HUNTON ANDREWS KURTH

HUNTON ANDREWS KURTH LLP
2200 PENNSYLVANIA AVENUE, NW
WASHINGTON, D.C. 20037-1701

TEL 202 • 955 • 1500
FAX 202 • 778 • 2201

AARON M. FLYNN
DIRECT DIAL: 202 • 955 • 1681
EMAIL: flynna@HuntonAK.com

August 13, 2018

FILE NO: 31531.010005

The Hon. Andrew Wheeler
United State Environmental Protection Agency Headquarters
William Jefferson Clinton Building
1200 Pennsylvania Avenue, N.W.
Mail Code: 1101A
Washington, DC 20460

Re: Comments of the Utility Air Regulatory Group on the U.S. Environmental Protection Agency's Advance Notice of Proposed Rulemaking, "Increasing Consistency and Transparency in Considering Costs and Benefits in the Rulemaking Process," EPA-HQ-OA-2018-0107

Dear Administrator Wheeler:

The Utility Air Regulatory Group ("UARG") appreciates this opportunity to comment on the U.S. Environmental Protection Agency's ("EPA" or the "Agency") Advance Notice of Proposed Rulemaking ("ANPRM"), entitled "Increasing Consistency and Transparency in Considering Costs and Benefits in the Rulemaking Process." 83 Fed. Reg. 27,524 (June 13, 2018).

UARG is a not-for-profit group of individual electric generating companies and national trade associations. UARG participates on behalf of certain of its members collectively in Clean Air Act ("CAA") administrative proceedings that affect electric generators and in litigation arising from those proceedings. The vast majority of electric energy in the United States is generated by individual members of UARG and/or members of UARG's trade association members. These companies collectively have invested over one hundred billion dollars to reduce emissions of air pollutants regulated under the CAA. According to EPA data, since 1990, electric generators have reduced their emissions of sulfur dioxide and nitrogen oxides by 92 and 84 percent, respectively. This in turn has led to substantial reductions in ambient levels of fine particulate matter and ozone. Electric generators have also cut mercury air emissions by nearly 90 percent since 2006. In addition, data collected by the U.S. Energy Information Administration indicate that electric generators have reduced emissions of carbon dioxide 27 percent below 2005 levels. All of this has been achieved while the U.S. economy and energy consumption have continued to grow.

Although the ANPRM would apply generally to all of EPA's actions, UARG's comments focus on CAA-related issues and on issues raised in the ANPRM regarding which UARG has particular expertise. As explained in the ANPRM, EPA is generally obligated to prepare a cost-benefit analysis, called a Regulatory Impact Analysis ("RIA"), for significant regulatory actions under Executive Order 12866, and the statutes that EPA administers often call for or authorize the consideration of costs and benefits in regulatory decision-making. *Id*. at 27,525. EPA is correct to acknowledge that the various statutory provisions addressing cost-benefit consideration impose different standards, use different terminology, and, in some instances, direct consideration of costs and benefits in conjunction with other factors. UARG supports EPA's efforts to harmonize cost-benefit terminology and to adopt consistent and transparent analytical methodologies across statutes. Of course, different statutory standards may require EPA to adopt different approaches to cost-benefit analyses depending on the statutory provision under which EPA is acting. In such instances, UARG believes there is value in developing rules or guidance that clearly set forth the manner in which costs and benefits will be considered pursuant to specific statutory provisions. Providing the public with a clear understanding of how costs and benefits will be considered in a rulemaking proceeding and setting appropriate standards to govern such consideration in advance of future rulemakings will improve the public's ability to provide meaningful comments on EPA's proposals and support the Agency's goal of increasing transparency and consistency in undertaking such analyses. An ad hoc approach where governing standards may shift from rulemaking to rulemaking, even when EPA invokes the same statutory authority, limits the public's confidence in EPA's actions, hinders effective public comment, and results in arbitrary and unpredictable outcomes.

The ANPRM poses a number of specific questions in its requests for comment. Two of those questions address issues on which UARG has particular expertise:

> [T]o what extent should EPA develop a general rule on how the Agency will weigh the benefits from reductions in pollutants that were not directly regulated (often called "co-benefits" or "ancillary benefits") or how it will weigh key analytical issues (e.g., uncertainty, baseline assumptions, limited environmental modeling, treatment of regulating multiple pollutants within one regulatory action) when deciding the stringency of future regulations?

> To what extent would it be helpful for EPA to require consideration of cumulative regulatory costs and benefits of multiple regulations during the rulemaking process, including how such consideration may affect the design or implementation of a regulation (i.e., longer or different compliance timeframes)?

Id. at 27,527. UARG has addressed these issues in a number of comments submitted to EPA. As a general matter, UARG believes that in the past EPA often has improperly relied on "co-benefits" from reductions in pollutants that have not been the actual subject of the regulation at issue when those pollutants are already regulated under other provisions of the CAA, such as the national ambient air quality standards ("NAAQS") for criteria air pollutants. In some instances, those co-benefits have dominated the benefits that EPA has predicted. In many of those cases, co-benefits were in fact the only benefits that EPA quantified.

Two recent reports by NERA Economic Consulting that UARG commissioned to encourage EPA to undertake regulatory reform demonstrate the problems with the Agency's existing approach to evaluating co-benefits. Those reports are included as enclosures to this letter.

The first, entitled "An Evaluation of the $PM_{2.5}$ Health Benefits Estimates in Regulatory Impact Analyses for Recent Air Regulations" (Dec. 2011) ("$PM_{2.5}$ RIA Evaluation"), examines EPA's practice of estimating benefits from reducing ambient fine particulate matter ("$PM_{2.5}$") in various rulemakings under the CAA. The $PM_{2.5}$ RIA Evaluation examined all RIAs released for CAA rulemakings since 1997, the year EPA promulgated its first NAAQS for $PM_{2.5}$. $PM_{2.5}$ RIA Evaluation at 6. The $PM_{2.5}$ RIA Evaluation concluded that a majority of benefits – and sometimes all of the benefits – calculated by EPA in those RIAs have resulted from reductions in $PM_{2.5}$ even when the regulation under review was not targeting $PM_{2.5}$. *Id*. at 7. The $PM_{2.5}$ RIA Evaluation also concluded that a trend toward almost complete reliance on $PM_{2.5}$-related health co-benefits has increased over time. *Id*.

The $PM_{2.5}$ RIA Evaluation demonstrates that EPA's practice with respect to including co-benefits of reductions in separately regulated pollutants runs counter to the economic principles underpinning cost-benefit analyses. *Id*. at 9-13. In fact, the mathematical analysis described in that report shows that including co-benefits of separately regulated criteria air pollutants can actually drive the resulting regulation in the opposite direction from what a properly conducted cost-benefit analysis would support. *Id*. at 11-12. The $PM_{2.5}$ RIA Evaluation also includes an analysis of EPA's methodology for evaluating $PM_{2.5}$ risks and the many uncertainties that affect the reliability of EPA's conclusions. *Id*. at 16-29. It concludes that the Agency has not acknowledged these quantifiable uncertainties and has exacerbated them by extrapolating risks for $PM_{2.5}$ concentrations below the lowest measured level of ambient average $PM_{2.5}$ at which health or welfare effects have been observed, *i.e.*, identifying risk at levels for which EPA has not provided scientific support. *Id*. at 24. This has had the effect of increasing projected mortality by a factor of 3.6, such that EPA estimated in one RIA that 16% to 22% of all deaths in the Eastern United States in 2005 were caused by $PM_{2.5}$, which is highly unlikely. *Id*. at 24-25.

The $PM_{2.5}$ RIA Evaluation also raises significant concerns about potential double-counting of $PM_{2.5}$ co-benefits as EPA continues to cite such emission reductions as support for non-$PM_{2.5}$ rulemakings. *Id*. at 29. EPA's process for preventing double-counting has not been thorough or consistent for several reasons. For example, many RIAs are prepared simultaneously with or prior to implementation of existing rules, leading to inaccurate baseline assumptions. How the baseline is developed will impact which $PM_{2.5}$ reductions will be counted as co-benefits, and failure to account accurately for rules that will or are reasonably anticipated to be implemented distorts a cost-benefit analysis. *Id*. at 29-30. The $PM_{2.5}$ RIA Evaluation recommends that EPA adopt additional practices to safeguard against these problems. First, for any RIA accounting for co-benefits from a pollutant that a rule does not directly address, the baseline for that RIA should include all existing rules, even if those rules have not been fully implemented. *Id*. at 30. Second, any such RIA should also incorporate any reasonably anticipated future standards or rules before allowing any co-benefits from a pollutant that is not the subject of the rule at issue to be counted. *Id*. at 30-31. The $PM_{2.5}$ RIA Evaluation recommends that, to accomplish these objectives, EPA give consideration to at least two baselines:

> Baseline A: Include only the present level of current standards, but ensure that all of them are simulated as attained at their respective attainment deadlines.
>
> Baseline B: Incorporate reasoned assumptions regarding levels of new regulations that are known to be on the verge of modification, even if not yet promulgated or even proposed, and accounting for their future attainment deadlines. (For example, Baseline B would incorporate a reasoned estimate of the most stringent potential level of a tightened $PM_{2.5}$ NAAQS level that may be implemented within the next decade.)

Id. at 31.

Similarly, double-counting results from EPA's practice of reporting costs and benefits for a single year when baseline emissions are expected to continue to decline after the year selected. *Id*. The $PM_{2.5}$ RIA Evaluation recommends that regulatory compliance costs and benefits instead be considered on a present-value basis. *Id*. It further recommends that if benefits and costs are reported for only a single year, the year selected should be one in which all other regulations in the baseline will be fully implemented. *Id*. at 32.

The second report enclosed with this letter, entitled "Technical Comments on EPA's Regulatory Impact Analysis for the Proposed Repeal of the Clean Power Plan" (Apr. 2018) ("CPP RIA Comments"), reviews EPA's approach to conducting the cost-benefit analysis in support of the proposed repeal of the Clean Power Plan ("CPP"). The CPP RIA Comments conclude that EPA's cost-benefit analysis in support of the proposed CPP repeal rule marks a significant improvement over past RIAs and that it serves as a good model for future cost-benefit analyses under the CAA. In particular, the CPP RIA Comments describe a number of improvements with regard to transparency and discussion of uncertainties, issues also raised by the ANPRM. CPP RIA Comments at 1-5. The comments also identify a number of areas where additional improvements would increase the utility of the proposed CPP repeal RIA and future RIAs. *Id*. at 5-7.

Of particular relevance here, the CPP RIA Comments address EPA's presentation of co-benefits from reductions in criteria air pollutants. *Id*. at 19-31. The comments note methodological differences between the RIA in support of the CPP repeal proposal and EPA's 2015 RIA in support of the final rule promulgating the CPP. Although the CPP RIA Comments provide justification for excluding criteria pollutant co-benefits altogether, consistent with the analysis presented in the $PM_{2.5}$ RIA Evaluation, they also explain that EPA's approach in the CPP repeal RIA better describes than EPA's past RIAs the uncertainties that affect the Agency's calculations, including the lack of confidence in the existence of concentration-response functions at lower baseline ambient concentrations. *Id*. at 20-22. Specifically, the CPP RIA Comments support EPA's decision to present estimates of co-benefits only for those areas where $PM_{2.5}$ concentrations are above the lowest measured level identified in the relevant scientific studies and counting only those $PM_{2.5}$ co-benefits that occur in areas where $PM_{2.5}$ concentrations are above the current annual NAAQS for $PM_{2.5}$. *Id*.

