGY FOR ESTIMATING EMISSION REDUCTIONS AND COMPLIANCE COSTS

This section provides an overview of EPA's methodology for estimating the potential emission reductions and compliance costs to achieve a proposed ozone standard of 65 ppb, relative to the current standard of 75 ppb. We summarize EPA's analysis in terms of three basic steps:

1. Develop a Baseline projection of ozone levels and precursor emissions;
2. Estimate the state-level reductions in emissions from the Baseline needed to comply with alternative ozone standards and identify "known" and "unknown" controls to achieve those reductions; and
3. Estimate the costs of the emission controls needed to comply with alternative ozone standards.

The sections below summarize EPA's methodology and results for each of these three steps. We do not include EPA's estimates for California, which are based on a different methodology than that developed for the other states. Note that in some cases we provide comments on EPA's methodology that indicate our concerns with EPA's methodology; these concerns are developed in more detail in Section III of this report.

A. EPA Baseline Projections of Ozone and Precursor Emissions

The costs of attaining a new ozone standard depend on ambient air quality in the future, consistent with the timing of the attainment deadlines that areas will face under a revised ozone standard. EPA developed a Baseline projection of ozone concentrations and precursor emissions for the year 2025. The 2025 information formed the basis for a 2025 "snapshot" analysis of annualized attainment costs.

The EPA Baseline was developed by modifying a 2025 "Base Case" projection to reflect three additional modifications: (1) EPA's proposed Clean Power Plan (CPP), (2) the current ozone NAAQS (75 ppb), and (3) post-2025 vehicle emissions in California.

1. The 2025 "Base Case" Emissions Projection

EPA began its analysis with the Ozone NAAQS Emissions Modeling Platform (2011v6.1), which projected NO_X, VOC, and other emissions from 2011 inventory levels to future years 2018 and 2025. This projection included most regulations and programs currently "on the books," including MATS, CAIR, most NSPS, and Tier 3 vehicle standards.

Emissions in this EPA "Base Case" projection are divided into sectors of emissions sources, which we group into five emissions "source categories":

1. *EGU* – Electricity generating units;

2. *Point* – Non-EGU point sources, such as industrial boilers, cement kilns, and petroleum refineries;

3. *Area* – Area sources, such as dry cleaners, commercial buildings, and residential buildings;

4. *Onroad* – Onroad mobile sources such as passenger cars, light-duty trucks, and heavy-duty trucks; and

5. *Nonroad* – Nonroad mobile sources, such as locomotives, aircraft, marine vessels, construction equipment, and agricultural equipment.

EPA focused its ozone analysis on those anthropogenic emissions that can be reduced using domestic controls or programs. Fires and biogenic emissions, as well as tribal data and exclusive economic zone (EEZ) emissions, were excluded from EPA's analyses (EPA 2014a p. 3-14 and Table 3-3). Figure 1 shows the 2025 "Base Case" emissions projection by source category for the lower 48 states excluding California.

Figure 1. EPA 2025 "Base Case" Emissions by Source Category, Excluding California (1000s of tons)

	NO_X	VOC
Total	**7,684**	**9,487**
EGU	1,442	40
Point	1,749	950
Area	1,706	6,368
Onroad	1,333	976
Nonroad	1,454	1,153

Note: Anthropogenic NO_X and VOC emissions (excluding fires and biogenic sources) in the lower 48 states (excluding California, tribal regions, and EEZ emissions). Nonroad VOC emissions in EPA (2014a) Tables 3-1 and 3-3 differ slightly from nonroad VOC emissions in the raw 2025 "Base Case" projection files used for this figure (a difference of less than 10,000 tons).
Source: EPA 2014b and 2014c

2. Modifications to the 2025 "Base Case"

To develop its Baseline scenario, EPA then made three adjustments to the 2025 "Base Case" to reflect other developments that (according to EPA) would take place regardless of whether a new ozone standard were implemented.

a. EPA's Proposed Clean Power Plan

EPA adjusted the 2025 "Base Case" emissions to reflect compliance with EPA's proposed CPP under section 111(d) of the Clean Air Act. The impact of the CPP on NO_X emissions was estimated using simulations conducted with the IPM model of Option 1 of the CPP Proposed Rule,[5] and assuming "state-level compliance" with that option (EPA 2014a p. 4-1, 4-5, and 3-11).[6]

b. The Current Ozone NAAQS (75 ppb)

EPA further adjusted 2025 "Base Case" emissions to reflect compliance with the current ozone NAAQS of 75 ppb. EPA projected that 11 counties, all in California or Texas, would exceed the current 75 ppb standard in 2025 in the Base Case (EPA 2014a, Figure 4-1). Emission controls and compliance costs associated with meeting the current standard are not attributable to a new ozone NAAQS, so EPA includes them in the EPA Baseline.

c. Post-2025 Vehicle Emissions in California

EPA notes that parts of California probably would not be required to meet a new ozone standard until sometime in the 2030s (EPA 2014a p. 1-9). When simulating costs to attain the new standard in California, EPA attempted to look at incremental tons that would need to be reduced in the 2030s, rather than in 2025. Thus, for California's attainment costs, EPA developed a Baseline from the 2025 inventory that is intended to reflect a yet-later year, called "post-2025." This "post-2025" Baseline for California includes an additional reduction of 14,000 tons of NO_X and 6,000 tons of VOC that EPA projected will occur between 2025 and 2030 due to further implementation of current vehicle regulations (EPA 2014a, p. 1-9, 3A-25).

Due to the later attainment year in California, EPA presented California information separately from the rest of the lower 48 states in its RIA. For consistency with the non-California tables in the EPA RIA, we have excluded California from all tables and figures in this report.

---

[5] EPA estimated that Option 1 in the CPP Proposed Rule would reduce U.S. CO_2 power plant emissions by 30% in 2030, relative to the 2005 emission level. (Option 2 would have less stringent emission rate targets and different compliance timing.) This analysis was based on emission rate targets developed using four "Building Blocks" – heat rate improvements at coal units, increased utilization of natural gas combined cycle units, increases in renewables and nuclear energy, and increases in end-use energy efficiency.

[6] We presume that EPA adjusted only NO_X emissions to get from its Ozone NAAQS "Base Case" to the Ozone NAAQS Baseline. This presumption is based on our review of EPA's statements about VOCs in the RIA for the CPP Proposed Rule; this document suggests that EPA may have estimated VOC emissions changes due to the CPP in calculations outside of its compliance modeling (EPA 2014h, p. 4A-7), but it later states that VOC emissions changes from the CPP are insignificant as a reason why EPA did not account for them when assessing ozone co-benefits of the CPP Proposed Rule (EPA 2014h, 4A-17). Even if EPA did include undocumented VOC reductions from the CPP Proposed Rule in constructing the ozone NAAQS Baseline, this adjustment would have had minimal effect on emissions and cost estimates.

3. Summary of the EPA Calculation of Baseline NO_X Emissions

Figure 2 summarizes the development of the EPA Baseline NO_X emissions projection, including the three adjustments to the 2025 "Base Case" projection.

Figure 2. Development of EPA Baseline NO_X Emissions by Source Category (tons)

	2025 "Base Case"	Baseline Adjustments		EPA Baseline
		Clean Power Plan	75 ppb (TX)	
US (excluding CA)	**7,683,845**	**431,155**	**44,830**	**7,207,434**
Northeast	1,184,694	55,250	-	1,129,444
Midwest	1,770,593	37,343	-	1,733,250
Central	2,175,956	160,340	45,256	1,970,360
Southwest	712,913	50,474	-	662,439
Rest of US (excluding CA)	1,839,690	127,748	-	1,711,941

Note: Anthropogenic NO_X emissions (excluding fires and biogenic sources) in the lower 48 states (excluding California, tribal regions, and EEZ emissions).
Source: EPA 2014b, 2014e, 2014f, 2014k

B. EPA Estimates of Required Precursor Emission Reductions and Known Controls

Given its Baseline scenario, EPA then determined which areas of the U.S. would still be in nonattainment by 2025 if no additional controls were applied. EPA then estimated additional reductions in NO_X and VOC emissions that would be needed to comply with new ozone standards and then developed an illustrative "control strategy" to achieve those reductions.

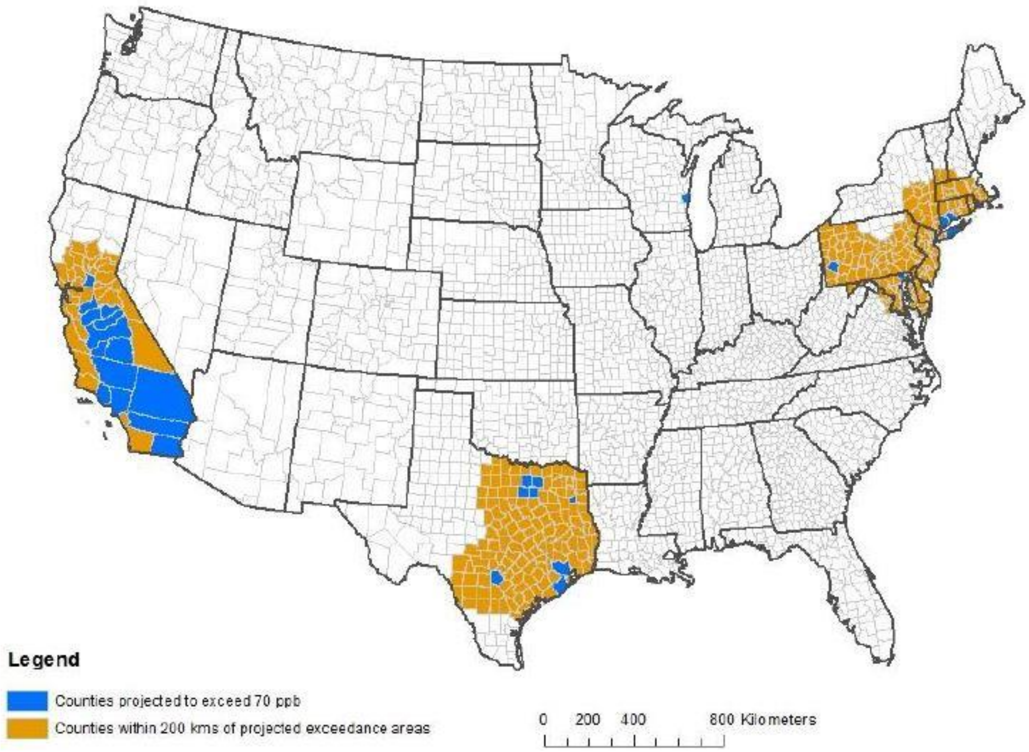
Note that EPA's decision to focus on 2025 Baseline conditions does not account for nonattainment designations that will occur *prior to 2025*, which in turn can lead to an understatement of necessary emission reductions to achieve a revised ozone standard. EPA will likely make nonattainment designations in 2017 based on monitored ozone levels during 2014 through 2016 (EPA 2014a p. 1-8). Because substantial emissions reductions are projected to occur *between 2018 and 2025* in EPA's "Base Case", there would likely be substantially more areas that will actually be designated as nonattainment under a new ozone NAAQS than would be projected by considering only 2025 Baseline conditions. Those additional nonattainment areas would face attainment dates around the end of 2020 or 2023 (for marginal and moderate designations, respectively). Thus, to the extent that needed emissions reductions that EPA projected to occur in its Baseline *by 2025* do not actually occur before 2023, EPA's method has understated the extent of nonattainment designations and also likely has understated the overall costs of attainment of a more stringent standard. This important feature of EPA's methodology is discussed further in Section III.

1. Required NO_X Emission Reductions

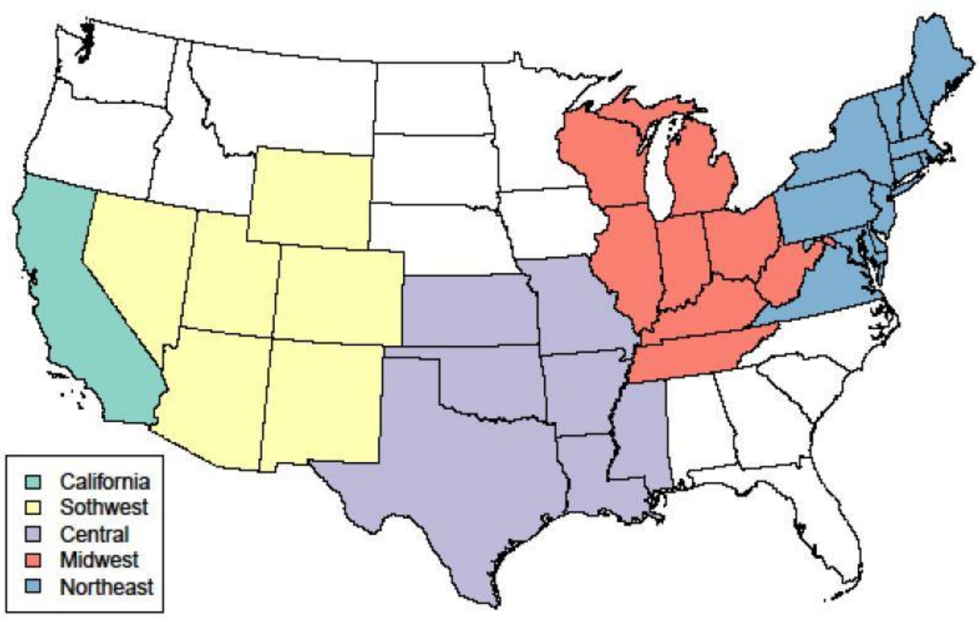
Using only the 2025 "Base Case" conditions, EPA applied emissions scenarios to estimate the responsiveness of ozone design values to region-wide reductions in emissions. Figure 3 below shows the two sets of regions used to model the responsiveness of ozone to changes in NO_X emissions.[7] The three smaller "buffer" regions in the top map were used to model the responsiveness of ozone to a set of identified NO_X controls implemented near monitors with projected ozone concentrations greater than 70 ppb. The five larger regions following state borders shown in the bottom map were used to analyze responsiveness to across-the-board reductions in 2025 "Base Case" NO_X emissions. For example, EPA estimated the change in ozone concentration at each ozone monitor in the Southwest if there were to be a 50% across-the-board reduction in 2025 "Base Case" NO_X emissions throughout the Southwest region.

[7] EPA also applied one nationwide air quality modeling scenario to estimate the responsiveness of ozone to the NO_X reductions estimated by EPA to result from Option 1 of the proposed Clean Power Plan (EPA 2014a Table 3-2). EPA used the results of this scenario to develop the Baseline for its ozone RIA analysis.

Figure 3. EPA Air Quality Modeling Regions



Note: California, Texas, and Northeast "buffers" used for determining ozone response to explicit controls
Source: EPA 2014a Figure 3-2



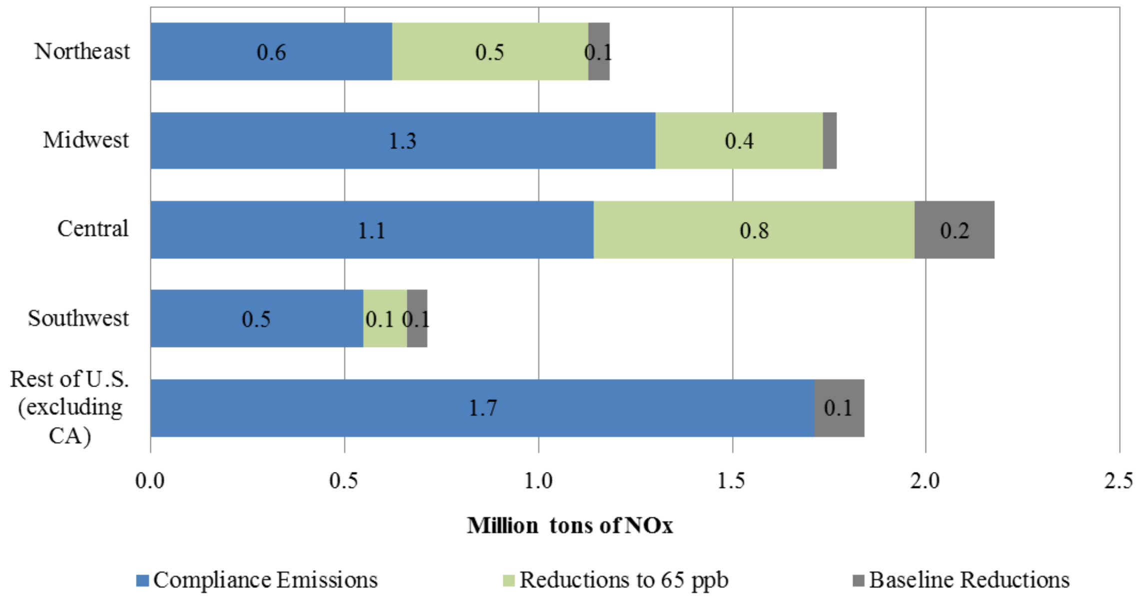
Note: 5 regions used for determining ozone response to across-the-board emissions reductions
Source: EPA 2014a Figure 3-3

These air quality scenarios resulted in estimates of "relative response factors" – the approximate change in ozone design values at an ozone monitor estimated to result from a *regional* change in precursor emissions. To determine how many tons of emission reductions would be required to meet each alternative ozone standard, EPA applied emission reductions within each of the regions until the ozone concentration at every monitor within the respective region (as calculated using the "relative response factors") was projected to meet that standard.[8] Figure 4 shows each region's 2025 "Base Case" NO_X emissions (as the full length of each horizontal bar), the regional emission reductions EPA assumed would be part of the RIA's Baseline (*i.e.*, the grey portions of each bar), and additional NO_X reductions EPA projected to be needed to comply with a 65 ppb standard in EPA's analysis (green portions of each bar). The remainder of each bar (the blue portion) shows the total tons of NO_X that EPA estimates may remain in each region while fully attaining the 65 ppb alternative standard. That remainder is called "compliance emissions."

As noted above, these results are based on EPA's approach that determined incremental tons of reduction needed for attainment only when the year 2025 has been reached, whereas the nonattainment designations will be based on conditions that exist prior to 2018, and EPA expects most of the associated attainment deadlines to be around the end of 2020 or 2023 (EPA 2014a p. 1-8).

[8] Note that EPA excluded 26 rural or remote monitors in the West and Southwest from its analysis due to low modeled responsiveness to NO_X reductions, mostly due to transport from California and Mexico (EPA 2014a p. 3A-54). EPA suggests that these areas could pursue regulatory relief from a tighter ozone NAAQS. EPA projected that all 26 of these excluded monitors would be in attainment with a 70 ppb ozone standard in EPA's 2025 Baseline, but 15 of these monitors are projected to exceed a 65 ppb ozone standard. To the extent that these areas are *unable* to obtain exemptions from NAAQS requirements, they could require additional emissions reductions (and control costs) that are not captured in EPA's analysis.

Figure 4. Regional Base Case NO_X Emissions and Amounts of Reduction Projected to Be Needed for Compliance with a 65 ppb Ozone Standard (Including Reductions EPA Has Assumed Will Be Part of Its Baseline)



Note: Anthropogenic NO_X emissions (excluding fires and biogenic sources) in the lower 48 states (excluding California, tribal regions, and EEZ emissions)

Source: EPA 2014b, 2014e, 2014f, 2014g, 2014k, 2014l

2. Develop Control Strategy

To achieve the emission reductions necessary for compliance (*i.e.*, the quantity of tons shown by the green portions of the horizontal bars in the above figure), EPA developed a control strategy consisting of "known" controls (*i.e.*, control actions that EPA has identified) and, if additional reductions are needed, "unknown" controls (*i.e.*, control measures that EPA has not identified in its data supporting this RIA).

a. EPA Known Controls

EPA identified some known controls for four of the five emissions source categories. No controls were identified for emissions in the onroad source category "because they are largely addressed in existing rules such as the recent Tier 3 rule" (EPA 2014a p. 4-12).

- To reduce NO_X emissions, EPA identified selective catalytic reduction (SCR) controls for EGUs; point and area source controls including low-NO_X burners (LNB), catalytic reduction controls (SCR, selective non-catalytic reduction or SNCR, and non-selective catalytic reduction or NSCR), and OXY-firing; and diesel SCR and engine rebuild or upgrade retrofits for nonroad sources.

- For VOC emissions, EPA applied a variety of work practice and materials changes in addition to add-on controls for point and area sources (EPA 2014a p. 4A-12).

Figure 5 summarizes the known control technologies and associated NO_X reductions that EPA developed for its 65 ppb control strategy.

Figure 5. EPA Known Control Technologies for a 65 ppb Ozone Standard (Incremental to the EPA Baseline)

NO_X		VOC	
Control Technology	**Emission Reductions (tons)**	**Control Technology**	**Emission Reductions (tons)**
Total	**1,123,514**	**Total**	**105,766**
EGU	**204,616**	**EGU**	**0**
SCR	204,616		
Point	**444,034**	**Point**	**4,118**
Low Emission Combustion	126,959	Permanent Total Enclosure (PTE)	1,554
SCR	94,970	Solvent Recovery System	842
LNB and SCR	66,610	Add-on controls, work practices & materials	564
LNB	37,383	Other	1,157
NSCR	33,553		
OXY-Firing	29,546		
Adjust Air to Fuel Ratio & Ignition Retard	27,057		
Other	27,956		
Area	**462,026**	**Area**	**101,649**
NSCR	291,136	Reformulation	55,990
LNB (1997 AQMD)	57,351	Incineration	26,164
Water heater + LNB Space Heaters	57,314	LPV Relief Valve	7,317
Low Emission Combustion	47,074	RACT	5,988
Other	9,151	Other	6,189
Onroad	**0**	**Onroad**	**0**
Nonroad	**12,837**	**Nonroad**	**0**
Diesel SCR and Engine Rebuild/Upgrade	12,837		

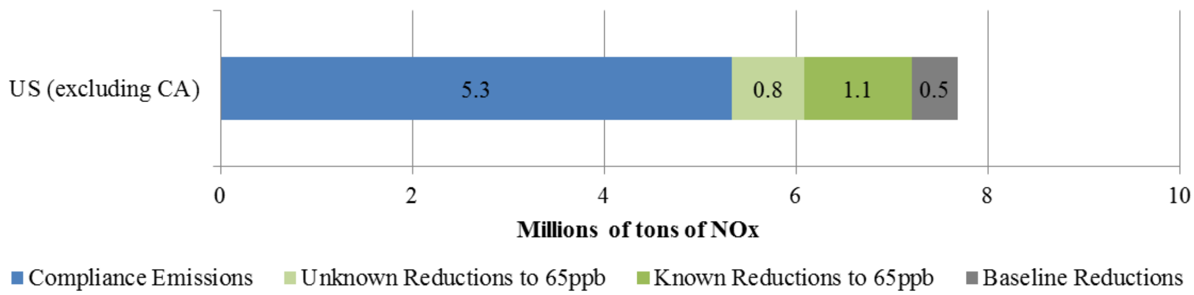
Note: EPA chose not to include any onroad controls in its NO_X analysis because onroad vehicles are subject to Tier 3 emissions standards.
Source: EPA 2014g

b. EPA Unknown Controls

The known controls that EPA identified were insufficient for attainment with a new standard of 65 ppb in 2025 for every region except the Southwest. Rather than strive to determine what the remaining sources of emissions would be, and what types of controls might be viable for such sources, EPA's illustrative control strategy calls the remainder of the required reductions unknown controls. Indeed, EPA provided no numerical examples (much less a thorough accounting) of existing measures that could make up the necessary unknown controls.

Figure 6 summarizes EPA's illustrative NO_X control strategy for the lower 48 states for a 65 ppb standard. Starting from the EPA Baseline, known controls and then unknown controls were applied to achieve an emissions level consistent with 65 ppb. EPA's NO_X control strategy for 65 ppb relied upon approximately 750,000 tons of reductions from unknown controls (excluding California). This compares to reductions from known controls of about 1.1 million tons. Thus, EPA estimated that reductions from unknown controls represent approximately 40% of the total tons of NO_X reductions required for attainment with a new standard of 65 ppb in 2025.