The CPP RIA Comments recommend additional improvements to EPA's approach should the Agency continue to present analysis of criteria pollutant co-benefits in future RIAs. For instance, the comments recommend that EPA conduct and present a sensitivity analysis reflecting declining confidence levels in risk estimates, as it did for $PM_{2.5}$ in the CPP repeal

RIA, for any other criteria air pollutants, like ozone, that the Agency evaluates. *Id*. at 23. The comments also recommend changes to EPA's methodology for conducting its "cutpoint" sensitivity analysis. The comments support EPA's efforts to identify cutpoint concentrations below which health effects cease to occur and EPA's decision to zero-out risks for populations living in areas with concentrations below the cutpoint level. *Id*. The comments also explain, however, that logical consistency suggests that risk would only start to rise above zero as concentrations rise above the cutpoint where the concentration-response relationship is assumed to begin to exist. *Id*. at 23-24. Accordingly, population-wide health risk should not be projected to instantly jump to non-trivial levels when the ambient concentration is only trivially higher than that cutpoint value, as EPA's cutpoint sensitivity analysis assumes. *Id*. at 24. Instead, the amount of risk should be determined by the degree to which the exposure level exceeds the cutpoint concentration (*i.e.*, by the location's ambient concentration minus the cutpoint). *Id*.

UARG encourages EPA to consider the detailed technical analyses contained in these two economic reports as the Agency continues to assess ways of achieving the important goal of increasing the consistency, transparency, and utility of RIAs and cost-benefit analysis in general. The enclosed reports provide considerable support for excluding or, at the least, more carefully circumscribing the use of projections of co-benefits from reductions in pollutants regulated under the NAAQS program and other provisions of the CAA. UARG appreciates EPA's efforts and thoughtful approach to addressing these important issues. We look forward to commenting on the Agency's future proposals on these matters.

Sincerely,

Aaron M. Flynn

Enclosures:

1. An Evaluation of the $PM_{2.5}$ Health Benefits Estimates in Regulatory Impact Analyses for Recent Air Regulations (Dec. 2011)

2. Technical Comments on EPA's Regulatory Impact Analysis for the Proposed Repeal of the Clean Power Plan (Apr. 2018)

cc: Brittany Bolen, Associate Administrator, Office of Policy
Elizabeth Kopits, National Center for Environmental Economics, Office of Policy

Enclosure 1

AN EVALUATION OF THE $PM_{2.5}$ HEALTH BENEFITS ESTIMATES IN REGULATORY IMPACT ANALYSES FOR RECENT AIR REGULATIONS

NERA
Economic Consulting

Final Report
Prepared for the Utility Air Regulatory Group

Anne E. Smith, Ph.D.
Senior Vice President
NERA Economic Consulting
1255 23rd Street NW
Washington, DC 20037

December, 2011

An Evaluation of the $PM_{2.5}$ Health Benefits Estimates in Regulatory Impact Analyses for Recent Air Regulations

Anne E. Smith, Ph.D.
NERA Economic Consulting[1]

December, 2011

Abstract.

When preparing its Regulatory Impact Analyses (RIAs) for regulations under the Clean Air Act (CAA) that are not intended to control ambient fine particulate matter ($PM_{2.5}$), the US Environmental Protection Agency (EPA) often predicts reductions of ambient $PM_{2.5}$ that may occur coincidentally, and attributes so-called "$PM_{2.5}$ co-benefits" to those coincidental reductions. This paper reviews and evaluates EPA's practice of including $PM_{2.5}$ co-benefits in its RIAs for non-PM rules. It is based on review of 57 individual CAA-related RIAs released since EPA promulgated its first $PM_{2.5}$ national ambient air quality standard (NAAQS) and finds that EPA has been relying on $PM_{2.5}$ co-benefits estimates to create an apparent benefit-cost justification for almost all of its non-PM CAA rules. This paper then evaluates that practice from multiple perspectives: theoretical, practical, scientific, and analytical. It concludes that co-benefits from separately-regulated pollutants, such as $PM_{2.5}$, should not be reported as part of the total benefits estimates in an RIA, nor should they be included in public announcements of the benefits of a new regulation. EPA should reform the manner in which it defines its baselines of emissions for each RIA, and provide more temporal information on benefits and costs to eliminate problems of double-counting. This paper also concludes that EPA should reform its current methods of calculating benefits from reductions in ambient $PM_{2.5}$ even in its PM-related rules, because it finds that as EPA's reliance on co-benefits has increased, EPA has shifted to less credible methods of estimating $PM_{2.5}$ benefits.

[1] The author acknowledges and thanks Suresh Moolgavkar, W. David Montgomery, and Mike King for their helpful and insightful comments and suggestions on drafts of this paper. The author also thanks Shirley Xiong for her careful and persevering assistance in reviewing and documenting the nearly 60 RIAs relied on in this study. Any remaining errors are solely my responsibility.

1. Introduction and Synopsis

Regulatory Impact Analyses (RIAs) are documents required by an Executive Order (EO) of the President to be submitted to the Office of Management and Budget (OMB) by all agencies proposing new major regulations. RIAs' quality and usefulness have been a substantial interest for the past thirty years. Policy analysts have written many papers and reports identifying the ways RIAs provide value to policy making and offering suggestions for improvement.[2] This paper reviews and evaluates the US Environmental Protection Agency's (EPA's) practice of estimating benefits from reducing ambient fine particulate matter ($PM_{2.5}$) in its RIAs for rulemakings under the Clean Air Act (CAA).

In recent years, EPA has relied on reductions of ambient $PM_{2.5}$ as the primary source of benefits in most of its RIAs for CAA-related regulations – even for regulations not specifically to protect the public health from exposures to ambient $PM_{2.5}$. When the regulation is not targeting $PM_{2.5}$, they are called "co-benefits" because they result from changes in ambient $PM_{2.5}$ levels projected to follow coincidentally from efforts to reduce other types of air pollutants. Questions and concerns have been raised by many in policy making and policy analysis communities about EPA's reliance on such co-benefits.

Based on review of CAA-related RIAs since 1997, this paper identifies the degree of EPA's reliance on $PM_{2.5}$ co-benefits. It then examines EPA's co-benefits practice from multiple perspectives: theoretical, practical, scientific, and analytical. It finds that the theoretical formulation of benefit-cost analysis (BCA) – a key underpinning of RIAs – does not support inclusion of co-benefits from pollutants subject to their own, separate regulation. Also, allowing such co-benefits to dominate RIAs detracts from RIAs' most valuable practical role, which is to help guide us toward regulations that provide cost-effective, minimally-complex management of societal resources. From a scientific perspective, this review finds EPA's estimates of the risks of $PM_{2.5}$ have become less and less credible as EPA has come to rely more and more heavily on them to justify regulation of other pollutants. It also finds that use of co-benefits in many RIAs being prepared simultaneously degrades the analytical rigor of benefits accounting across the body of RIAs as a group, with double-counting and related analytical maladies resulting.

Accordingly, this paper recommends changes in how RIA baselines are set in order to eliminate problems of double-counting and inappropriate benefit-cost comparisons. It also concludes that:

- Public announcements about the benefits of a new regulation should not include co-benefits of pollutants that are already directly regulated; nor should such co-benefits be included in the total benefits reported in RIA Executive Summaries.
- EPA should reform its practice of calculating benefits from reductions in ambient $PM_{2.5}$ by using more credible sets of risk analysis assumptions, and eliminating extrapolations.

[2] Examples include Morgenstern (1997), Hahn and Dudley (2007), and Harrington *et al.* (2009).

This paper is organized as follows. The next section provides background on the history and purpose of RIAs as the general requirement under which EPA is producing its CAA-related RIAs. It is followed by a summary of EPA's growing reliance on $PM_{2.5}$ co-benefits identified through a review of RIAs dating back to 1997, when EPA released its first regulation of ambient $PM_{2.5}$. The four sections after that examine EPA's co-benefits practice from four different perspectives: theoretical, practical, scientific, and analytical, and conclude the practice is problematic from each of these perspectives. The last section recaps findings and recommendations made throughout the paper and draws further conclusions.

2. History and Purpose of RIAs

The practice of using BCA for assessing the appropriateness of public policies dates back well before RIAs were required, but was relatively sporadic. This changed in 1981 when President Ronald Reagan issued EO 12291. EO 12291 required that a BCA be prepared and submitted to the OMB for each major regulation issued by the Federal government. That EO required that each new major rule be demonstrated to provide greater benefits than its costs,[3] using the term "regulatory impact analysis" for the document making this demonstration.[4] The requirement that benefits be greater than costs is certainly a prerequisite for passing any BCA test; nevertheless, the economically-proper definition of a benefit-cost optimum – the BCA basis for determining the appropriate stringency of a standard – is that the incremental or "marginal" cost of making a standard tighter is equal to the marginal benefits that such tightening would provide. This is because net benefits are at their maximum level when marginal costs equal marginal benefits. Subsequent guidance for conducting RIAs requires that several alternative standards be evaluated in the RIA. This is to help steer the selected alternative to the one that would offer the highest net benefits without requiring a precise optimization using marginal analysis.[5]

EO 12291's requirement that benefits exceed costs was at odds with the fact that many standards, including National Ambient Air Quality Standards (NAAQSs) for criteria pollutants, and National Emissions Standard for Hazardous Air Pollutants (NESHAPs) for air toxics, must be set without regard to costs. The CAA requires that each NAAQS

[3] Section 2 of EO 12291 specifically required, *inter alia*, that "(b) Regulatory action shall not be undertaken unless the potential benefits to society for the regulation outweigh the potential costs to society; (c) Regulatory objectives shall be chosen to maximize the net benefits to society; (d) Among alternative approaches to any given regulatory objective, the alternative involving the least net cost to society shall be chosen." These are overtly the requirements of standard BCA-based decision making.

[4] EO 12291, Section 3.

[5] Guidance has been provided over the years. The most current version of guidance, known as "Circular A-4," states that: "In general, both the benefits and costs associated with a regulation will increase with the level of stringency (although marginal costs generally increase with stringency, whereas marginal benefits may decrease). You should study alternative levels of stringency to understand more fully the relationship between stringency and the size and distribution of benefits and costs among different groups." (OMB, 2003, p.8).

be set at a level that protects the public health with "an adequate margin of safety,"[6] and has been interpreted to require that this level be set without regard for their costs. The CAA's requirements for NESHAP rules are more complex, but the most commonly required provision used under a NESHAP rule is maximum achievable control technology (MACT). The least stringent emissions level for a MACT (the "MACT floor") is determined based solely on the average performance achieved by the best 12% of existing technologies for a given production process, regardless of what cost achieving that MACT floor may impose on facilities that do not already have that emissions rate.[7] Thus the requirement of EO 12291 that all major regulations demonstrate they could pass the most basic requirement of BCA was instantly at odds with the legal framework for CAA rules. Resolution of this inconsistency was addressed by a provision in EO 12291 that the BCA provisions be applied "to the extent permitted by law."[8]

An executive order requirement for RIAs for all major regulations has remained in effect since 1981, but has evolved. In particular, President Bill Clinton issued EO 12866 in 1993 which revokes EO 12291, but replaces it with very similar requirements for assessment of regulatory impacts of major rulemakings.[9] Other than instituting some procedural changes, EO 12866 primarily moderates the emphasis of EO 12291 on meeting benefit-cost criteria. However, the change is one of degree only and the fundamental underpinnings of RIAs in BCA remains apparent. For example, EO 12866 states:

> *In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating. Costs and benefits shall be understood to include both quantifiable measures (to the fullest extent that these can be usefully estimated) and qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider. Further, in choosing among alternative regulatory approaches, agencies should select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity), unless a statute requires another regulatory approach.*[10]

[6] 42 USC §7409(b)(1).