Figure 6. U.S. Summary of EPA NO_X Control Strategy for a 65 ppb Ozone Standard



Note: Anthropogenic NO_X emissions and reductions (excluding fires and biogenic sources) in the lower 48 states (excluding California, tribal regions, and EEZ emissions)
Source: EPA 2014b, 2014e, 2014f, 2014g, 2014k, 2014l

C. EPA Estimates of Compliance Costs

The final step in EPA's compliance cost analysis was to estimate the annualized costs of implementing the measures in EPA's control strategy. The costs are divided into known and unknown controls.

1. Cost of Known Controls

EPA estimated costs for the known point, area, and nonroad controls using the EPA Control Strategy Tool (CoST). Typically an average annualized cost-per-ton value was estimated and multiplied by emission reductions to find total cost. EGU costs for SCR controls were estimated using EPA's input assumptions to the IPM model. Known control costs included EPA's estimates of capital and O&M but excluded monitoring and administrative costs related to demonstrating compliance. Figure 7 summarizes the cost per ton and total cost of known controls in each source category for a 65 ppb ozone standard.

Figure 7. EPA Annualized Known Control Costs by Source Category for a 65 ppb Ozone Standard (millions of 2011 dollars)

	Reductions for 65 ppb Incremental to Baseline (tons)	Average Cost per Ton (2011$)	Total Annualized Known Control Cost (million 2011$)
NO_X	**1,123,514**	**$2,953**	**$3,317**
EGU	204,616	$8,273	$1,693
Point	444,034	$2,727	$1,211
Area	462,026	$769	$355
Onroad	-	-	-
Nonroad	12,837	$4,536	$58
VOC	**105,766**	**$7,954**	**$841**
EGU	-	-	-
Point	4,118	$5,136	$21
Area	101,649	$8,068	$820
Onroad	-	-	-
Nonroad	-	-	-
Total	**N/A**	**N/A**	**$4,159**

Note: Known controls applied to anthropogenic emissions sources in the lower 48 states. California had no known controls incremental to the EPA Baseline.

Source: EPA 2014g

2. Cost of Unknown Controls

EPA applied an average cost of $15,000 per ton to all reductions from unknown controls, regardless of the source category or location of the source. Figure 8 summarizes the implications of this assumption for the costs of unknown emission reductions to achieve a 65 ppb ozone standard. Note that although the figure lists cost estimates by region, the cost per ton does not differ among the regions.

Figure 8. EPA Annualized Unknown Control Costs by Region for a 65 ppb Ozone Standard

	NO_X Reductions (thousand tons)	Annualized Cost (million 2011$)
Total (excluding CA)	**752**	**$11,282**
Northeast	337	$5,048
Midwest	66	$983
Central	350	$5,252
Southwest	0	-

Note: Cost by region calculated using EPA's average cost assumption of $15,000 per ton. There were no unknown VOC controls in EPA's control strategy for 65 ppb. Totals may differ slightly from U.S. summaries in the EPA (2014a) due to rounding in the RIA.

Source: EPA 2014l and NERA calculations

EPA noted that it is inherently difficult to estimate the cost of emission control measures that have not been identified. To address this uncertainty, EPA performed a sensitivity analysis with two different assumptions on the average cost of unknown controls—$10,000 per ton and $20,000 per ton. Figure 9 shows the unknown control costs in EPA's analysis under these alternative cost assumptions.

Figure 9. EPA Annualized Unknown Control Costs Sensitivity by Region for a 65 ppb Ozone Standard

	NO_X Reductions	**Annualized Cost (million 2011$)**	
	Thousand Tons	"Low" ($10,000/ton)	"High" ($20,000/ton)
Total (excluding CA)	**752**	**$7,522**	**$15,043**
Northeast	337	$3,365	$6,731
Midwest	66	$655	$1,311
Central	350	$3,501	$7,002
Southwest	0	-	-

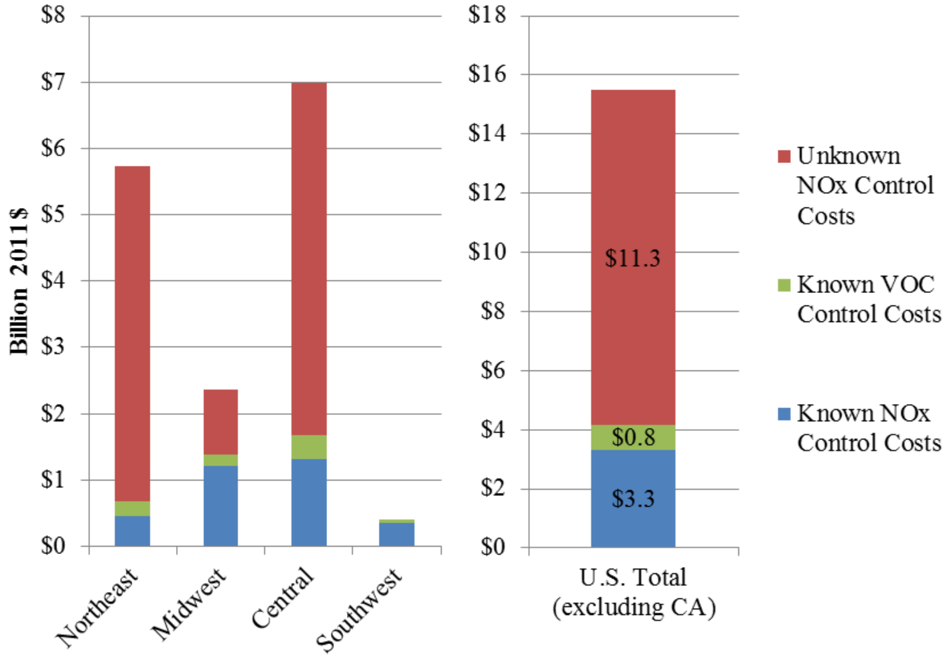
Note: Cost by region calculated using EPA's average cost sensitivities of $10,000 and $20,000 per ton. There were no unknown VOC controls in EPA's control strategy for 65 ppb. Totals may differ slightly from U.S. summaries in the EPA (2014a) due to rounding in the RIA.

Source: EPA 2014l and NERA calculations

3. Summary of EPA Compliance Costs

Figure 10 summarizes EPA's compliance cost estimates for a 65 ppb ozone standard, both by region and for the lower 48 states as a whole. EPA estimated total U.S. annualized compliance costs of $15.4 billion in 2025 (excluding California), about 73% of which is due to the estimate of the unknown controls' costs.

Figure 10. EPA Annualized Control Costs by Region for a 65 ppb Ozone Standard (Excluding California)



Note: Costs are incremental to the EPA Baseline. There were no unknown VOC controls in EPA's control strategy for 65 ppb.

Source: EPA 2014g, EPA 2014l, and NERA calculations

III. CONCERNS WITH EPA'S EMISSION AND COMPLIANCE COST ANALYSIS

This section summarizes our reviews of the emissions and cost information in the EPA RIA. We organize the review and discussion into two major areas.

1. Concerns related to EPA's determination of required emission reductions; and

2. Concerns related to EPA's estimates of unknown control costs.

For each of the individual issues, we summarize the key EPA assumption and then discuss potential concerns with the methodology and the implications of the concerns for EPA's estimated compliance costs. Where possible, we provide quantitative assessments of the magnitude of potential error. The final subsection provides our summary of the potential significance of these concerns.

A. Concerns Related to EPA's Determination of Compliance Emission Reductions

1. EPA Assumed All States Would Need to Comply in 2025 Although Some States Are Likely to Require Compliance Earlier

a. EPA Assumption Regarding Compliance Date

Under the Clean Air Act, if the ozone NAAQS is revised in 2015 as planned, nonattainment areas will be designated and assigned classifications and attainment years based on ozone design value data available in 2017. Design values are three-year averages of certified monitor readings, and so the nonattainment designations will be based on monitor readings taken during 2014 through 2016. In short, nonattainment with the proposed new ozone NAAQS will be determined based on essentially current conditions. Following the 2017 designations, states would then develop control strategies and implement controls over a period of years such that each nonattainment area's design value will be at the level of the new standard by its specified attainment year. Given current data, it is reasonable to expect that most areas that would be designated nonattainment in 2017 with a 65 ppb potential standard would be classified as either marginal or moderate status, with attainment dates around the end of 2020 and 2023, respectively. Areas that fail to comply by their attainment dates would be reclassified to a higher category, with the attendant more burdensome regulatory restrictions.

EPA's RIA cost analysis did not reflect these legal requirements. Instead, EPA performed a "snapshot" analysis of annualized compliance costs in 2025, citing three reasons:

1. Data and resource limitations made it difficult to estimate multiple years of costs (EPA 2014a, p. ES-14);

2. 2025 would reflect the "remaining air quality concerns" for nonattainment areas with moderate classifications (EPA 2014a p. 1-8); and

3. It would be a near-comprehensive picture of costs since most areas will probably be required to comply with a new ozone standard by 2025 (EPA 2014a p. 1-8).

The result is that the RIA did not correctly assess the likely timing of needed emission reductions, and hence also failed to correctly assess incremental emissions control costs of alternative ozone standards relative to Baseline spending. The RIA also failed to correctly characterize the extent of areas across the U.S. that will have to contend with nonattainment status from 2017 and for multiple years thereafter.[9] We discuss the concerns this creates for EPA's compliance cost estimates in more detail below.

b. Concerns with EPA Assumption

As EPA indicated, nearly all areas would need to comply with a new ozone standard by 2025, but the implications for attainment effort prior to 2025 are much more complex than the RIA analysis assumed. Following promulgation of a final rule, by 2017 EPA would develop designations and "classifications" for all areas, using the most recent design value available in 2017. Each classification would have an associated attainment year. Areas further from attainment of the new standard in the year when classifications are assigned would be given more time to comply. Figure 11 below summarizes EPA's assessments of the likely attainment years associated with different state classifications.

Figure 11. EPA Area Classifications and Likely Attainment Dates

Classification	Likely Attainment Date
Marginal	late 2020 or early 2021
Moderate	late 2023 or early 2024*
Serious	late 2026 or early 2027
Severe 15	late 2032 or early 2033
Extreme	late 2037 or early 2038

*Moderate nonattainment areas may qualify for two 1-year extensions
Source: EPA 2014a, p. 1-8

Nonattainment areas need to implement all necessary emission controls at least a year *prior* to their attainment date in order to demonstrate compliance on schedule.[10] This implies that

[9] Even if an area is marginal in its attainment, and successfully achieves attainment by 2020, it will not be able to be redesignated to attainment status for at least two additional years. States that are in moderate nonattainment are unlikely to be able to return to attainment status until about 2025 even if they do meet their attainment deadline of 2023.

[10] In order to demonstrate attainment, areas need to have a compliant "design value" – a 3-year average metric of historical ozone concentrations. The Clean Air Act allows for two one-year extensions of an area's attainment date,

marginal areas would need to implement all controls prior to the area's ozone season in 2020 for an attainment date in early 2021, and moderate areas would need to implement all controls prior to the area's ozone season in 2023 for attainment in early 2024. (Available monitoring data indicate that nearly all areas that are likely to be designated as nonattainment would probably fall into the marginal or moderate classification for any of the proposed alternative standards.)

Despite these facts, in the RIA EPA implicitly equates the need for potential reductions to achieve attainment in 2025 (based on 2025 emission levels) with an area's attainment designation, which would be based on emission levels prior to area designations in 2017 or 2018. EPA's 2025 analysis does not indicate the number of areas of the U.S. that can be expected to fall into nonattainment in 2017 as a result of a downward revision of the ozone standard in 2015, but rather focuses on areas that will still have design values above the NAAQS in 2025. In reality, additional areas outside of the regions EPA projects will need more emissions reductions as of 2025 might be designated as nonattainment based on recent historical ozone concentrations and may need to come into attainment prior to 2025. The effect of EPA's approach is not only to understate the extent of nonattainment designations that will be made in 2017, but also to understate the timing of emissions reduction needs, and the potential number of reductions relative to the earlier Baseline years. EPA's cost analysis does not account for the need for some portion of its 2025 Baseline emissions reductions to occur at least two years earlier than EPA has projected them to occur – and at least five years earlier if marginally-classified areas are to avoid being bumped up to the more onerous moderate classification after 2020.