[7] 42 USC §7412(d)(3)(A).

[8] EO 12291, Section 2.

[9] Interestingly, EO 12866 did not use the term "regulatory impact assessment" despite the similarity of its requirements. Apparently as a result, after the issuance of Clinton's EO 12866, and for the remainder of his years in office, the term RIA was largely replaced by "Economic Impact Analysis" (EIA) as the name of these EO-mandated documents. After about 2002, the term RIA came back into use, and remains the term used today. This temporary change in the common name for the regulatory assessment documents submitted to OMB can be confusing when performing reviews of RIAs and the methodological practices associated with them. This paper will refer to all of them as RIAs, although the titles of some of the documents cited do not use that term.

[10] EO 12866, Section 1(a).

As the excerpt above reveals, EO 12866 no longer requires that benefits be greater than costs. Also, it broadens the criteria to be considered to include more allowance for qualitative and non-quantifiable benefits. This is reinforced by the following language:

> *Each agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs.*[11]

As a result, the purpose of RIAs has been more clearly defined as one of providing decision-relevant information in a structured, coherent and transparent format. Costs and benefits still play a central role, but are not treated as if they should be determinative, even in situations where the law allows consideration of costs. Most policy analysts, including most economists, have been supportive of this broader purpose of RIAs.

In 2011, President Barack Obama issued EO 13563 to supplement EO 12866: "to improve regulation and regulatory review." EO 13563 requires that "equity, human dignity, fairness, and distributive impacts" be considered, in addition to the requirements of EO 12866.[12] This last modification does not alter the fundamental view of the role and purpose of RIAs: EO 13563 states that the purpose of RIAs is that regulations will be adopted based "upon a reasoned determination that its benefits justify its costs" and also that each agency "tailor its regulations to impose the least burden on society" and "select, in choosing among regulatory approaches, those approaches that maximize net benefits."[13] It also, importantly, notes that agencies should strive to reduce regulatory requirements that are "redundant, inconsistent, or overlapping."[14]

Thus, RIAs have an original foundation in BCA, but they rarely have been used strictly as BCA-based decision documents. Their practical value in policy making is that they can provide a structured assessment of the merits of individual regulations, so that policymakers and the public can have a clear understanding of the overall burden and positive contributions of individual regulations.[15] This practical role is quite clearly stated in OMB's "Circular A-4," which is the present OMB guidance for conducting RIAs:

> *Regulatory analysis is a tool regulatory agencies use to anticipate and evaluate the likely consequences of rules. It provides a formal way of organizing the evidence on the key effects, good and bad, of the various alternatives that should be considered in developing regulations. The*

---

[11] EO 12866, Section 1(b)(6).

[12] EO 13563, Section 1(c)).

[13] EO 13563, Section 1(b).

[14] EO 13563, Section 3.

[15] See, for example, Arrow *et al.* (1996).

motivation is to (1) learn if the benefits of an action are likely to justify the costs or (2) discover which of various possible alternatives would be the most cost-effective.[16]

Similarly, as RIAs are prepared for multiple different rules required by certain sections of law, such as a NESHAP under the CAA, the combined set of RIAs can help create an understanding of the overall merits of the way the controlling laws have been written. With time, good RIA practice should help identify laws that are poorly written, or regulatory approaches that implement laws in an ineffective manner. Political pressure to revise ineffective laws may result in better long-term legislation or regulatory practice. The fact that this role is recognized as valuable may be one reason why the requirement for RIAs has endured for thirty years and through Administrations with differing political perspectives. Whatever the merits of RIAs may be, they do face one problem with respect to serving their most valuable public policy objective. They are not subject to any formal public or peer review process other than review by OMB's Office of Information and Regulatory Affairs (OIRA).[17]

3. Evidence of the Predominance of $PM_{2.5}$ Co-Benefits in RIAs for Air Regulations

The research for this paper sought to identify and obtain all of the RIAs released for rulemakings under the CAA since 1997, which was the year in which EPA released its first NAAQS for $PM_{2.5}$. EPA's first estimates of mortality benefits from reducing ambient $PM_{2.5}$ were developed as part of that 1997 NAAQS policy decision, which makes 1997 an appropriate starting point for tracing the history of the use of $PM_{2.5}$ co-benefits in CAA-related RIAs. Creation of a list of RIAs to include in this study started with the identification of major regulations that the US EPA Air Office has submitted to OMB since 1997.[18] The list was then expanded to include RIAs for major air regulations still in the proposal stage.[19] This process identified 57 rules, 54 of which are final and 3 of which have been recently proposed and not yet been finalized.

---

[16] OMB (2003), pp. 1-2.

[17] The importance of extensive external review is highlighted in the sixth principle of the appropriate use of BCA in RIAs in Arrow *et al*. (1996), p. 221.

[18] This was done by going to http://www.reginfo.gov/public/do/eoAdvancedSearch# on the OMB website, and filtering for rules that met the following selection criteria: submitted by the EPA Air Office, concluded, final rule, major, and completed in any year since 1997. One rule that appeared on the resulting list was excluded (the renewable fuels standard known as "RFS2") because it is required under the Energy Independence and Security Act of 2007, not the CAA. One rule found on the OMB website fit the selection criteria, but did not appear when the filter was applied. This rule (the Petroleum Refineries NSPS rule concluded 12/10/08) was included.

[19] These were identified from RIAs posted on the EPA RIA website as of October 31, 2011 (at http://www.epa.gov/ttnecas1/ria.html). During initial research, the final RIA for the proposed air toxics rule for electricity generating units (EGUs) was all that was available. This rule, which is called the "EGU MACT rule" in this paper, was finalized in December 2011. This paper relies on results from the RIA for the final EGU MACT rule for its conclusions, but the paper quotes statements made by EPA and others that

A greater challenge was obtaining copies of the RIAs for all of the rules on this list. Neither OMB nor EPA maintains a complete, publicly-available record of RIAs. Also, an RIA is apparently not usually placed in its associated rulemaking docket. This situation may be a limitation in the completeness of dockets, or may be because RIAs are not required by the legal rulemaking procedures, but only by executive order.[20] Although *Federal Register* Notices of Rulemakings often summarize information from the RIAs, these sources were not always sufficient, because they may report total benefits estimated, but without the details needed to disaggregate those totals into direct benefits, $PM_{2.5}$ health-related co-benefits, and any other types of co-benefits.

At this point in time, this study has found either the final RIA itself, or sufficient information in other rulemaking documents to understand what EPA did to analyze the benefits and associated costs for 51 of the 57 rules identified, 48 of which are final rules and 3 of which are recently proposed rules. References for the source documents used are provided in Appendix A for all 57, with, where possible, page references for the relevant information on benefit and cost estimates found for each rule. Summary tables in the body of this paper are based on the references in Appendix A. Any RIAs that are quoted or described in greater detail in this paper are also listed in the References section of this paper.

This review of CAA RIAs since 1997 found that as EPA releases each of its proposed and final air quality rules, it typically emphasizes that the rule will generate health benefits that exceed its costs. However, close inspection of the associated RIAs reveals that a majority of those benefits – sometimes *all* of them – are from reductions in $PM_{2.5,}$ even for air regulations that are targeting clean air objectives other than $PM_{2.5}$. For many of those regulations, the bulk of the benefits estimates in their RIAs are attributable to reductions in already-low concentrations of ambient $PM_{2.5}$ that EPA has predicted will occur *coincidentally* as a result of regulation of those non-PM pollutant(s).

Figure 1 provides a summary of the role of $PM_{2.5}$ co-benefits in all of the air regulation RIAs that were for rules <u>not</u> targeting $PM_{2.5}$-related health risks and which provided any quantified benefits estimates at all. The rulemakings are listed in chronological order (based on the date the rules were finalized), so that one can observe the trend over time since 1997 in how frequently EPA has relied on $PM_{2.5}$ co-benefits, and the general degree of importance those co-benefits played in lending EPA a benefit-cost case for each rule. Figure 1 shows that a trend towards almost complete reliance on $PM_{2.5}$-related health co-benefits has grown over time. The main exceptions in recent years have been rules addressing greenhouse gases (GHGs) under the CAA. (The GHG-related RIAs all report negative costs, so $PM_{2.5}$ co-benefits are not necessary to make a benefit-cost justification in any case.)

---

used numbers from the final RIA for the proposed EGU MACT rule. Care is taken to clarify where information in this paper refers to information released with the proposed EGU MACT rule.

[20] Although EO 12866 requires that all communications between OIRA and the agencies, White House and public be added to the docket, our experience has been that the RIAs themselves cannot been found in all the respective dockets.

Figure 1. Summary of Degree of Reliance on $PM_{2.5}$-Related Co-Benefits in RIAs Since 1997 for Major Non-PM Rulemakings under the CAA
(RIAs with no quantified benefits at all are not in this table. Where ranges of benefit and/or cost estimates are provided, percentages are based on upper bound of both the benefits and cost estimates. Estimates using the 7% discount rates are used in all cases.)

Year	RIAs for Rules Not Targeting Ambient PM 2.5	PM Co-Benefits Are >50% of Total	PM Co-Benefits Are Only Benefits Quantified
1997	Ozone NAAQS (.12 1hr=>.08 8hr)	×	
1997	Pulp&Paper NESHAP		
1998	NOx SIP Call & Section 126 Petitions		
1999	Regional Haze Rule	×	
1999	Final Section 126 Petition Rule	×	
2004	Stationary Reciprocating Internal Combustion Engine NESHAP	×	
2004	Industrial Boilers & Process Heaters NESHAP	×	×
2005	Clean Air Mercury Rule	×	
2005	Clean Air Visibility Rule/BART Guidelines	×	
2006	Stationary Compression Ignition Internal Combustion Engine NSPS		
2007	Control of HAP from mobile sources	×	×
2008	Ozone NAAQS (.08 8hr =>.075 8hr)	×	
2008	Lead (Pb) NAAQS	×	
2009	New Marine Compress'n-Ign Engines >30 L per Cylinder	×	
2010	Reciprocating Internal Combustion Engines NESHAP – Comp. Ignit.	×	×
2010	EPA/NHTSA Joint Light-Duty GHG & CAFES		
2010	SO2 NAAQS (1-hr, 75 ppb)	×	> 99.9%
2010	Existing Stationary Compression Ignition Engines NESHAP	×	×
2011	Industrial, Comm, and Institutional Boilers NESHAP	×	×
2011	Indus'l, Comm'l, and Institutional Boilers & Process Heaters NESHAP	×	×
2011	Comm'l & Indus'l Solid Waste Incin. Units NSPS & Emission G'lines	×	×
2011	Control of GHG from Medium & Heavy-Duty Vehicles		
2011	Ozone Reconsideration NAAQS	×	
2011	Utility Boiler MACT NESHAP *(Final Rule's RIA)*	×	≥ 99%
2011	Mercury Cell Chlor Alkali Plant Mercury Emissions NESHAP	×	
2011	Sewage Sludge Incineration Units NSPS & Emission Guidelines	×	×

The practice of including co-benefits in RIAs is not new. Examples where co-benefits of one sort or another played a significant role in the evaluation of an RIA can be found as early as 1984.[21] However, the current situation is dramatically different from past examples. First, the pollutant for which co-benefits are being claimed is already stringently regulated – in fact, the CAA language defining the required stringency implies stringency greater than the BCA optimum (this point is explained in the next section). Second, these $PM_{2.5}$ co-benefits not only dominate the majority of RIAs for EPA's non-PM rules, but in many cases they are the only benefit that is being quantified at all.