As a result, using 2025 for a "snapshot" analysis of emissions, reduction needs, and costs initially appears complete, but is misleadingly so because it is in effect assuming that marginal and moderate states will be able to take advantage of Baseline emissions reductions that EPA projects will not occur until *after their required (pre-2025) attainment dates*. The most significant concern is for marginal areas, which would need to implement controls by 2020; ozone precursor emissions in these areas would need to be reduced from their Baseline level down to a level consistent with attainment *by 2020*, while EPA's analysis does not "check" for this outcome until 2025. Baseline emissions are projected to decline over time from 2018 through 2025, so greater reductions would be needed for attainment at the end of 2020 than in 2025.

Our assessment does not take into account the additional legal and administrative complications that might arise for some nonattainment areas. The Clean Air Act does provide some flexibility with respect to attainment dates, but this flexibility usually comes with increased requirements and costs. Moreover, whether the flexibility is granted and what additional requirements (and costs) would be involved is difficult to assess. EPA did not provide such assessments as a

but one year of historical concentrations below the ozone NAAQS (with one allowed exceedance) is still required by the attainment date (Clean Air Act, Section 181(a)(5)) in order to avoid being "bumped up" to a more severe classification, with attending more burdensome regulatory restrictions on the designated regions' emitters and governments.

rationale for assuming all non-California regions would comply in 2025, in conflict with their own estimates of compliance dates for marginal and moderate categories.

c. Implications of EPA Assumption for Compliance Costs

To the extent that regions and states would need to comply before 2025 and thus not be able to take advantage of the substantial reductions in Baseline NO_X emissions that EPA projects for the period from 2018 to 2025, EPA's methodology will overlook some of the actual costs that would be incurred. These costs are relevant for the regions and states that would be classified as marginal and moderate.

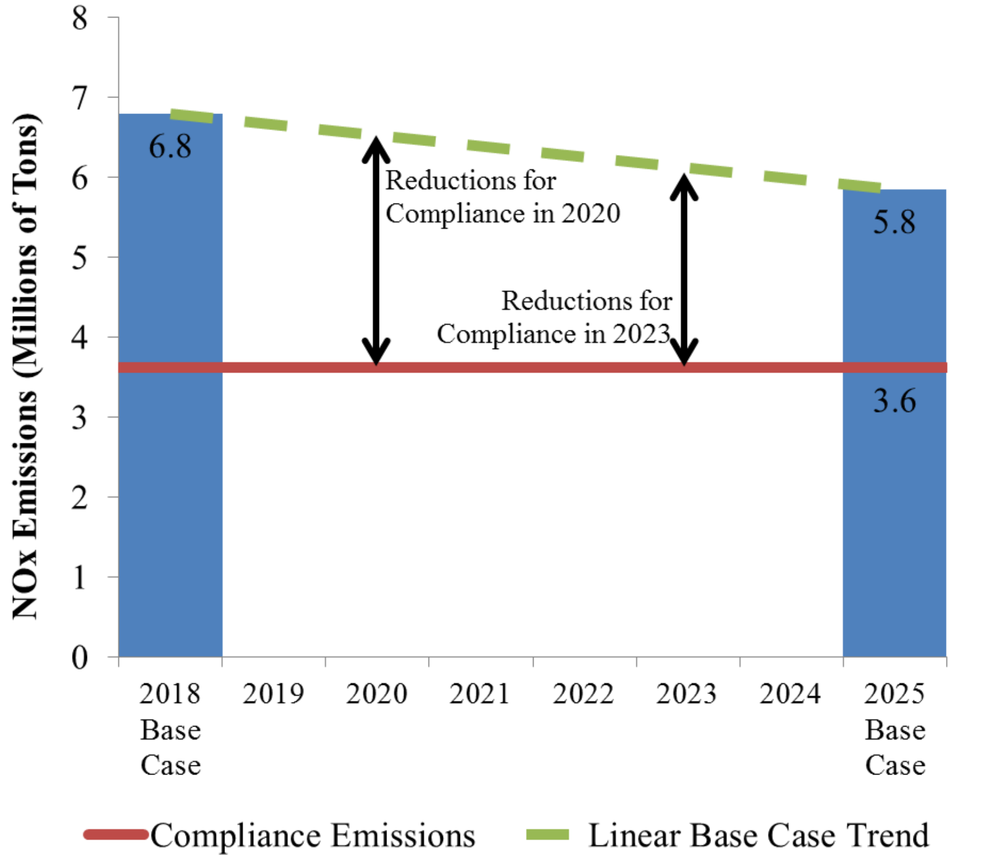
Figure 12 illustrates the relative importance of this concern. The bars on the chart show EPA's projections of 2018 and 2025 "Base Case" NO_X emissions in states that EPA projects would require reductions *in 2025* to come into attainment with a 65 ppb standard.[11] The red line shows the level of NO_X emissions that would bring these states into attainment with a 65 ppb ozone standard according to the EPA RIA. Based upon the likely attainment schedule for a revised ozone NAAQS, most states with nonattainment areas would need to finish implementing emissions controls *prior to 2025* (by 2020 for marginal states and by 2023 for moderate states). "Base Case" emissions (estimated by the green dotted line) are higher in earlier years, so the gap between the green and red line—the reductions needed to reach attainment—will be greater than EPA estimated using the 2025 projection.

In summary, this concern suggests that EPA has understated the non-California compliance costs of meeting a 65 ppb ozone standard, and made their timing appear to occur later than they will actually have to occur. Further, these data do not indicate the extent to which additional areas might be in nonattainment in 2017 and need to make reductions prior to 2025. This would represent an additional understatement of the overall regulatory impact of promulgating a tightened ozone standard in 2015.

---

[11] As discussed above, additional states might have areas that will be in attainment *in 2025* but would require reductions for attainment in an *earlier* year (e.g., 2020). These states are not included in Figure 12.

Figure 12. "Base Case" vs. 65 ppb Compliance NO_X Emissions, 2018 – 2025 (States Requiring Reductions for 65 ppb, Excluding California)



Note: Figure includes only states that required NO_X reductions as part of EPA's control strategy for 65 ppb, excluding California. The "compliance emissions" level consistent with an ozone concentration of 65 ppb is derived from EPA's 2025 "snapshot" analysis and assumed to be constant across years.

Source: EPA 2014a, 2014d, and NERA calculations as described in text

2. EPA Assumes Controls for Multistate Regions Rather than for Individual States

a. EPA Assumption

As discussed in Section II, EPA estimated the emission reductions needed to comply with alternative ozone standards using regional air quality modeling scenarios and the implied response factors at ozone monitors (*i.e.*, the responsiveness of ozone monitors to *regional* reductions in ozone precursor emissions). In broad terms, EPA first applied known NO_X and VOC controls within each region, locating emission reductions near the monitors with the highest ozone readings where possible but ultimately extending throughout each region (EPA 2014a p. 3-24). If known controls alone could not bring all of the ozone monitors in a region into attainment, EPA then applied region-wide emission reductions from unknown controls.

b. Concerns with EPA Assumption

As EPA acknowledged, the illustrative control strategy in the EPA RIA has little geographic specificity (EPA 2014a p. 3-23). Under EPA's approach, known controls were applied in specific locations, but they were applied in any location where they might be found within the multi-state region, even if they were not located in a state with a nonattaining monitor, or in close proximity to a nonattaining monitor within the state. Similarly, unknown controls were applied without any locational specificity across the entire multi-state region until all monitors throughout that region reached attainment. Applying reductions in such broad strokes using response factors is necessarily crude. EPA attempted to improve its estimates by performing multiple air quality modeling sensitivities in some regions,[12] but there is still significant uncertainty in this approach (even beyond the uncertainty inherent in any air quality modeling projection). To our knowledge, EPA did not perform air quality modeling of its final control strategies that would serve as a "check" that the final combination of regional controls in EPA's analysis (which were developed using response factors) actually corresponds closely to attainment in all areas.

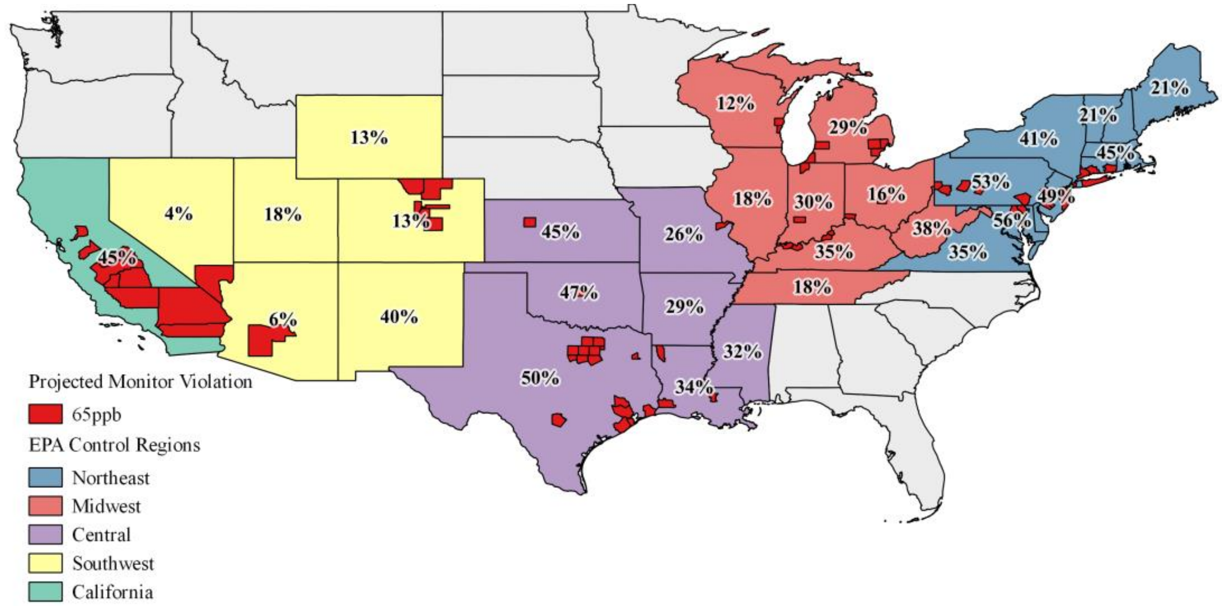
Beyond general uncertainty, there are two potential issues with this modeling approach, both of which were acknowledged in the EPA RIA. First, except in a few areas along regional borders, EPA did not account for emissions transport across regions.[13] EPA concluded that this could lead to an overstatement of emission reductions necessary for compliance since downwind regions might benefit from emissions reductions in upwind regions (EPA 2014a p. 3-23). However, to the degree that regional ozone concentrations are affected by transport, the conditions in upwind regions could also *increase* the need for local emissions reductions; the net effect of ignoring regional transport on required emission reductions is ambiguous.

Second, EPA's approach hinges on the assumption that states in the same region would choose to coordinate their control strategies. More specifically, EPA's analysis implicitly assumes that states with less severe nonattainment areas or with no nonattainment areas at all would implement control measures to help other states (either by choice or requirement). Figure 13 shows the percentage NO_X reductions from the EPA Baseline in each state for a 65 ppb standard. The figure also indicates counties where EPA projects monitors in nonattainment with a potential 65 ppb ozone standard in the 2025 Baseline.

[12] These additional sensitivities captured some of the nonlinearity in the responsiveness of ozone concentrations to NO_X emissions reductions.

[13] Except for monitors in Pittsburgh, Buffalo, and the Illinois suburbs of St. Louis, which fell along regional borders, monitors were assumed to only be affected by within-region emission changes (EPA 2014a p. 3-23).

Figure 13. Percentage NO_X Reduction Required by State and Counties with Nonattaining Monitors in the 2025 Baseline (65 ppb Standard)



Note: State percentage reduction to 65 ppb assumes that regional unknown control reductions are distributed to states in proportion to 2025 “Base Case” emissions. We excluded remote, rural monitors in the Western U.S. that EPA estimates are relatively unresponsive to NO_X reductions and may be able to pursue regulatory relief.

Source: EPA modeling regions from EPA 2014a, Figure 3-3. Counties with monitor violations from EPA 2014a, Tables 3A-7 through 3A-11. Percentage reduction to 65 ppb from NERA calculations using EPA 2014a, 2014g, 2014k, and 2014l.

In each of the regions in EPA’s analysis (except California), two or more states are projected to have no monitors above 65 ppb in the 2025 Baseline; however, due to EPA’s multi-state modeling approach and compliance strategy, every state in those regions has reductions and costs for a potential 65 ppb standard. Figure 14 summarizes the implications for EPA’s analysis, indicating the share of reductions and costs in each region coming from states that are projected to be in attainment of a 65 ppb standard in the 2025 Baseline.

Figure 14. Regional NO_X Reductions and Costs by Nonattainment Status for 65 ppb (Incremental to the EPA Baseline)

	Northeast	Midwest	Central	Southwest	US (Excluding CA)
Reductions (1000s of tons)					
States with non-attaining monitors	389	294	767	74	1,524
States w/out non-attaining monitors	119	137	57	39	352
Total	**508**	**430**	**824**	**113**	**1,876**
Costs (millions of 2011 dollars)					
States with non-attaining monitors	$4,502	$1,644	$6,490	$245	$12,882
States w/out non-attaining monitors	$1,233	$726	$440	$160	$2,559
Total	**$5,735**	**$2,370**	**$6,931**	**$405**	**$15,441**

Note: Cost by region calculated using controls applied to anthropogenic NO_X and VOC emissions sources in the lower 48 states (excluding California, tribal regions, and EEZ emissions) and using EPA's average unknown control cost assumption of $15,000 per ton for unknown controls. Totals may differ slightly from U.S. summaries in the EPA (2014a) due to rounding in the RIA.

Source: EPA 2014a Tables 3A-7 through 3A-11; EPA 2014b, 2014e, 2014f, 2014g, 2014l; NERA calculations as described in text

Regional coordination similar to the assumptions in EPA's RIA would require some mechanism – either a "SIP Call" or formal agreements among states.[14] Some regions may not develop multi-state programs to comply with a new ozone standard absent additional EPA regulations (which are not being proposed by EPA at this time).

c. Implications of EPA Assumption for Compliance Costs

Modifying EPA's methodology to reflect state-level compliance – concentrating emission reductions only in states with non-attaining monitors – would have two opposing effects on the cost estimates in EPA's RIA. The states needing increased emission reductions would likely need to resort to more expensive control technologies in-state instead of relying on less expensive emission reductions in neighboring states, which would increase total compliance costs. However, EPA stated that "emissions reductions are likely to have lower impact when they occur further from the monitor location," so fewer emission reductions might be required if all controls were implemented in states with nonattaining monitors (EPA 2014a p. 3-24).

In summary, the countervailing impacts on compliance costs make it impossible to unambiguously determine whether addressing this concern would lead to higher or lower compliance costs without a correct, state-specific analysis. However, we note that EPA's clear difficulty in identifying as much as 40% of the needed controls (excluding California) indicates a strong likelihood that states with the most intensive nonattainment will be at a point of rapidly

[14] EPA references historical experience of the Ozone Transport Commission, which implemented the NO_X Budget Trading Program for the mid-Atlantic and Northeast states in the 2000s (EPA 2014a p. 3-23).

increasing marginal costs of control. Our own analyses (discussed below) support this possibility. Rapidly increasing marginal costs could easily dominate the need for somewhat fewer tons of reduction if those reductions are shifted to in-state sources. In fact, some of the assumed out-of-state emissions reductions may occur closer to the nonattainment area than would additional in-state controls, since nonattainment areas are often near state borders (see Figure 14).[15] At a minimum, we note that the RIA's approach of allowing controls from out of state to be a significant part of the assumed control strategy is too far from the reality of control strategies for its cost estimates to be considered reliable. EPA should provide an analysis that does include state-by-state compliance strategies.[16]

3. EPA Finds Large Reductions in Mobile Source "Base Case" Emissions from 2018 to 2025

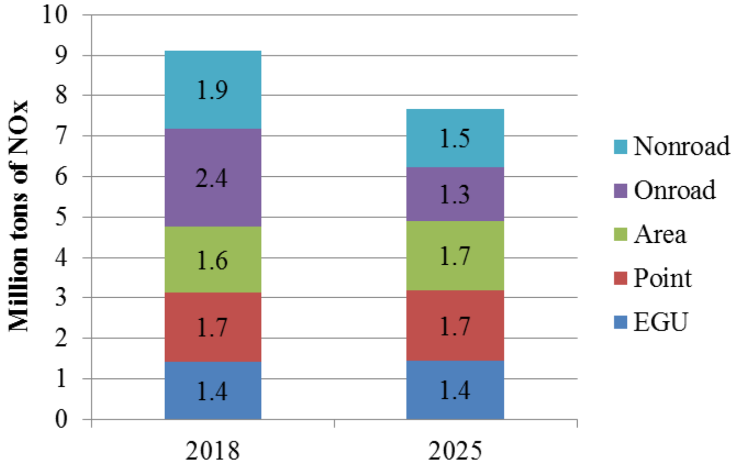
a. EPA Assumption

As discussed above, EPA's compliance cost analysis was based on an emissions projection for 2025. EPA projects a dramatic decrease in "Base Case" onroad and nonroad NO_X emissions between 2018 and 2025. This decrease reflects both implementation of on-the-books emissions standards for onroad vehicles (including Tier 3 standards), off-road equipment, and marine vessels, as well as projected vehicle usage patterns and vehicle fleet turnover. EPA's projected "Base Case" NO_X emissions in 2018 and 2025 are summarized by emissions source category in Figure 15.

[15] Additionally, ozone forms from precursors emitted at sometimes relatively long distances. In fact, precursor emissions reductions can decrease ozone concentrations in their local vicinity, even as they elevate ozone concentrations at more distant locations.

[16] We also note, however, that doing so will be uninformative unless EPA also adopts a more realistic way to deal with whether marginal costs are increasing as more and more unknown controls are assumed, as we discuss later in this section.

Figure 15. EPA "Base Case" NO_X Emissions in 2018 and 2025 (Excluding California)



Note: Anthropogenic NO_X emissions (excluding fires and biogenic sources) in the lower 48 states (excluding California, tribal regions, and EEZ emissions).
Source: EPA 2014b

The large decrease in "Base Case" onroad and nonroad emissions has the effect of bringing nonattaining areas closer to attainment in the 2025 Baseline. Because EPA treated all costs associated with those reductions as "costless" with respect to the new ozone standard, these have the effect of resulting in lower costs for attainment than if attainment needs were assessed with respect to earlier points in time.

b. Concerns with EPA Assumption

Tier 3 onroad vehicle emission standards presumably account for a large share of these "Base Case" NO_X reductions. Tier 3 includes both a gasoline sulfur standard that will be fully implemented by 2017 and tailpipe emission standards for new vehicles which will phase in from 2017 to 2025.[17] It is important to note that Tier 3 tailpipe standards do not affect emissions from the existing stock of vehicles, so tailpipe emissions only improve as vehicles are scrapped and replaced with new, Tier-3-compliant vehicles over time (due to age, failure, accident, *etc*.). Credible assumptions about this fleet turnover are critical for any emissions projection accounting for Tier 3 standards.

EPA does not provide specific information on the important modeling assumptions used to estimate onroad mobile source NO_X emissions. In addition to potential concern about whether the assumed fleet turnover rate is overly optimistic, another question is whether the NO_X emission reductions are due in part to the vehicle greenhouse gas emission standards (commonly known as CAFE standards), which are scheduled to become increasingly stringent for the 2022

[17] Gasoline sulfur standards: http://www.epa.gov/otaq/documents/tier3/420f14007.pdf

Tailpipe standards: http://www.epa.gov/otaq/documents/tier3/420f14009.pdf through 2025 model years. These standards are subject to a mid-term evaluation in 2018, which could result in less stringent requirements, and thereby result in fewer Baseline NO_X reductions (*e.g.*, through fewer electric cars in the fleet). In all, the onroad NO_X reductions by 2025 may not be as large as EPA calculated, and if so, costs to attain the new NAAQS would be understated. Even without these understatement concerns, the need for some of those reductions to occur earlier than 2025 does imply an understatement of compliance costs.

c. Implications of EPA Assumption

We were unable to analyze the fleet turnover assumptions or the effect of the greenhouse gas emission standards in EPA's onroad mobile emissions modeling for this report, so their implication for EPA's compliance cost estimates based on the 2025 conditions alone (as EPA relies on) is uncertain. If the reduction in onroad and nonroad emissions from 2018 to 2025 is overstated, additional emission controls would be required and EPA's compliance cost estimates would be understated; if the onroad and nonroad reductions were understated in EPA's 2025 "Base Case" projection, the compliance cost estimates would be overstated.

However, there is a more important concern with the reliance on the projected large downward trend in mobile source emissions that is not as ambiguous in its direction, and it is tied to the problematic use of the 2025 "snapshot" for determining the proposed rule's cost. It is quite clear that what may appear to be "anyway" attainment considered from the vantage point of 2025 could be hiding more extensive nonattainment starting substantially earlier. Much of those Baseline mobile source reductions may need to be sped up in time to deal with the need to reduce emissions for some regions and states substantially earlier than 2025. That will imply costs that the EPA RIA did not account for, and at earlier dates. Thus, even if the fleet turnover assumptions prove correct, the RIA would understate compliance costs by relying on that fleet turnover through 2025.

Furthermore, because the mobile source reductions are not under EPA's control, but depend on actual consumer decisions about when to buy new vehicles, the method for obtaining those reductions earlier than Baseline is either relatively costly incentives for early vehicle scrappage, or finding other types of controls that can be mandated directly by the regulator, which are presently unidentifiable (and hence also likely to have relatively higher marginal costs than EPA's RIA is assuming).

In summary, the heavy reliance of the RIA cost estimates on mobile source emissions reduction that will only occur gradually and which are not directly under the control of regulators has resulted in an understatement. We also note that given the importance of the dramatic reduction in mobile source emissions as a general matter, a reader of EPA's RIA should be concerned that projected vehicle age distributions and turnover are not discussed plainly and supported by evidence in either the EPA RIA or in the support documentation for the "Base Case" projection.

4. EPA Included CPP in the Baseline, Resulting in Lower Compliance Costs to Achieve the Standard

a. EPA Assumption

As discussed in Section II, EPA assumed that the proposed CPP rule will be adopted as part of its Baseline. While the objective of the proposed CPP is to reduce CO_2 emissions in the electric generation sector, the resulting shifts away from coal-fired generation and toward natural gas-fired and renewables generation would also result in significant NO_X reductions for EGUs – 436,000 tons across the lower 48 states according to EPA's analysis using the IPM model. These reductions would help areas to attain new, tighter ozone standards, but the costs of these shifts in the generation mix would be attributable to the CPP.

b. Concern with EPA Assumption

EPA does not generally include proposed rules in its Baseline; analytical baselines typically include only rules and regulations that are already on-the-books (as in EPA's "Base Case" emissions projections). As EPA acknowledged in the ozone RIA, "There is significant uncertainty about the illustration of the impact of rules, especially the CPP because it is a proposal and because it contains significant flexibility for states to determine how to choose measures to comply with the standard" (EPA 2014a p. 4-24).

Including a proposed rule is not only inconsistent with its usual practice, but is particularly unwarranted given the vast uncertainty about the future of that proposed rule. The CPP proposal is subject to enormous dispute over its viability and legality. EPA has already signaled that it is considering changes to the proposed rule that could significantly alter its effects on emissions of ozone precursors prior to 2025. It is thus highly speculative for inclusion in any Baseline of another rule that will go into effect in the next few years. Even assuming the proposal is implemented as proposed, the potential impacts of the CPP on NO_X emissions are also highly speculative.

If the CPP were not implemented, EPA's Baseline NO_X emissions in 2025 would be higher across the country. This would raise the ozone NAAQS's estimated costs because the costs of some of the CPP reductions would then be attributed to compliance with the proposed ozone revision. It could also increase the number of areas that would be projected to be in nonattainment, though EPA's projection of 2025 "Base Case" ozone design values suggests that new nonattainment areas for 65 ppb would fall within states that already require emissions reductions in EPA's analysis (EPA 2014a Tables 3A-7 through 3A-11). This latter effect is thus less of a concern to us than the understatement of costs that has resulted from this assumption.