Section 6 will discuss a number of reasons why these $PM_{2.5}$ co-benefits are overstated. That discussion also implies that the direct benefits that EPA is estimating in its RIAs for rules that do directly address $PM_{2.5}$ risks are also overstated. However, the intervening two sections first address the reasons why reliance on $PM_{2.5}$ co-benefits in non-PM rulemakings is inappropriate theoretically, inconsistent with the stated objectives of requiring RIAs to be prepared, and promotes excessively complex, duplicative and cost-ineffective regulation for the nation.

4. EPA's Use of $PM_{2.5}$ Co-Benefits in RIAs Is Inconsistent with Theoretical Underpinnings of Benefit-Cost Analysis

Although RIAs are no longer intended to serve solely as BCAs, BCA is clearly a core tenet of the exercise of producing RIAs. For this reason, it is important to explore from a theoretical perspective what BCA implies about the use of "co-benefits." As this section will demonstrate, the theoretical underpinnings of BCA do not support EPA's practice of adding co-benefits of <u>separately-regulated</u> pollutants into the total benefits estimates in RIAs, even when there are significant interrelationships between the pollutants in terms of the technologies that control them, their atmospheric formation, or health or welfare responses. In fact, the analysis in this section demonstrates that EPA's co-benefits practice actually moves the resulting benefit-cost comparison *in the wrong* direction from what BCA would advise if the pollutants for which co-benefits are being calculated are criteria pollutants already regulated under a NAAQS.

The purpose of BCA when applied to a policy choice, such as determining the level of an emissions standard, is to identify the level that would provide the highest net benefits (and also to ensure that those net benefits would be positive). The optimization objective for choosing a required amount of reduction of a single pollutant is mathematically stated as:

$$\underset{\{P\}}{\text{Maximize}}\ B(P)-C(P) \qquad \text{[i]}$$

where "P" stands for the amount of reduction in the pollutant in question, B(P) represents the benefits achieved given the amount of emissions reduction P, and C(P) represents the

[21] See, for example, the case study on the RIA for the lead phase-out regulations by A. Nichols in Chapter 4 of Morgenstern (1997).

costs of achieving the emissions reduction P. The BCA-optimal degree of reduction is identified by mathematically differentiating equation (i) with respect to P and setting it equal to zero, as in equation (ii):

$$dB/dP - dC/dP = 0 \qquad [ii]$$

This is known as the "first-order condition" for the optimization. One can see from equation (ii) that in the single-pollutant situation the BCA-optimal reduction for P is where the marginal benefit of P equals the marginal cost of P.

Consider now the somewhat more complex situation of performing a BCA for multiple pollutants simultaneously. For example, if two pollutants are to be controlled so that the net benefits of the combined regulations are optimized, the optimization objective is written as:

$$\underset{\{P, H\}}{\text{Maximize}} \; B(P,H)-C(P,H) \qquad [iii]$$

where P stands for reduction in the first pollutant and H for reduction in the second pollutant.[22] Optimization of equation (iii) requires the simultaneous solution of two equations. The two equations are the first-order conditions for each pollutant separately, which requires differentiating the above objective function first with respect to P and second with respect to H and setting both equal to zero:

$$\partial B/\partial P - \partial C/\partial P = 0 \qquad [iv\text{-}1]$$

$$\partial B/\partial H - \partial C/\partial H = 0 \qquad [iv\text{-}2]$$

Equations (iv-1) and (iv-2) show that if the standards for multiple pollutants can be selected simultaneously, then the level at which to set each one is decided without any reference to the changes in benefits or costs that would come from any other of the simultaneously-regulated pollutants. In other words, there is no term in the joint optimality conditions that represents co-benefits from any of the other pollutants. The decision about levels for H must be made assuming that P will be set at its optimal level, and vice versa.

In reality, the CAA does not give EPA the ability to actually set regulations in this simultaneous manner. The optimality rules become more complex when one must choose the level of one pollutant given that levels of other, interrelated pollutants have been *separately* established. This more realistic BCA situation can be represented by building on the two-pollutant BCA optimization of equation [iii]. Assume now that the

---

[22] For a person who wishes to read through this section with a specific emissions control policy example in mind, think of P as representing $PM_{2.5}$, and think of H as representing an air toxic such as mercury. As $PM_{2.5}$ precursors are reduced, so too is mercury, and vice versa. Total benefits, B, are a function of the amount of reduction in both $PM_{2.5}$ and mercury. Similarly, changes in policy costs, C, are a function of the reduction in both $PM_{2.5}$ and mercury that must be achieved.

policymaker can only control one pollutant, say by choosing H, while accepting that P has already been regulated to the level $P=P^N$. Now, the optimization objective is stated as:

$$\underset{\{H\}}{\text{Maximize}} \; B(P^N,H)-C(P^N,H) \qquad [v]$$

This gives rise to a single first-order condition for H which replaces the first-order condition for H in equation (iv-2):

$$(\partial B/\partial H - \partial C/\partial H) = (\partial C/\partial P - \partial B/\partial P)*dP/dH, \textit{ evaluated at } P=P^N \qquad [vi]$$

Equation (vi) is similar to equation (iv-2), except that instead of choosing H make the left-hand side (LHS) equal to zero, the LHS now should be made equal to the complex term that appears on the right-hand side (RHS) of equation (vi). This RHS term includes the marginal cost and marginal benefit of P (evaluated at $P=P^N$), as well as a term dP/dH. These elements of the RHS term clearly relate to co-benefits from the other separately-regulated pollutant, P, but the RHS term is not equal to P's co-benefits, specifically.[23] Thus, equation (vi) reveals how interactions of P with H would properly be incorporated into a BCA for choosing the optimal level of H. One cannot conclude that there is a theoretical rationale for including co-benefits of separately-regulated pollutants in a BCA for setting a standard on another pollutant unless the term on the RHS of equation (vi) were equal to what EPA calculates as co-benefits (*i.e.*, $\partial B/\partial P*dP/dH$), which it clearly is not. In fact, as will be explained below, equation (vi) actually implies that adding a separately-regulated pollutant's co-benefits into a BCA-based evaluation of any other pollutant regulation can drive the resulting regulation in the opposite direction from what BCA would advise.

The first thing to note about the RHS term of equation (vi) is that if P^N were to be set at the BCA-optimal level for P, then the RHS would equal zero.[24] In that case, equation (vi) would be identical to equation (iv-2), thus indicating that H should be selected without any reference to any co-effects from P. In this case, co-benefits of a separately-regulated pollutant clearly should not play any role in the BCA for another pollutant.

Consider now the alternative case in which P^N is *not* set at the BCA-optimal level for P. Although the RHS of equation (vi) is non-zero in this case, it still indicates that EPA's method of including co-benefits from P in a BCA for H is inappropriate. The non-zero RHS term can be interpreted as a measure of the degree to which the non-optimized choice of P *diverges* from its own first-best optimality condition, multiplied by dP/dH. If

---

[23] For example, dP/dH, which stands for the change in the level of P when H is changed, reflects coincidental additional reduction in P beyond its existing reduction level for the given reduction requirement on H. In other words, dP/dH is the physical co-*reduction* in P when a standard is set on H. Thus, the co-*benefit* from coincidental changes in P that result from choosing a level for H, which is what EPA includes in its RIAs, would be equal to $\partial B/\partial P*dP/dH$.

[24] This is because the portion of the RHS term in parentheses is consistent with the LHS of equation (iv-1), and thus equals zero if P^N is set at its optimal level where its own marginal costs equal its own marginal benefits, as prescribed by equation (iv-1).

co-benefits are positive, and P^N is over-controlled with respect to its BCA-optimal level, then the RHS of equation (vi) will be positive, because over-control occurs when the marginal costs of P have exceeded its marginal benefits, which in turn means that ($\partial C/\partial H - \partial B/\partial H) > 0$.[25] Thus, if P has been *over*-controlled with respect of its BCA optimum, equation (vi) tells us that H should then be *under*-controlled with respect to *its* BCA optimum. That is, the LHS of equation (vi) will need to be positive too, which means that H should not be controlled beyond a point where its own marginal benefits become equal to or less than its own marginal costs.[26] Similarly, if P is under-controlled, then equation (vi) indicates that H should be controlled to a level beyond its own BCA-optimum.

The case of P being *over*-controlled is of particular interest and relevance to $PM_{2.5}$ co-benefits. This is because the legal framework that determines what the EPA Administrator must select as a standard for ambient $PM_{2.5}$ clearly drives towards over-control of $PM_{2.5}$ with respect to its own BCA optimum.[27] The key implication is that if $PM_{2.5}$ co-benefits should be considered at all in a BCA for another pollutant (such as air toxics or ozone), they should enter as a *negative* term on the benefits side of the ledger, and not as a positive one. <u>Thus, estimates of the co-benefits from $PM_{2.5}$ *specifically* should not be incorporated into BCAs for any other pollutants being controlled under the CAA</u>, and when they are included, this only serves to drive other policies *away* from what would be their appropriate level, based on BCA principles.

In fact, this conclusion can be stated more broadly, that <u>co-benefits from any pollutant that is regulated as a criteria pollutant with a NAAQS that conforms with the requirements of CAA Section 109 should not be included in the BCA of any other pollutant</u>. This is because Section 109 requires over-control of all criteria pollutants with respect to their own BCA optima, due to Section 109's requirement for an adequate margin of safety when setting a NAAQS.

---

[25] Because co-benefits are positive, dP/dH is positive (*i.e.,* if pollutant H is reduced, then pollutant P is also reduced), so the sign of the term on the RHS is equal to the sign of the term in parentheses.

[26] The degree of under-control of H is not easily inferred without more situation-specific technical information, but the term that determines how much to over- or under-control H is not determined by simply adding the monetary co-benefits of P to the BCA for H. One can determine however that the amount of adjustment is <u>less</u> than the monetary co-benefits of P: the adjustment should be equal to $(\partial C/\partial P - \partial B/\partial P) * dP/dH$, and this is less than $\partial B/\partial P * dP/dH$, which is the monetary measure of co-benefits of P.

[27] The requirement that a NAAQS be set at a level that protects the public health with a margin of safety is equivalent to saying that it should be set at a point where no further material public health improvements would be expected to be gained by tightening the standard any further. In fact, the "margin of safety" implies that the standard be set a notch beyond that point of no further expected gains. In terms of a benefits curve, this would be a point where the benefits curve (as a function of ambient pollutant reduction) becomes flat, or at least that there is a significant probability in the mind of the Administrator that it is flat by that point. When the benefits curve is flat, marginal benefit equals zero. However, since marginal costs will always be increasing for all levels of reduction up to 100% reduction, the point where the Administrator must set the NAAQS is a point where marginal costs are greater than marginal benefits. Thus the point where marginal cost *equals* marginal benefit, which defines the BCA-optimal degree of reduction, is at a lesser level of than what the CAA requires for a NAAQS determination.

The fact that the CAA results in over-control of criteria pollutants *with respect to their BCA-optima* can be no surprise to analysts familiar with BCA. However, it might be useful to bring this point into the open in the way RIAs are conducted for criteria pollutants (and any other pollutants that must be regulated without regard to costs). If a NAAQS has indeed been set to a point where it provides an adequate margin of safety, its RIA *should* show that it fails the marginal BCA test. If RIAs are to more effectively serve in the role of providing sound and policy-relevant information to policymakers and the public about the impacts of new regulations, they should strive to actually quantify the net cost that our society is paying for that margin of safety in its air pollution rules. The purpose of recrafting CAA-related RIAs in this manner would not be to demonstrate that NAAQS rules fail a benefit-cost test that the CAA does not allow in the first place; rather, it would be to inform ourselves about the *degree* to which we are accepting higher costs in order to have the extra degree of public health safety that is mandated by the CAA, and apparently desired by the public.

To summarize, the analysis in this section establishes that EPA's practice of adding co-benefits of pollutants that are separately subject to policymaker control into the total benefits reported in RIAs for other pollutants is not supported by BCA theory. This conclusion holds whether or not the other pollutants are being regulated to their own BCA-optimal levels. This analysis has also demonstrated that EPA's practice of including co-benefits of criteria pollutants in its RIAs actually intensifies the pressure towards over-control relative to what BCA would prescribe that already exists in the standard-setting requirements of the CAA.

5. EPA's Use of $PM_{2.5}$ Co-Benefits Subverts the Practical Purpose of RIAs as an Informational Device for Improving Policy Making

As noted in Section 2, RIAs are no longer viewed as having to justify policy decisions based solely on BCA principles. They are now viewed as assessments that should help inform the public and policymakers on a variety of impacts that can be anticipated to result from each new major regulation, all of which are viewed as having relevance to societal objectives. People who feel that this structured informational role of RIAs is more important than its BCA-related role *per se* may argue that there is merit in understanding each rule's co-benefits, even those that come from separately-regulated co-pollutants such as $PM_{2.5}$. Unfortunately, EPA's use of $PM_{2.5}$ benefits as the predominant (often the *only*) quantified benefit in RIAs undercuts the objective of providing the public with a transparent understanding of the relative merits of each type of regulation.

Quantification of $PM_{2.5}$ co-benefits creates particular problems when they are reported as part of the total benefits of a rule in the Executive Summary of an RIA. Including them in the summary of the RIA, which is where the benefits of a rule are compared to its costs, and then also including them in public announcements about net benefits and benefit-cost ratios of new rules creates confusion for the public and other audiences who have little time to study the details of the underlying analysis in each RIA. An example of the confusion that can be created is in the following quote from the EPA Administrator regarding the benefits case for controlling air toxics from electricity generating units (EGUs), known as the "Proposed EGU MACT" rule:

> *When these new standards are finalized, they will assist in preventing 11,000 heart attacks, 17,000 premature deaths, 120,000 cases of childhood asthma symptoms and approximately 11,000 fewer cases of acute bronchitis among children each year. Hospital visits will be reduced and nearly 850,000 fewer days of work will be missed due to illness.*[28]

The fact is that every one of the benefits in the quote above comes from EPA's predicted $PM_{2.5}$ co-benefits, and not from any of the reductions in air toxics that are the purpose of that rule.[29] Anyone with the time and interest can read the RIA from which these numbers came, and may realize that these are $PM_{2.5}$-related benefits. However, not every such motivated reader would also realize that $PM_{2.5}$ is not an air toxic, and that those $PM_{2.5}$-related benefits would be more certain and more cost-effectively obtained through a different regulation altogether than an air toxics rule (*i.e.*, through the $PM_{2.5}$ NAAQS). By including those $PM_{2.5}$ co-benefits as part of the "total benefits" reported in the RIA for the Proposed EGU MACT rule, EPA encourages this misunderstanding.[30] The statements can become even more misleading in the hands of advocates outside of EPA. For example, the following statement in testimony by an advocate outside of EPA before the House Energy and Commerce Committee on the Proposed EGU MACT rule gives the distinct impression to readers that air toxics from power plants are killing and otherwise harming massive numbers of people:

> *EPA's proposed mercury and air toxics standards for power plants that burn coal and oil are projected to save as many as 17,000 American lives every year by 2015. These standards also will prevent up to 11,000 cases of heart attacks, 120,000 cases of asthma attacks, 11,000 cases of acute bronchitis among children, 12,000 emergency room and hospital visits and 850,000 lost work days every year.*[31]

---

[28] Quote from Administrator Jackson in EPA Air News Release (HQ), "EPA Extends Public Comment on Mercury and Air Toxics Standards," June 21, 2011. (In the RIA for the final EGU MACT rule the "17,000 premature deaths" has been reduced to 11,000, but this quote was made before the RIA for the final EGU MACT was released in December 2011.)

[29] This can be confirmed by reviewing the RIA for the Proposed EGU MACT rule, which is EPA (2011a).

[30] Any counter-argument that co-benefits are essential to add into an RIA's statement of a new rule's total benefits would require one to argue that RIAs have a BCA function. As has been demonstrated above, the principles of BCA, when scrutinized, prescribe that co-benefits of an already-regulated pollutant not be added in the comparison of benefits and costs of a regulation for a different pollutant.

[31] John D. Walke, Natural Resources Defense Council, Testimony at Hearing on "Recent EPA Rulemakings Relating To Boilers, Cement Manufacturing Plants, And Utilities," before the Subcommittee on Energy and Power, Committee on Energy and Commerce, U. S. House of Representatives, April 15, 2011.

EPA's reliance on co-benefits estimates thus undercuts the transparency that RIAs are supposed to bring to assessments of the impacts of new rules. Lack of transparency enables misleading advocacy.

Reliance on co-benefits creates another problem that undercuts the practical value of RIAs: it shields EPA from pressure to improve its ability to describe, characterize and even quantify the health and welfare benefits for the other pollutants that it is charged with regulating. The EGU MACT RIA is not the worst case in this regard. As Figure 1 shows, during the period 2009-2011, EPA released 13 CAA-related RIAs that provided quantitative estimates of benefits and in which $PM_{2.5}$ was a co-benefit rather than a direct benefit. $PM_{2.5}$ co-benefits accounted from more than half of the total benefits in all but 2 of the 13.[32] EPA did not even attempt to quantify the direct benefits in 6 of those RIAs: $PM_{2.5}$ co-benefits accounted for 100% of the total benefits identified in those RIAs. In two more of those 13 RIAs, although some direct benefits estimates were provided, $PM_{2.5}$ co-benefits accounted for more than 99% of the total reported benefits. In essence, EPA has been abdicating its responsibility to make a clear direct benefits case for its air rules, particularly those for air toxics. Furthermore, although EPA has quantified direct benefits for the new standards it has set for other criteria pollutants, it is relying on its $PM_{2.5}$ co-benefits estimates to create its case that those other NAAQS revisions will produce benefits greater than their costs, when in fact their direct benefits are often miniscule compared to their costs.

Clearly, EPA's $PM_{2.5}$ co-benefits habit is allowing EPA to avoid grappling with the important task of making a case that all of these other pollutants really require tighter controls. It may be possible for that case to be made for some of those pollutants, but a high degree of complacency and analytical laziness has instead taken root as EPA has found it can more easily rely on simplistically-derived estimates of co-benefits from a pollutant that it has every authority it needs, and indeed the legal *requirement*, to directly regulate to levels that are safe for the public health. This situation is completely at odds with the purpose of RIAs, which is to provide a consistent, credible and thoughtful evaluation of the societal value gained with the increased regulatory burden that new rulemakings create. It also stymies scientific progress in risk assessment techniques and associated knowledge.

In summary, $PM_{2.5}$ co-benefits have become a device for keeping some regulations of dubious public policy value from transparent scrutiny. Although many of those regulations may be mandated by law, the degree of stringency imposed requires judgment by the Administrator, and co-benefits may be masking judgments that would not otherwise pass scrutiny. On a longer-term basis, this practice is also preventing RIAs from playing their most meaningful practical role, which is to help the policymaking

---

[32] The two RIAs out of the 13 rulemakings during 2009-2011 in which $PM_{2.5}$ co-benefits were not the predominant form of quantified benefits were rules to reduce mobile source greenhouse gases. EPA estimated negative costs for both of those greenhouse gas rules, so their benefits would have exceeded their costs even with zero direct benefits. EPA has developed a method for quantifying benefits from reductions in greenhouse gases, so while it does also report $PM_{2.5}$ co-benefits is in those two RIAs, the emphasis on them as the benefit-cost justification for the rule is less pronounced.

community identify those frameworks for regulation that may not be providing the value that they were originally expected to provide when enacted or otherwise established. Including $PM_{2.5}$ co-benefits in all air-related RIAs thus is preventing any meaningful identification of ways to reduce regulatory burdens while still meeting our national air quality objectives.

6. $PM_{2.5}$ Risk Estimates Have Become Increasingly Less Credible as EPA's Use of Them as Co-Benefits in Non-PM RIAs Has Grown

This paper has demonstrated that BCA theory does not support the role that EPA gives to $PM_{2.5}$ co-benefits, and that excessive reliance on them in its regulatory justifications is undercutting the more general purposes of RIAs for guiding policy making. This review of EPA's RIAs has also found that as EPA has used $PM_{2.5}$ co-benefits to justify more and more of its non-$PM_{2.5}$ rules, it has also moved to less and less scientifically-credible methods for estimating those co-benefits. These changes in methodology and assumptions have inflated the $PM_{2.5}$ co-benefits estimates dramatically (and also the direct $PM_{2.5}$ benefits estimates in rulemakings targeting $PM_{2.5}$).