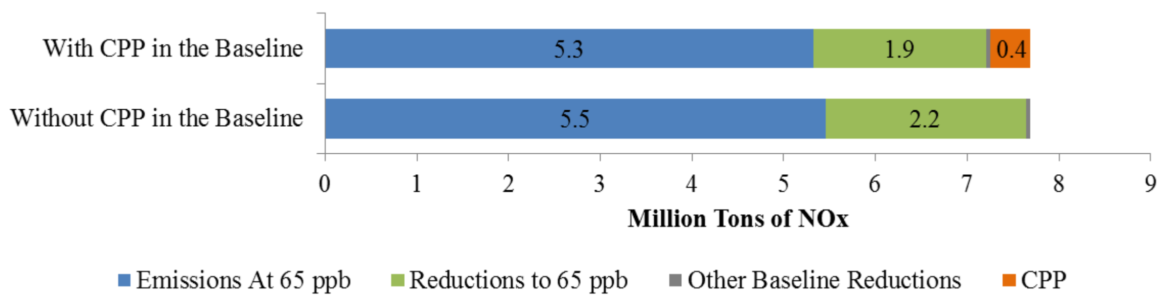
c. Implications of EPA Assumption

If the CPP were removed from EPA's Baseline, our analysis finds that states with needs for emissions reductions would require an additional 300,000 tons of NO_X reductions to get from the

Baseline to attainment with 65 ppb. (That is, we find that about 30% of NO_X reduction under the CPP would occur in regions without any nonattainment areas according to EPA's analysis, and thus would not be needed to for attainment of the 65 ppb standard.) We also determine that nearly all of these reductions will have to come from the unknown controls category. Figure 16 below summarizes the emissions and reductions impacts of the CPP for an ozone standard of 65 ppb. Since unknown controls are much more costly than known controls on a per-ton basis, this would dramatically increase the costs.

In an earlier NERA analysis (NERA, 2014) that illustrated how unknown control costs could be estimated from a more thorough review of the emissions inventory data and additional analysis, we determined that closure of power generating units in areas that affect projected nonattainment areas was one of the types of control that should be considered a part of EPA's unknown tons of reduction. This was not because closing such plants is inexpensive, but because it appears to be much more cost-effective than the other alternatives, such as early vehicle turnover. Nevertheless, we found that it could cost, *on average*, about $16,000/ton of NO_X removed, and that some of the closures needed to achieve a potential 60 ppb NAAQS would cost well above $30,000/ton. Whatever the cost per ton would be for meeting the 65 ppb alternative, it will likely be a candidate component of the unknown controls.

Figure 16. NO_X Reductions from Baseline for a 65 ppb Ozone Standard (Excluding CA)



Note: Figure excludes California. Emissions at 65 ppb are marginally lower when the CPP is included in the Baseline because some of the CPP reductions occur in regions without any nonattaining monitors; these NO_X reductions would not need to be "replaced" with additional controls if the CPP were removed from the EPA Baseline.

Source: EPA 2014b, 2014e, 2014f, 2014g, 2014k, 2014l

5. EPA's Ozone Analysis Uses a Different EGU "Base Case" Emissions Projection than EPA's Clean Power Plan

a. EPA Assumption

EPA's 2025 "Base Case" projection of EGU NO_X emissions was significantly lower in the ozone analysis than in the recent CPP proposal. However, EPA applied NO_X *reductions* from the CPP proposal analysis to the 2025 "Base Case" EGU emissions projection used for the ozone NAAQS analysis.

b. Concern with EPA Assumption

As part of the RIA for the CPP Proposed Rule, EPA projected NO_X emissions in both a base case without the CPP and a policy scenario including the CPP.[18] Base case EGU NO_X emissions were 1,554,000 tons in 2025 in EPA's CPP analysis. EPA developed a separate projection of 2025 "Base Case" EGU emissions for this RIA for the ozone NAAQS Proposed Rule using the same electricity sector model (*i.e.*, IPM) and projected NO_X emissions in this ozone "Base Case" of 1,475,000 tons – about 79,000 tons lower than the CPP base case.[19] A reduction in base case EGU emissions has the practical implication of reducing the emission controls needed for attainment of alternative ozone standards. It is concerning that there is such a significant change in base case EGU NO_X emissions between two recent EPA analyses, particularly given that both analyses purportedly used version 5.13 of the IPM model, calibrated to the U.S. Energy Information Administration's (EIA's) *Annual Energy Outlook* 2013 (EIA 2013) demand to develop their base case projections (EPA 2014h p. 3-46; EPA 2014i p. 86).

As discussed above, we are concerned that the proposed CPP should not be included in EPA's Baseline. Even if the CPP were implemented as proposed, the difference between the CPP and ozone EGU base case projections raises an additional concern about the application of the CPP projected reductions to EPA's ozone Base Case. EPA estimated that the CPP would reduce EGU NO_X emissions by about 436,000 tons in 2025 (EPA 2014e and 2014f).[20] The estimated emissions impact of the CPP depends in part on the assumptions in the base case used for EPA's CPP analysis. In its ozone analysis, however, EPA subtracted the CPP NO_X reductions from the *ozone* "Base Case" projection of EGU emissions. Given that the ozone "Base Case" EGU NO_X projection is significantly lower, it may reflect assumptions about additional coal and natural gas unit retirements or re-dispatch; these differing assumptions could lower the potential NO_X emission reductions attributable to the CPP.

c. Implications of EPA Assumption

We have not been able to determine why EPA's "Base Case" EGU NO_X projection is lower in EPA's ozone analysis than in its CPP analysis. If EPA's "Base Case" EGU NO_X emissions were understated, that understatement would reduce the controls needed for compliance with a new ozone standard and would cause EPA to understate compliance costs.

Applying the CPP NO_X reduction estimates to a lower "Base Case" EGU emissions level likely overstates the NO_X reductions attributable to the CPP (since some of the policy-induced NO_X reductions from EPA's CPP modeling likely take place in the new "Base Case"). EPA assumed

[18] Note that EPA's ozone analysis distinguished between a "Base Case" (which does not include the CPP) and a Baseline (which does include the CPP). EPA's CPP analysis has a single base case.

[19] These total EGU emissions figures exclude tribal and offshore data, but include data for California.

[20] These NO_X reductions are for the Option 1 State CPP scenario, which was used in EPA's ozone analysis (EPA 2014a p. 3-11).

the CPP reduces NO_X emissions by about 436,000 tons; given the complexities of dispatch modeling, it is difficult to tell how much this reduction would be diminished as a result of EPA's lower "Base Case" NO_X projection. Regardless of the magnitude, this inconsistency in EPA's analysis understates the controls needed for compliance with a new ozone standard and thus understates compliance costs.

B. Concerns Related to EPA's Calculation of Unknown Control Costs

Fully 40% of the estimated tons of reduction needed to attain a standard set at 65 ppb (excluding California) come from unknown controls, and even using EPA's approach, this category accounts for about 73% of the estimated compliance costs. EPA's approach probably greatly understated the costs of these unknown controls, as we explain in this section. Along with the use of the 2025 snapshot to determine the extent of nonattainment and emissions reduction needs, the way that EPA handled the unknown control costs is probably the other most significant reason to believe that the RIA is understating the costs of a potential revision to the ozone NAAQS.

1. EPA Assumed an Average Cost of $15,000 per Ton of Emission Reductions from Unknown Controls as Its Basic Assumption

a. EPA Assumption

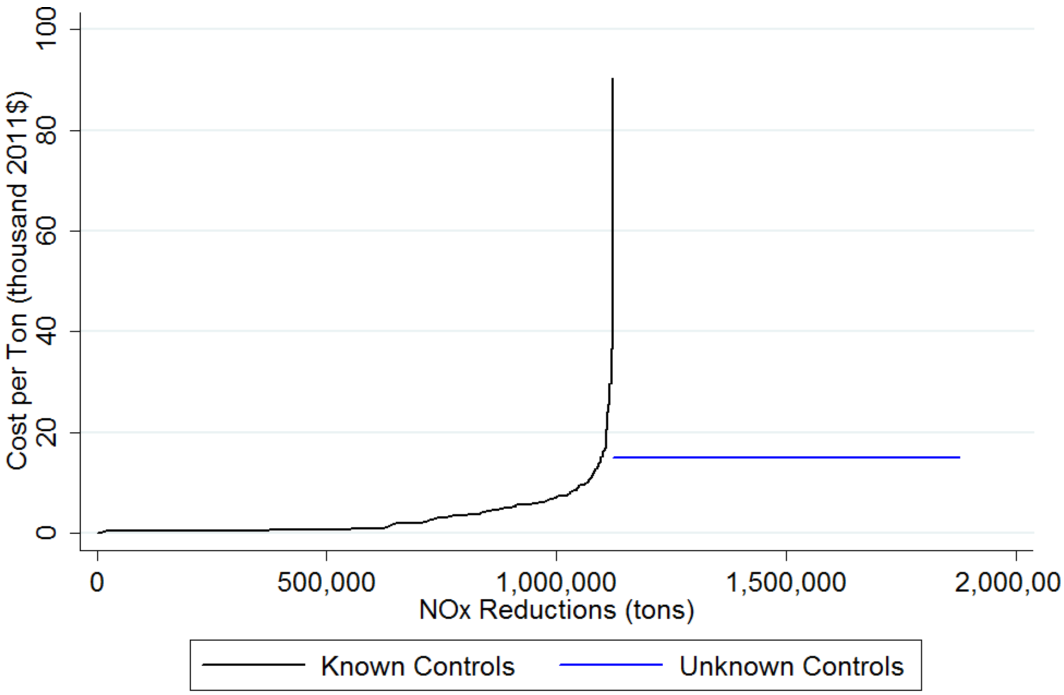
EPA applied a single average cost value of $15,000 per ton to all reductions from unknown controls. EPA provided the following rationales for taking this simple approach:

- EPA's Science Advisory Board stated in 2007 that, of the three unknown control cost methods proposed by EPA, "assuming a fixed cost/ton appears to be the simplest and most straightforward" (EPA 2014a p. 7-27).
- The EPA analysis does not include all *currently* available controls since CoST focuses on a "limited set of emissions inventory sectors" (EPA 2014a p. 7-12 and 7-28). Unknown controls could include these currently available (and presumably less expensive) controls as well as more expensive technologies or more extreme measures.
- Historically, EPA has sometimes overestimated the cost of unknown controls and has failed to account for certain innovations (EPA 2014a p. 7-14).
- Future technological innovation can change the pollution abatement cost curve by making existing controls more efficient or less costly or by introducing new inexpensive controls (EPA 2014a p. 7-18).
- "Learning by doing" can reduce the cost of existing control technologies (EPA 2014a p. 7-20).

- Annualized NO_X offset prices in several areas in nonattainment with the current ozone NAAQS (75 ppb) are still less than $15,000 per ton.

Figure 17 shows the unknown controls required for 65 pp and EPA's $15,000 per ton assumption in the context of EPA's known control costs for 65 ppb.

Figure 17. U.S. NO_X Reductions and Cost per Ton for EPA 65 ppb Control Strategy, Incremental to EPA Baseline (Excluding California)



Note: Controls are from the EPA Baseline. EPA assumes the average cost of unknown controls is $15,000 per ton. Figure excludes 105,000 tons of reductions from unknown controls in California. The few known controls greater than $15,000 per ton in EPA's analysis are either EGU SCR controls or non-EGU point source controls replacing existing controls (leading to a high *incremental* cost per ton).

Source: EPA 2014g and EPA 2014l

b. Concerns Regarding EPA Assumption

There are many problems with EPA's various justifications for assuming an average cost of $15,000 per ton for reductions from unknown controls, which we explain here.

EPA argues that the EPA Science Advisory Board recommended the use of the "average cost" approach in 2007. The Science Advisory Board preferred the average cost method presented by EPA at the time because of its clarity and simplicity. This endorsement says nothing of the method's *accuracy*. The original white paper reviewed by the Science Advisory Board explains the significant uncertainty in the value used for the average cost approach:

> "The general argument against this option is that the $10,000 per ton cap appears arbitrary - we have been unable to identify an independent basis for establishing

> $10,000 per ton as a reasonable ceiling on the costs of NAAQS compliance measures. In addition, there is some evidence that areas are spending more than this amount on some existing measures…" (812 Project Team 2007, p. 7).