To explain the methodological issues, it is necessary that the reader first understand the general elements of the scientific basis for EPA's $PM_{2.5}$ risk calculations. These calculations are all based on the presumption that statistical correlations between health effects levels and ambient air quality are causal in nature. The illustrative example of how these studies are performed and then used to calculate risk changes from hypothetical changes in ambient $PM_{2.5}$ levels will be based on the "chronic exposure" studies that are the starting point for EPA's estimates of mortality risks from $PM_{2.5}$. The focus of this discussion will be on mortality because $PM_{2.5}$ mortality benefits estimates account for over 90% (and as much as 97%) of the total $PM_{2.5}$-health benefits estimates in EPA's RIAs. All of the categories of $PM_{2.5}$ morbidity benefits account for as little as 3% of the estimated $PM_{2.5}$ co-benefits estimates, particularly when the upper-bound mortality estimates are reported.[33]

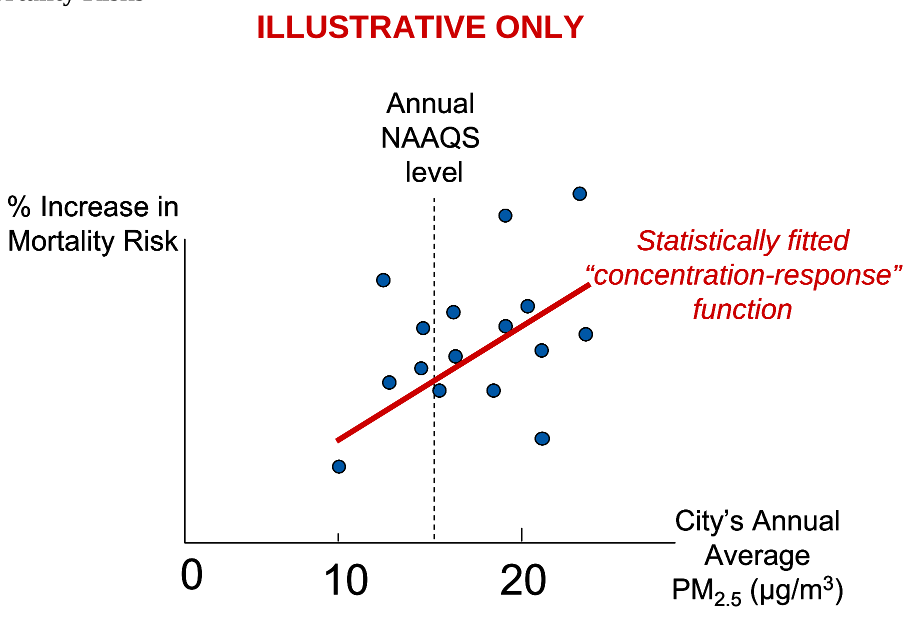
For the chronic exposure mortality-risk studies, a database is created of many individuals living in multiple cities across the US. Researchers then track the survival outcomes of those individuals over time to build up estimates of the relative mortality risk at each age level in each of the different cities where these individuals, or "cohorts" live. After enough deaths have been observed (which can require as much as a decade), the researchers assess whether a statistical correlation exists between the estimated relative mortality risk in each city and the cities' average ambient $PM_{2.5}$ concentrations. This statistical analysis also attempts to control for all the other major factors that contribute to mortality risk, which is a daunting and perhaps elusive goal, given limitations in the availability of the relevant data.

---

[33] A single morbidity category, chronic bronchitis, accounts for about half of all the morbidity benefits value. EPA's estimates of chronic bronchitis risks are also based on a "chronic exposure" type of study. The rest of the morbidity benefits (as little as 1.5% of the total $PM_{2.5}$ co-benefits) are based on "acute exposure" types of studies that differ in a number of ways from the illustrative example that this section provides.

Figure 2 provides a simplified illustration of the way that population risk information from the chronic exposure studies produces an equation that EPA uses to calculate mortality risks from current and changed levels of $PM_{2.5}$. Each dot in the figure represents the percent increase in mortality risk for an entire city,[34] plotted against each city's respective annual average monitored ambient $PM_{2.5}$ concentration. The heights of the dots on the vertical axis should be viewed as the percent differences in mortality risks that remain across the cities after first controlling for and removing other risk factors for which data can be obtained (*e.g.*, age, income level, smoking status, weight, local climate, *etc*.). The placement of each dot on the horizontal axis reflects that city's average concentration of ambient $PM_{2.5}$ as measured at central monitoring stations. The statistical analysis then estimates the line through these data points that provides the most likely explanation of their scatter.[35] The most important attribute of this line is its slope, *i.e.*, the percent risk increase per additional $\mu g/m^3$ of ambient $PM_{2.5}$. The estimated slope is a single constant percent per $\mu g/m^3$ from the city with the lowest measured $PM_{2.5}$ concentration to that with the highest measured concentration. This statistically-fitted curve is called the "concentration-response" function, because it associates risk with city-wide concentrations of ambient $PM_{2.5}$ measured at monitoring stations. Monitored concentrations serve as rough proxies for individuals' exposures to $PM_{2.5}$, which certainly vary among the individuals within a city, but are not known.

Figure 2. Illustration of Basis of Concentration-Response Functions in Cross-City Comparisons of Relative Mortality Risks



[34] The absolute risk varies by age, but the statistical estimation method used in the $PM_{2.5}$ chronic exposure mortality studies (the "Cox Proportional Hazards model") assumes that any increase in risk due to a city's average ambient $PM_{2.5}$ level increases risk by the same proportion for all age groups. Thus, relative risks can be summarized as a single dot for each city in the study.

[35] The formula for the fitted relationship is in a "log-linear" form. It appears as a line in the illustrative figure because the y-axis units are the *percentage* increase in risk per increment of $PM_{2.5}$ concentration, which is stated in absolute units.

The ambient concentrations observed in each study fall within a range. For example, in the illustrative figure, the range is roughly from 10 μg/m^3 to 25 μg/m^3. There is no factual evidence to indicate the shape of the concentration-response function below or above this range, which is why the red line in Figure 2 does not extend beyond the range of the observed data. A term that will figure prominently in the discussion below is the *lowest measured level* (LML) of ambient average $PM_{2.5}$. This term refers the average city-wide $PM_{2.5}$ concentration of the "cleanest" city in the dataset from which a concentration-response function has been estimated. In the illustrative figure, the LML is about 10 μg/m^3.

Each chronic exposure study has a different number of cities, or data points. One widely-cited database is called the American Cancer Society (ACS) cohort. This database includes people (the "cohort") residing in over a hundred cities. Statistical estimates of a $PM_{2.5}$-mortality slope based on the ACS cohort usually include from 50 to 160 cities, or data points as shown in Figure 2. A commonly-cited slope estimate based on the ACS cohort is from Pope *et al.* (2002), which is often used by EPA to estimate its lower bound $PM_{2.5}$ mortality benefits estimates. Another widely-cited database is the Harvard "Six-Cities" cohort. As its name implies, it offers a slope estimated from only six data points. One slope estimate based on the Six Cities cohort is reported in Laden *et al.* (2006), which is notable here as the study on which EPA presently bases its upper bound $PM_{2.5}$ mortality benefits estimates.

Most (but not all) $PM_{2.5}$ researchers studying the ACS, Six-Cities, and several other cohort datasets have reported that the estimated slope of the concentration-response curve is positive, and statistically significant. However, this fact does not eliminate uncertainties about the size of the risk, nor about whether the association is causal. A discussion of the many uncertainties that remain is provided before turning to how the estimated relationship is being used by EPA to predict benefits from regulations that would reduce ambient concentrations of $PM_{2.5}$ in certain areas of the US.

First, there are usually relatively few data points near the upper and lower ends of the range of ambient $PM_{2.5}$ data. This causes the confidence interval on the slope estimate to widen progressively as one moves from concentrations near the average among the cities studied out to the extremes of the observed data. The confidence interval on the relative risk associated with cities with concentrations at the LML may be very wide. This means that the slope may be lower or higher than that which has been estimated over the full range of data. One may not even be able to statistically assert that the $PM_{2.5}$-risk relationship is non-zero for concentrations at or near the LML, even when the average slope estimated over the full range of $PM_{2.5}$ levels is statistically significant. Thus, there is much greater uncertainty about the size of the $PM_{2.5}$ effect at lower ambient concentrations, such as at the LML, than is usually acknowledged.

Second, data point "scatter" lies beneath the average relationship that the fitted line summarizes. This implies that the estimated concentration-response curve will be a poorer predictor of the change in risk that will be experienced in any specific city than it may be for predicting average risks over many different cities. It also follows that uncertainties in predicted responses to reductions in $PM_{2.5}$ levels in cities that were not in the original dataset will be even greater than the statistical confidence intervals imply.

Third, there is great uncertainty on the true shape of the concentration-response relationship. Researchers report they have not been able to identify any shape that is statistically superior to the log-linear form, but this does not mean that the actual relationship is log-linear. There are numerous problems in the quality of the data being used that can undercut the ability to detect shape. Thus, even within the observed data range, uncertainty remains about the shape of the estimated concentration-response function. However, there is no ability at all to determine statistically whether or not the slope of the curve continues unchanged below the LML, as ambient $PM_{2.5}$ concentrations approach near-zero levels, because there are no observations in that range at all.[36] In situations such as this, researchers usually attempt to use mechanistic understanding of the phenomenon being estimated to guide shape assumptions. However, EPA has not been able to provide any mechanistic explanation of how current ambient levels of $PM_{2.5}$ may increase risk of death, and so there can be no help from mechanistic reasoning. Any extrapolation of the concentration-response relationship below the LML is therefore subject to much greater uncertainty than the statistical confidence intervals might suggest.

Fourth, there is substantial uncertainty in defining the appropriate concentration to serve as the best proxy for levels of $PM_{2.5}$ to which the individuals in the study cohort have been exposed.[37] EPA now states that the LML for the ACS cohort is 7.5 $\mu g/m^3$, and 10 $\mu g/m^3$ for the Six-Cities cohort. However, the LML for the ACS cohort averaged about 10 $\mu g/m^3$ during 1979-1983, which spans the time that cohort was recruited (in 1982). The LML for the Six-Cities cohort averaged about 11 $\mu g/m^3$ during 1979-1985, although that cohort was recruited earlier still, in 1974-1977. But even relying on these earlier, higher concentration levels as estimates of the levels that might account for observed differences in mortality risk levels is open to question. Recall that the estimates of differences in mortality risk across cities are built up by following the survival outcomes of the people in each city over many years. This means that the observations of their mortality risks at each age, if attributable to air pollution at all, could be a result of exposures they experienced many years in the past, or that they accumulated over a long period of time.

Take the ACS cohort as an example. The ACS cohort was first established in 1982. At the time that the individuals were recruited for the ACS study, they had to be at least 30 years old and their average age in 1982 was 56 years. Thus all of the individuals in the ACS database had been exposed to US pollution levels since at least 1952 (*i.e.*, 30 years before 1982), and the average individual in the database experienced US pollution levels

---

[36] Efforts to explore shape near the LML have produced inconsistent results. Some researchers report finding upward curvature and others report finding downward curvature. At present, no consensus or weight of evidence can be said to exist on this matter.

[37] Recall also that the term "concentration-response function" is used to remind us that none of these studies actually measure what *exposures* the individuals tracked were receiving. An assumption is made that the average exposure across individuals in each city can be approximated by the readings at that city's ambient monitors. All individuals in a city are assumed to be exposed to the same concentrations.

dating back to 1926. As researchers using the ACS database have stated "In the 1950s, levels of air pollution in most North American and European cities were 10 to 50 times higher than those found today."[38] Since the mortality risk estimated for each city is based on many years of tracking these people, recent average $PM_{2.5}$ concentrations such as those in 2000 cannot be viewed as indicative of the $PM_{2.5}$ exposure level that most affected their observed survival outcomes. Those individuals who had not already died by 2000 would have already lived at least 44 years of their lives while being exposed to earlier, higher $PM_{2.5}$ levels. To say that the estimated mortality-risk relationship has been observed down to the level of the lowest $PM_{2.5}$ concentration most recently measured in any of these cities is close to assuming that recent lower levels of $PM_{2.5}$ accounted for the health outcomes of people who died as much as several decades ago. The same issues are present with the Six-Cities and all other cohorts being used in $PM_{2.5}$ epidemiological studies of risks due to chronic exposures to $PM_{2.5}$.

Fifth, none of the $PM_{2.5}$-risk estimates that EPA relies on for a concentration-response function slope assumption has been estimated while also accounting for the relative levels of pollutants other than $PM_{2.5}$. The presumption is being made that $PM_{2.5}$ is the sole air pollutant contributing to observations of an increased average mortality risk associated with higher average ambient pollution. Nevertheless, some studies have controlled for other pollutants. For example, the ACS cohort's slope with respect to $PM_{2.5}$ was found in 2000 to be much smaller and statistically insignificant when another pollutant (SO_2) was included in the analysis.[39] Since 2000, not a single study based on that ACS cohort has reported an estimate of the $PM_{2.5}$ slope that came from a model that also accounted for SO_2.

Sixth, unlike other pollutants, the chemical and physical composition of $PM_{2.5}$ varies over space and time,[40] but none of these statistical studies have sufficient data yet to try to determine the degree to which some $PM_{2.5}$ constituents account for more of the observed associations than other constituents. The concentration-response functions that EPA constructs from these types of epidemiological studies all assume that every one of the multiple types of $PM_{2.5}$ is equally potent. This assumption is not realistic when one considers the wide variety in the chemical properties of the many major components of ambient $PM_{2.5}$ concentrations. This fact creates substantial unquantified uncertainty in estimates of benefits from future decreases in $PM_{2.5}$ concentrations except in the unlikely case there all the individual constituents would be reduced by the same percentage. This source of uncertainty in benefits estimates becomes particularly extreme for regulations would only reduce one type of $PM_{2.5}$ constituent. Reduction of that single type of $PM_{2.5}$

---

[38] Krewski *et al*. (2000), p. 33.

[39] Krewski *et al*. (2000).

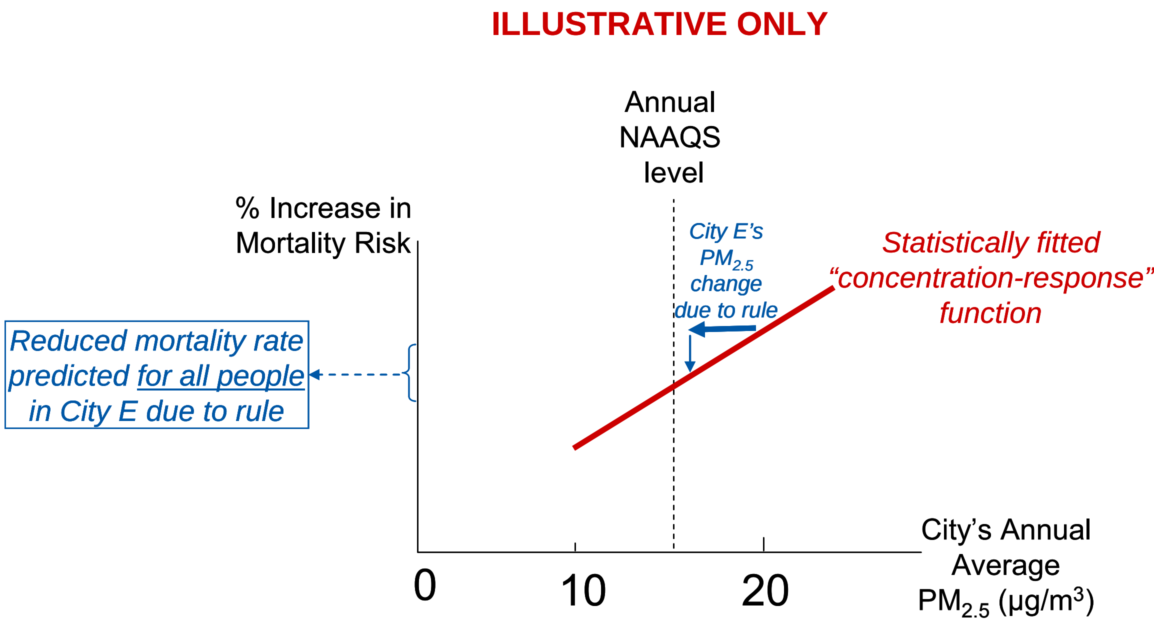
[40] $PM_{2.5}$ comprises all compounds in the ambient air that are not in the form of a gas; it includes compounds that are as physically different as solid particles and very fine liquid droplets. Chemically, the constituents that may be found in the ambient mass that counts as $PM_{2.5}$ include a diversity of compounds including dust, soot (elemental carbon), sulfates, nitrates, and secondary organic compounds. Some are soluble and some are insoluble, and each has its own distinct physiological impact when inhaled. Not only is $PM_{2.5}$ a hodge-podge of compounds, but the mix differs dramatically from location to location and temporally at any given location.

could have no effect at all on health, or it could have even greater effect than EPA predicts using its equal-toxicity assumption. EPA has never attempted to quantify this uncertainty in any of its benefits estimates. This is a particular concern for co-benefits estimates in RIAs for non-PM rules, because co-benefits are often based on changes in a single constituent that happens to be linked with reductions of the non-PM pollutant. For example, almost all of the 11,000 deaths attributable to $PM_{2.5}$ co-benefits in the Final EGU MACT rule RIA are due to reductions in sulfates alone.

These six uncertainties represent just a few of the uncertainties that exist for the "concentration-response" function's ability to predict how much mortality will be reduced if national ambient $PM_{2.5}$ is decreased. At present, the only statement of statistical uncertainty that EPA provides for an estimate based on any individual epidemiological study reflects only the statistical confidence of the overall slope of the estimate. As explained above, this is not an appropriate measure of the uncertainty of predictions of risk at concentrations at the extreme ends of the observed dataset, such as those at and just above the LML. But these six types of technical problems imply larger uncertainties than even the expanded confidence bounds would imply, and undercut confidence in interpreting the statistical association as causal in nature. Nevertheless, EPA uses the slope estimates from these studies to predict risk from changes in $PM_{2.5}$ that will occur in the future, and in many locations that were not even studied, as explained next.

The next figure, Figure 3, illustrates how EPA uses the slope that is estimated from cohort studies to project $PM_{2.5}$ deaths due to changes in baseline $PM_{2.5}$ levels. *First, and foremost, EPA starts by presuming that the statistically-estimated concentration-response slope represents a causal relationship with $PM_{2.5}$ and that pollutant alone.* As the figure shows, EPA just takes the average slope from one of the studies, and then determines how much the mortality rate in a given city (not necessarily one in the original study) will be reduced if its ambient $PM_{2.5}$ concentrations are reduced. Consider, for example, "City E" in the illustrative figure, which has a baseline annual average $PM_{2.5}$ concentration of 20 $\mu g/m^3$ that is projected to decline to about 16 $\mu g/m^3$ under an hypothetical regulation. EPA's risk assessment calculation for that regulation would assume that every person residing in City E will experience a drop in mortality risk equal to the vertical drop along the concentration-response function, as indicated by the blue arrows in Figure 3.

Figure 3. Illustration of Calculation of Reduced Premature Deaths Due to Changes in Predicted Ambient Average $PM_{2.5}$ Levels in a City ("City E")



In its national benefits analyses, EPA performs the same computation as shown for illustrative "City E" for the changes in $PM_{2.5}$ concentrations that EPA projects for every county in the US. All those changes – assumed to benefit every resident of any county or city in which a change in $PM_{2.5}$ is projected to occur – are added up to produce EPA's estimate of the national reduction in deaths due to $PM_{2.5}$ from a regulation. Very small changes in $PM_{2.5}$ (and therefore in $PM_{2.5}$-related mortality risk) thus can produce very large changes in estimated premature deaths, if spread over a population of about 300 million people. For example, the 11,000 deaths that EPA attributes as co-benefits in the RIA for the Final EGU MACT rule involve median changes in $PM_{2.5}$ concentrations of 0.36 $\mu g/m^3$ at simulated monitors.[41] Further, (as will be shown later in this paper) almost all of those small changes in ambient concentrations occur at very low levels of baseline $PM_{2.5}$ concentrations – levels for which no observed concentration-response function exists.

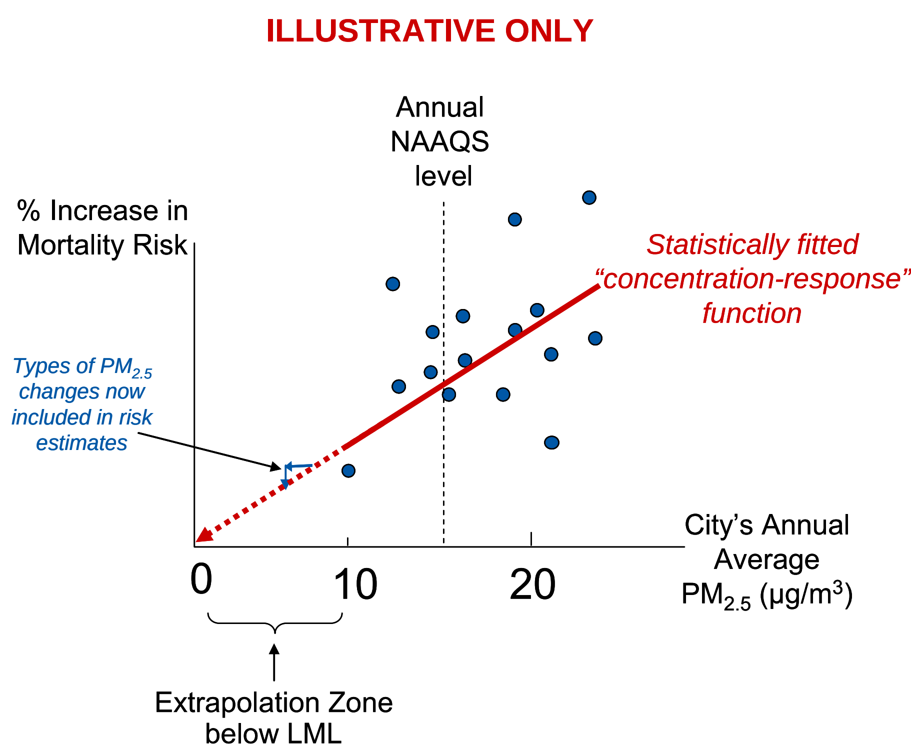
It should be apparent from the discussion above that EPA's estimates of the benefits from regulations that will reduce concentrations of $PM_{2.5}$ in certain locations are fraught with uncertainties, even for changes in $PM_{2.5}$ concentrations that occur above the most recently measured LML. However, in 2009, EPA modified its $PM_{2.5}$-mortality risk formula in a way that greatly increased its benefits estimates. In the illustrative examples above, risks were not computed for changes below the LML in the underlying epidemiological studies. That is, if ambient $PM_{2.5}$ in a location was already below the end of the curve (*e.g.*, at 10 $\mu g/m^3$ in the figures), then prior to 2009, EPA did not assume

[41] See EPA (2011c), p. 5B-4.

there was any further potential for $PM_{2.5}$-related mortality risk reduction in that location. However, starting in 2009, EPA decided that it would calculate risks to the lowest level projected by its air quality models, even though no observed or empirical evidence exists for what the slope of the concentration-response may be in that low-concentration zone.

Figure 4 shows this methodological change, building on the graphical illustrations of Figure 2 and Figure 3. Instead of calculating risks only in areas with $PM_{2.5}$ down to the LML of the study – the point at which all scientific evidence of a statistical association ends – EPA now assumes risks continue *at the same rates* to levels well below the range in which there is any scientific evidence to support those calculations. "Extrapolation" is the use of quantitative relationships outside of the range of evidence on which it was based.[42]

Figure 4. Illustration of the Extrapolation EPA Is Now Using to Calculate Risks in Areas with Ambient $PM_{2.5}$ Concentrations below the Lowest Measured Level in the Original Statistical Study



---

[42] Most elementary lectures on statistical methods such as regression warn the students that extrapolation of any statistically-derived relationships is a highly dubious exercise. For example, a summary of statistical regression methods carries the following warning: "After computing the regression line, you must not use it to predict values of the response for values of the explanatory variable outside the range of the data used to compute the line in the first place. This practice, called extrapolation, is dangerous because the original data can only produce a formula that describes the association for values found in the original data" (see http://emp.byui.edu/BrownD/Stats-intro/dscrptv/dscrptv_2_qunt_vars/smpl_lnr_rgrsn_ref.htm, accessed November 22, 2011, emphasis in original.)