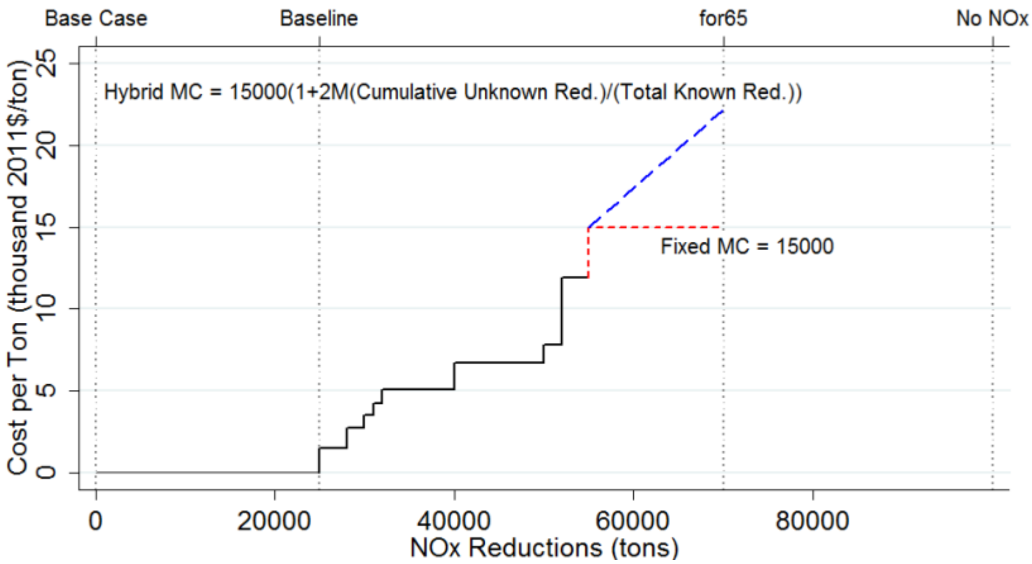
Naturally, some average cost per ton value exists that would approximate *actual* average compliance costs; however, the Science Advisory Board review gave no indication of what that value should be. Additionally, over seven years have passed since this 2007 guidance. EPA apparently has not prioritized the development of alternative methodologies and continues to rely on simplicity over improved accuracy in estimating unknown control costs.

During the 2008 and 2010 reviews of the ozone NAAQS, EPA did develop and present estimates based on an alternative methodology called the "hybrid" approach. This approach involved an upward-sloping extrapolation from the known control marginal abatement cost curve in order to estimate the cost of unknown controls. The slope of the extrapolation is dependent on the ratio of unknown to known control reductions; areas needing a high share of emission reductions from unknown controls have more rapidly increasing costs per ton for unknown controls. EPA explained the key advantage of this approach in its 2008 ozone analysis:

> "The hybrid methodology has the advantage of using the information about how significant the needed reductions from unspecified [unknown] control technology are relative to the known control measures and matching that with expected increasing per unit cost for going beyond the modeled [known] technology" (EPA 2008 p. 5-13).

Figure 18 illustrates the methodology for this hybrid approach in the context of an example marginal cost curve for NO_X reductions.

Figure 18. Marginal Cost Curve Example of EPA Average ("Fixed") and Hybrid Approach



Note: The slope of the hybrid marginal cost segment (in blue) depends on M, a constant loosely based on the difference between the highest-cost known control and an assumed maximum cost for unknown controls, as well as the highest ratio of unknown to known control cost across all regions expected to come into attainment.

Source: NERA illustration based on hybrid approach described in EPA (2008) pp. 5-10 to 5-18

EPA did not develop similar hybrid method cost estimates in the current ozone NAAQS proposal. Figure 19 shows EPA's estimates of unknown control costs using the average cost approach and NERA's estimates of costs for the same controls if EPA had once again applied its hybrid "mid" methodology. We estimate that annualized compliance costs would be \$3.7 billion higher using EPA's 2008 and 2010 hybrid method, with an average cost per ton for unknown controls of about \$20,000.

Figure 19. Unknown Control Costs for 65 ppb Using EPA Average ("Fixed") and Hybrid Approaches, Excluding California

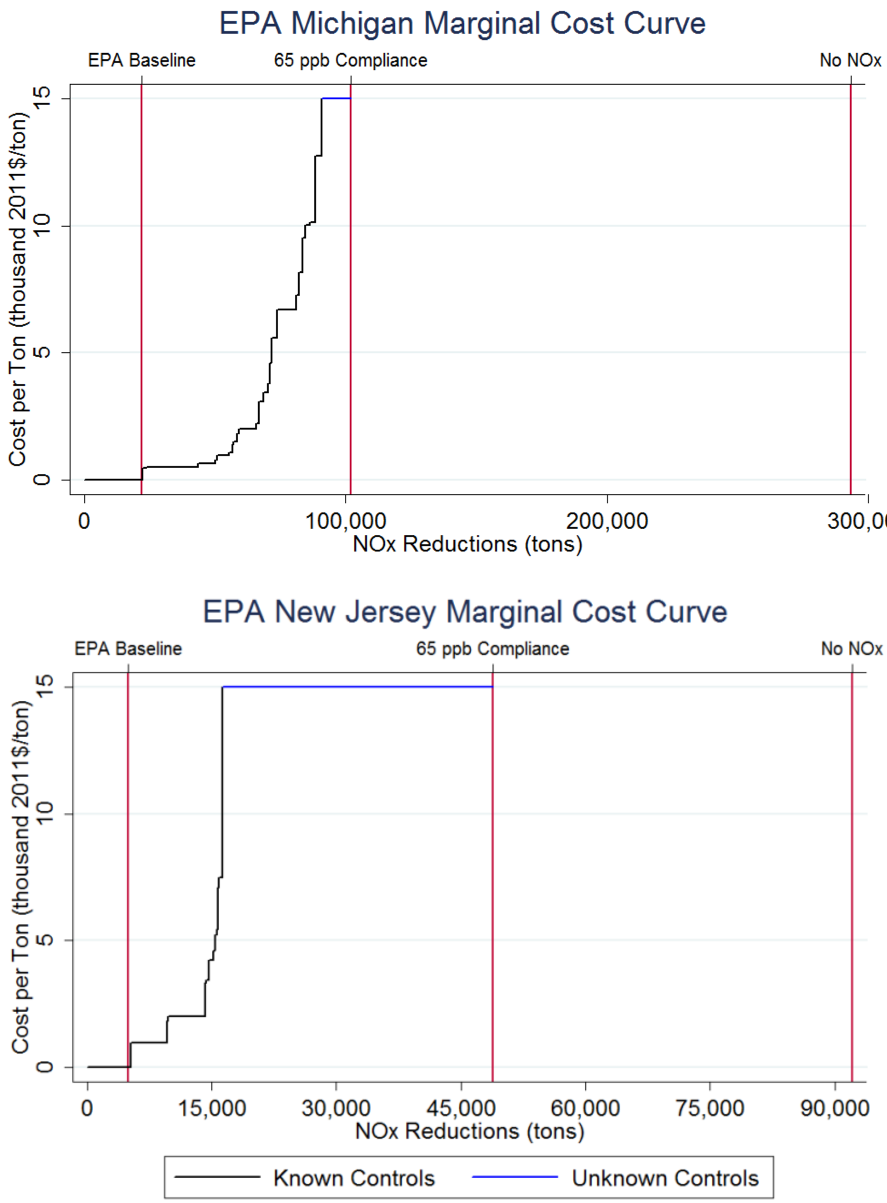
	Unknown Control Reductions (tons NO_X)	Control Costs (billion 2011$)	Average Cost per Ton (2011$)
EPA Average Cost Approach ($15k/ton)	752,162	$11.3	$15,000
EPA Hybrid "Mid" Approach (NERA Estimate)	752,162	$15.0	$19,954
Difference		+$3.7	+$4,954

Note: Figure excludes costs in California. Costs under the hybrid approach were calculated using the "mid"-multiplier (M = 0.24) chosen by EPA in its 2008 ozone analysis (EPA 2008). In EPA's 2008 analysis of a potential 75 ppb ozone standard, the highest regional average cost per ton of unknown controls using the hybrid "mid" methodology was $23,000.

Source: EPA (2008) pp. 5-10 to 5-18, EPA 2014l, and NERA calculations

The following examples illustrate the value of using regional information to inform assumptions about the cost of unknown controls (as in EPA's 2008 and 2010 hybrid method). Figure 20 illustrates that EPA's RIA analysis assumed $15,000 per ton for unknown controls regardless of whether a state requires 1,000 tons or 100,000 tons of NO_X reductions from unknown controls.

Figure 20. State Marginal Cost Curve Illustrations of EPA's 65 ppb Analysis



Note: Reductions from the 2025 "Base Case" to the EPA Baseline are assumed to be zero-cost. EPA regional unknown control reductions were distributed to states in proportion to "Base Case" 2025 emissions (consistent with EPA air quality modeling).

Source: EPA 2014g, EPA 2014l, EPA 2014b, and NERA calculations

EPA further argued that the known controls analyzed did not represent all currently available controls. Given the heavy reliance on unknown controls in EPA's analysis and the important implications of unknown control costs for the likely impacts of a new ozone standard, EPA should have made every effort to conduct a truly comprehensive analysis of currently available known controls. EPA's argument – that currently available controls not included in the EPA analysis could be a significant source of additional, inexpensive NO_X reductions – is not substantiated in EPA's RIA. In our 2014 analysis of a potential 60 ppb ozone standard, we concluded that "the identity of control options and their costs to achieve the emissions reductions needed for attainment" was perhaps the most important "gap" for EPA to address in future ozone analyses (NERA 2014 p. 45); four years after EPA's ozone NAAQS reconsideration in 2010 and six years after EPA developed the basic cost and emissions information, EPA has done relatively little to identify additional controls and address the largest uncertainty in its compliance cost analyses.

If additional controls do exist that would cost an average of $15,000 per ton, that means there are controls that must cost a good deal less than that too; but if such less expensive controls were currently available, presumably they would have already been identified. Based on the distribution of NO_X emissions remaining after the application of EPA's known controls, it is difficult to find an emissions source with both a large potential for additional reductions and an obvious additional control option. Figure 21 shows the emissions remaining in each emission source category after accounting for known controls. Many of the emissions remaining would be difficult or impossible for states to control further for the various major source categories.

- *EGU Sources.* Coal and natural gas power plants are already largely controlled as part of EPA's known control strategy.

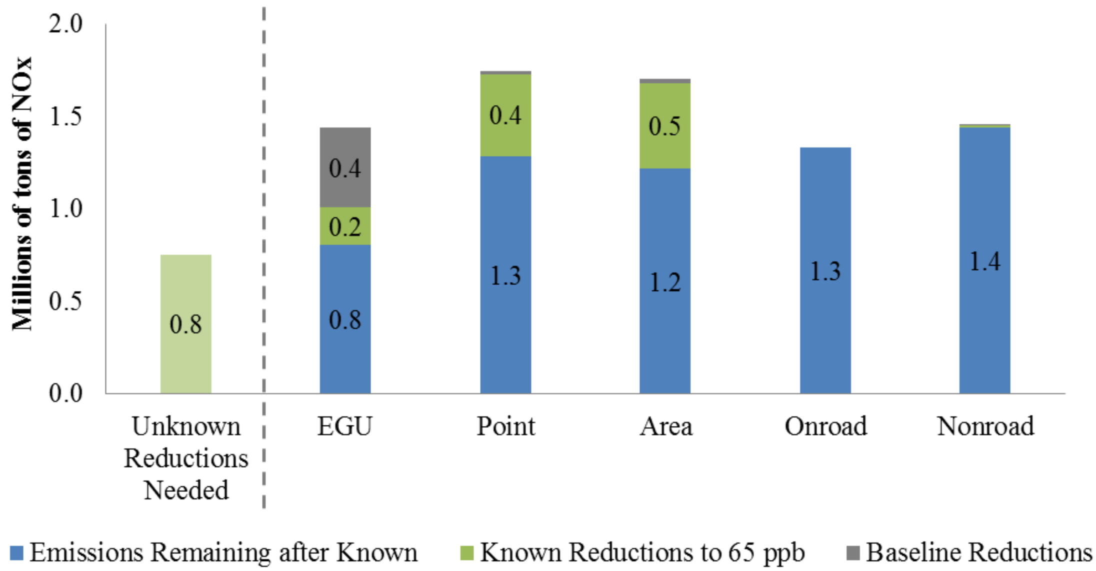
- *Point Sources.* Large point sources are the easiest to regulate and have already been subject to significant control.

- *Area Sources.* Many area sources such as space heating are highly diffuse, and the stock is difficult to regulate.

- *Onroad Sources.* Tier 3 vehicle emission standards have significantly reduced projected onroad emissions, limiting the possibility of significant, inexpensive controls.

- *Nonroad Sources.* One-third of residual nonroad emissions are from freight rail, an interstate activity not amenable to state-level control. Other nonroad mobile sources like construction equipment and marine vessels are also difficult to control at the state level.

Figure 21. NO_X Emissions Remaining After Known Controls for 65 ppb by Source Category by 2025 (Excluding California)



Note: Anthropogenic NO_X emissions and reductions (excluding fires and biogenic sources) in the lower 48 states (excluding California, tribal regions, and EEZ emissions)
Source: EPA 2014b, 2014e, 2014f, 2014g, 2014k, 2014l

EPA's arguments in favor of a $15,000 average cost per ton for unknown controls relied heavily on assumptions about technological progress and "learning by doing." While improved technology and learning do tend to improve the cost-effectiveness of emission control over time, both are highly uncertain, particularly in the short period between promulgation of a new ozone standard and the attainment dates for most areas. If area designations are determined in 2017, there would be three years for marginal areas and six years for moderate areas to implement necessary emission controls (and an even shorter timetable for moderate areas to submit an implementation plan); relying on new product development and significant production cost decreases seems highly problematic within such a tight timeframe. More importantly, as the figure above shows, most of the emissions remaining in 2025 will be from many diffuse sources, or from EGUs and point sources that are already highly controlled. New technologies are not likely to apply to retrofit of existing equipment and processes, and thus additional emission reductions are likely to require entirely new processes or replacements of existing equipment. This means that the implementation of "new technologies" would likely entail early scrappage or plant closures. It is this early turnover of still productive capital stock that translates into high compliance costs, likely much more than the cost of the replacement capital itself.

Finally, EPA suggested that historical NO_X offset prices validate the $15,000 average cost assumption. However, historical offset prices reflect the current ozone situation – a standard of 75 ppb, and that standard itself is only now starting to be implemented. Consistent with EPA's database of known control measures, some relatively inexpensive known controls are still available even in areas with nonattainment problems under the current standard. The relevant questions are 1) will additional controls be available *after* this supply of known controls is exhausted under a tighter ozone standard?, and, 2) at what cost? Until NO_X offsets prices reflect increased demand for unknown controls under a tighter ozone standard, offset prices only confirm what is already known about the cost of currently available controls.

c. Implications of the Concern

EPA's assumption on the costs of unknown controls has a major effect on its estimates of the overall compliance costs of a revised ozone standard. For a potential standard of 65 ppb, EPA found that about 40% of U.S. NO_X reductions (excluding California) would need to come from unknown controls. However, these unknown controls represent a much larger share of the estimated compliance costs; for the 65 ppb standard, unknown compliance costs represent about 73% of EPA's estimate of total annualized compliance costs (excluding California and assuming a $15,000 average cost per ton for emission reductions from unknown controls).

EPA's compliance cost estimates were primarily driven by a single, arbitrary assumption about the average cost of unknown controls, and modifications to that assumption could have a dramatic effect on the estimated costs and economic impacts of a new ozone standard.

2. EPA's Sensitivity Analysis Assumed a Low of $10,000 per Ton and a High of $20,000 per Ton for Emission Reductions from Unknown Controls

a. EPA Assumption

EPA noted that the costs of unknown controls are highly uncertain. To reflect the uncertainty, EPA calculated unknown costs assuming an average cost of $10,000 per ton for the "lower bound" and an average cost of $20,000 for an "upper bound."

b. Concerns with EPA Assumption

Given the highly arbitrary nature of EPA's average cost approach and selection of $15,000 per ton, EPA's sensitivity analysis on unknown control costs does little to indicate a range of likely values. The narrow sensitivity range is inconsistent with both the rest of EPA's cost analysis and with prior EPA analyses:

- EPA suggests that the accuracy range of the *known* control costs for non-EGU point and area sources is plus or minus 30%, yet EPA's sensitivity analysis of *unknown* control costs is performed at a range of only plus or minus 33% (EPA 2014a p. 7-39).

- The hybrid "mid" approach presented alongside the average cost method estimates in EPA's 2008 and 2010 ozone analyses would imply an *average* cost per ton of about $20,000 in the current analysis (the "upper bound" of EPA's cost sensitivity).

- The 2007 white paper on unknown control costs that was reviewed by the Science Advisory Board suggested possible assumptions that were outside EPA's $10,000 to $20,000 per ton sensitivity range. For example, "One option would be to use the effective marginal cost of I/M controls…between $25,000 and $30,000 per ton for both VOC and NO_X reductions" (812 Project Team 2007, p. 7).

EPA's only rationale for its cost sensitivity assumptions was, "This range is inclusive of the annualized NO_X offset prices observed in recent years in the areas likely to need unknown controls to achieve the proposed standard, and if anything, suggests the central estimate of $15,000/ton is conservative" (EPA 2014a p. 7-30). As discussed above, recent NO_X offset prices are not indicative of the average cost of future unknown controls, and they certainly do not reflect the *uncertainty* in estimating future average control costs. The cost range of EPA's sensitivity analysis and the declaration that EPA's primary unknown control cost estimate is "conservative" are unfounded.

c. Implications of EPA Assumption

Given indications of significant uncertainty in *known* control costs and the significant reliance on unidentified control measures to comply with a new ozone standard, EPA significantly understates the uncertainty in unknown control costs, and therefore significantly understates the uncertainty in total control costs.

C. Summary of Concerns

All seven of the concerns summarized in this section point to a conclusion that the EPA RIA understated the potential costs—including the range of potential costs—of meeting a more stringent ozone standard. Four of these concerns seem in our judgment likely to lead to a major understatement of compliance costs.

- *EPA used a 2025 "snapshot" to estimate incremental attainment needs, but nonattainment designations and attainment deadlines are earlier.* This assumption likely leads to a major understatement in the number of areas that will be in nonattainment as well as an understatement of the number of tons needed to be reduced compared to Baseline emissions and timing of the spending. Areas designated as marginal or moderate would likely have attainment dates around the end of 2020 and 2023, respectively, and would incur costs before 2025—costs that are disregarded (by assumption) in EPA's analysis. (Our assessment does not consider the complications of potential reclassifications of individual non-attainment areas.)

- *EPA included the proposed Clean Power Plan (CPP) in the Baseline.* EPA's inclusion of CPP emission reductions is not only inconsistent with its standard practice of only including promulgated regulations, but such a deviation from standard procedure is particularly unjustified given the enormous uncertainty in what carbon limits may actually be applied and how states would comply, and hence what NO_X emission reductions might actually occur as a result of EPA regulation of carbon emissions from existing electricity generating units. Without the proposed CPP in the Baseline, at least an additional 300,000 tons of NO_X reductions would be required for the 65 ppb standard, leading to a substantial increase in the estimated compliance costs.

- *EPA assumed a constant value of $15,000 per ton for all unknown emission reductions*. Controls that EPA referred to as unknown (*i.e.*, for which no compliance controls are identified) represent about 40% of EPA's estimated tons and about 73% of EPA's estimated costs to attain a 65 ppb ozone standard (excluding California). As one indication of the importance of this single assumption, we calculated that unknown control costs would increase by about $3.7 billion per year (*i.e.*, from $11.3 billion to $15.0 billion, excluding California) if EPA had used an alternate methodology presented in its own most recent prior ozone NAAQS cost assessment in 2010. Changing just this one aspect of the EPA methodology would lead to a total cost estimate of $19.2 billion to achieve a 65 ppb ozone standard (excluding California).

- *EPA assumed an uncertainty band for unknown costs of $10,000 to $20,000 per ton*. This arbitrary range seems likely to understate substantially the potential compliance costs. Given that unknown controls would have to reduce emissions from many diffuse area or mobile sources—since point sources are already highly controlled—the cost per ton could be substantial (*e.g.*, requiring early turnover of still productive capital stock such as residential or commercial heating).

In summary, our evaluation suggests that EPA has understated the potential compliance costs—including their likely range—of meeting a more stringent ozone standard. The costs of achieving a more stringent ozone standard could be substantially greater than even the very substantial costs EPA has estimated.

IV. REFERENCES

NERA Economic Consulting (NERA). 2014. "Assessing Economic Impacts of a Stricter National Ambient Air Quality Standard for Ozone." July.

U.S. Energy Information Administration (EIA). 2013. *Annual Energy Outlook 2013*.

U.S. Environmental Protection Agency (EPA). 2008. *Final Ozone NAAQS Regulatory Impact Analysis*. March. http://www.epa.gov/ttn/ecas/regdata/RIAs/452_R_08_003.pdf.

U.S. Environmental Protection Agency (EPA). 2010. *Supplemental Regulatory Impact Analysis (RIA) for the Reconsideration of the 2008 Ozone National Ambient Air Quality Standard (NAAQS)*. http://www.epa.gov/ttn/ecas/regdata/RIAs/s1-supplemental_analysis_full.pdf.

U.S Environmental Protection Agency (EPA). 2014a. *Regulatory Impact Analysis (RIA) of the Proposed Revisions to the National Ambient Air Quality Standards (NAAQS) for Ground-Level Ozone.* http://www.epa.gov/ttnecas1/regdata/RIAs/20141125ria.pdf

U.S Environmental Protection Agency (EPA). 2014b. *2011 and 2025* NO_X *Emissions County Sector Comparison*. ftp://ftp.epa.gov/EmisInventory/2011v6/ozone_naaqs/reports/2011ef_2025ef_county_sector_comparison_NOX.xlsx

U.S Environmental Protection Agency (EPA). 2014c. *2011 and 2025 VOC Emissions County Sector Comparison.* ftp://ftp.epa.gov/EmisInventory/2011v6/ozone_naaqs/reports/2011ef_2025ef_county_sector_comparison_VOC.xlsx

U.S Environmental Protection Agency (EPA). 2014d. *2011, 2018, and 2025 Emissions State Sector Comparison*. ftp://ftp.epa.gov/EmisInventory/2011v6/ozone_naaqs/reports/2011ef_2018ef_2025ef_state_sector_comparison.xlsx

U.S Environmental Protection Agency (EPA). 2014e. *Proposed Clean Power Plan: IPM State-Level Emissions, Base Case.* http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0602-0224

U.S Environmental Protection Agency (EPA). 2014f. *Proposed Clean Power Plan: IPM State-Level Emissions, Option 1 State.* http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0602-0228

U.S Environmental Protection Agency (EPA). 2014g. *O3 NAAQS RIA Control Strategy Results* NO_X *Controls for 65ppb Analysis Incremental to Baseline.* http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0169-0015

U.S Environmental Protection Agency (EPA). 2014h. *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power plants.* http://www2.epa.gov/sites/production/files/2014-06/documents/20140602ria-clean-power-plan.pdf

U.S Environmental Protection Agency (EPA). 2014i. *Technical Support Document (TSD): Preparation of Emissions Inventories for the Version 6.1, 2011 Emissions Modeling Platform.* http://www.epa.gov/ttn/chief/emch/2011v6/2011v6.1_2018_2025_base_EmisMod_TSD_nov2014_v6.pdf

U.S. Environmental Protection Agency (EPA). 2014j. *2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards*. Federal Register 77(199): pp 62624-63200. http://www.gpo.gov/fdsys/pkg/FR-2012-10-15/pdf/2012-21972.pdf

U.S Environmental Protection Agency (EPA). 2014k. *Updated 2014 O3 NAAQS RIA NOx Control Strategy Results – 75 ppb.* http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0169-0035

U.S Environmental Protection Agency (EPA). 2014l. *Emission Reductions Beyond Known Controls.* http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013-0169-0032

Second Section 812 Prospective Project Team (812 Project Team). 2007. *Methods to Estimate Costs of: (1) Unidentified Control Measures to meet NAAQS Requirements and (2) Direct Costs when Mark-up Factors are Present.* http://www.epa.gov/cleanairactbenefits/mar07/cost_estimation.pdf

NERA
ECONOMIC CONSULTING

200 Clarendon Street
11th Floor
Boston, MA 02116
617-927-4500

1255 23rd Street NW
Suite 600
Washington, DC 20037
202-466-3510

www.nera.com