In other words, in 2009, EPA suddenly started including an entirely new set of presumed risks in its RIAs, based entirely on an extrapolation that has little to no scientific support and without assessing the statistical confidence for predictions of risk changes even at the LMLs of the studies that EPA started from. This created a major change in the level of national mortality estimated to be due to $PM_{2.5}$ that EPA is assuming, because the majority of the US population resides in locations where ambient $PM_{2.5}$ concentrations are below 10 μg/m^3. Where EPA previously did not presume any risk for those people, EPA is now attributing as much health benefit per person in those areas from very small changes in $PM_{2.5}$ (*e.g.*, 0.36 μg/m^3) as it attributes per person for the same size change in areas that have ambient levels above the LML, and even in areas with $PM_{2.5}$ exceeding the "safe" $PM_{2.5}$ NAAQS level of 15 μg/m^3.

EPA's change in its risk analysis assumptions also dramatically inflated its estimates of baseline mortality due to $PM_{2.5}$ in areas with $PM_{2.5}$ above the LML. Prior to 2009, EPA assumed their risk was elevated only in proportion to the degree that their location's ambient $PM_{2.5}$ concentration exceeded the LML, but after 2009, EPA started to assume their risk was elevated in proportion to the degree that their location's ambient $PM_{2.5}$ exceeded background levels (which EPA assumes is about 1 μg/m^3).[43] For example, in an area with $PM_{2.5}$ equal to 16 μg/m^3, EPA used to calculate risks for an excess exposure of 6 μg/m^3 (*i.e.*, 16 minus an LML of about 10). Now, for that same population, EPA is assuming an excess exposure of 15 μg/m^3 (*i.e.*, 16 minus a background of about 1). This decision to calculate risks below the LML increased the estimated mortality risk in that illustrative type of location (*i.e.,* one that is above the LML) by 250%.

Overall, the decision in 2009 to extrapolate risks below the LML caused EPA's estimates of total US deaths due to $PM_{2.5}$ to nearly quadruple. Prior to 2009, EPA was calculating (for its upper bound RIA benefits estimates) that $PM_{2.5}$ caused up to 88,000 deaths nationwide in the relatively clean year of 2005; then, overnight in 2009, EPA changed that number to 320,000 deaths – an increase of a factor of 3.6. [44]

The fact that EPA's methodological change would increase EPA's estimates of deaths due to $PM_{2.5}$ in the year 2005 by a factor of 3.6 (or by about 232,000 more deaths) was never reported or peer reviewed. Although EPA points to concurrence from a committee

---

[43] "Background" level is supposed to represent the ambient concentration that would still remain if all manmade sources of emissions were to be eliminated. EPA formally uses an estimate it calls "policy-relevant background," which is supposed to represent US ambient concentrations if all US, Canadian and Mexican manmade emissions were to be eliminated, but does allow for contributions to US ambient concentrations from emissions in other locations such as Asia, Europe and South America.

[44] The fact that this inflation from 88,000 to over 320,000 was due solely to the decision to extrapolate below the LML is directly observable in EPA's *Quantitative Health Risk Assessment for $PM_{2.5}$* (EPA, 2010b). Appendix G of that document shows the 2005 national risk estimates based on the epidemiological study by Laden *et al.* when calculated just down to the LML, and also when calculated down to zero concentrations (EPA, 2010b, Table G-1, pp. G-6 to G-7). Although a risk estimate that extrapolates below the LML appears in this appendix, none of the CASAC-approved risk estimates in the main body of EPA (2010b) includes risks below the LML. The fact that EPA is actually using an estimate of 320,000 deaths due to $PM_{2.5}$ in 2005 is explicitly stated in EPA's RIA for the Cross-State Air Pollution Rule (EPA, 2011b, pp. 2-3).

of its Science Advisory Board (SAB) that it could extrapolate risks below the LML in its RIAs, there was no public discussion about that decision's implications for a huge inflation in the estimated number of lives that could still be saved through yet-more reductions of $PM_{2.5}$. There is also no evidence that the SAB committee that was asked to opine on this decision was offered any information on its quantitative implications. (Notably, that SAB committee was *not* CASAC. As a result, EPA is now using these inconsistent estimates of baseline $PM_{2.5}$-related deaths simultaneously in different contexts – EPA is using the smaller number of baseline deaths in its CASAC-reviewed risk analyses for the $PM_{2.5}$ NAAQS review, and it is using the larger number of baseline deaths in its RIAs that are generating the large co-benefits for non-$PM_{2.5}$ regulations, such as for air toxics regulations and for non-PM NAAQS, such as ozone.)

The quantitative inflation in $PM_{2.5}$-related mortality benefits through the non-scientific process of extrapolation below the LML is dramatic in its own right, but its lack of credibility becomes more clear when one considers what it means about the fraction of all deaths in the US that are due to $PM_{2.5.}$ EPA's presumption that 320,000 deaths in 2005 in the US were "due to $PM_{2.5}$" means that over 13% of all deaths in the US *on average* were due to $PM_{2.5}$.[45] The estimate of 13% of all deaths may seem implausible, but the fractions at the regional level are what gives one pause. These can be seen in Figure 5, which is found in EPA's final RIA for the Proposed EGU MACT rule.[46] Its legend has been adapted here to be consistent with the upper bound $PM_{2.5}$ mortality co-benefits estimates in the Final EGU MACT and other post-2009 RIAs. In other words, the scale shown in red font on Figure 5 is the scale that is consistent with 320,000 deaths due to $PM_{2.5}$ in 2005. It shows that EPA is assuming as a starting point for its benefits calculations that 16% to 22% of all deaths in 2005 were due to $PM_{2.5}$ in large expanses of the Eastern US (*i.e.*, in all of the red-colored counties on the map).

Another inference can be made from EPA's post-2009 method of extrapolating $PM_{2.5}$-related mortality risks below the LML. It implies that about 25% of all deaths *nationwide* were due to $PM_{2.5}$ as recently as 1980.[47] These assumptions, which underpin EPA's co-benefits calculations, stretch the bounds of credibility, and thus undercut the credibility of all of EPA's $PM_{2.5}$-related mortality benefits estimates.

EPA's post-2009 baseline risks are so large because EPA now assumes that there is no tapering off of relative risk as $PM_{2.5}$ exposure approaches zero. For years there has been a debate about whether the concentration-response relationship can truly be linear down

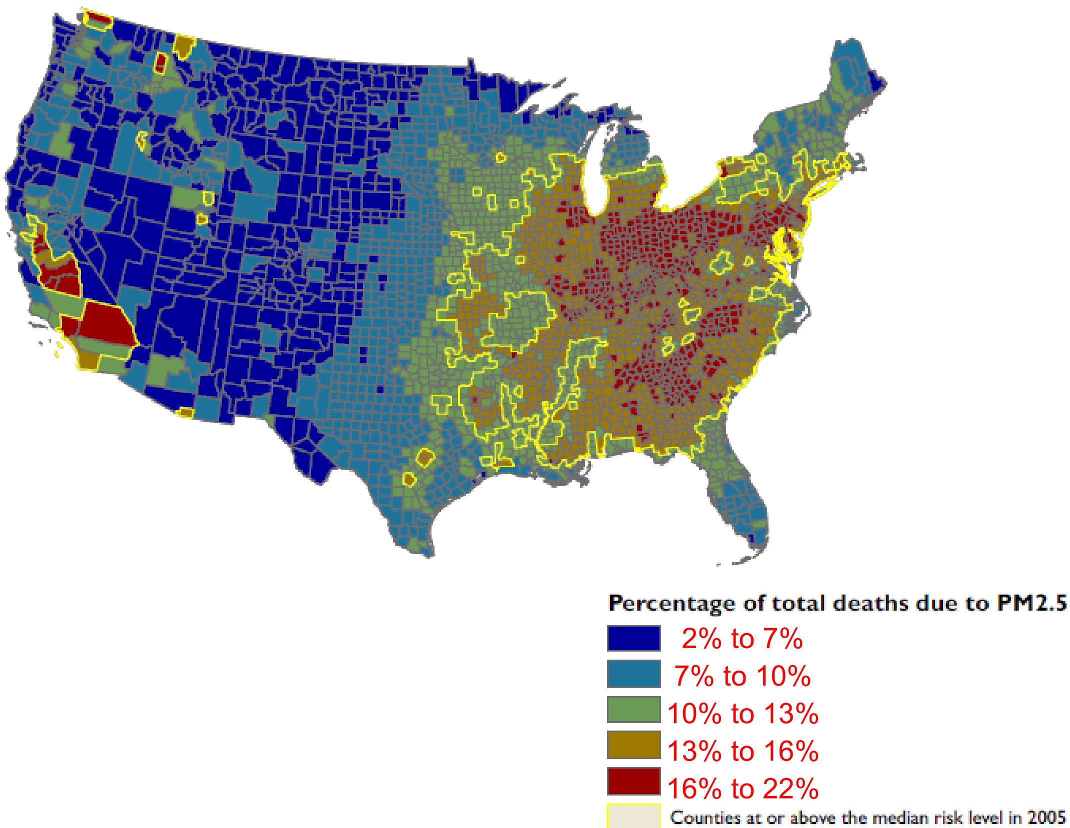
[45] In contrast, the estimate of 88,000 deaths is 4% of all US deaths. Although this starts to seem like a small number in comparison to the 13% that EPA now endorses, it is most likely also an overstatement of the true risks, for reasons discussed above, such as the difficulty in identifying the correct concentration to which elevated mortality risks should be attributed, the uncertainty in the appropriate LML to apply, and the presumption of causality itself in these risk calculations.

[46] Although this figure comes from the final RIA for the Proposed EGU MACT rule (EPA, 2011a), it is still applicable to the Final EGU MACT rule because it reports EPA's estimates of historical (*i.e.*, 2005) levels of mortality risk, which have not been affected by any of the changes in baselines or MACT-related co-reductions of ambient $PM_{2.5}$ that occurred between the proposed and final EGU MACT rule.

[47] See Smith (2011), pp. 14-16 for how this calculation is done.

to zero, but this debate has been focused on questions of statistical power and on basic principles of toxicology. The implication of the linear-to-zero/no-threshold assumption has never been debated in terms of its implication that an implausible proportion of total deaths in the US would be due to $PM_{2.5}$ – but perhaps now it should be debated that way too.

Figure 5. EPA-Produced Map Showing Percentage of Total Deaths due to $PM_{2.5}$ in the Year 2005, with Legend Adjusted by Author to Represent the $PM_{2.5}$ Risk Slope that EPA Uses for its Upper Bound $PM_{2.5}$ Risk Calculations. [48]



EPA's 2009 inflation in the number of estimated "deaths due to $PM_{2.5}$" has its greatest impact on risks calculated for very low $PM_{2.5}$ levels. Thus, its primary impact has been to increase co-benefits estimates for regulations that are not related to attaining the $PM_{2.5}$ NAAQS, such as the EGU MACT standard. That is, where EPA previously estimated

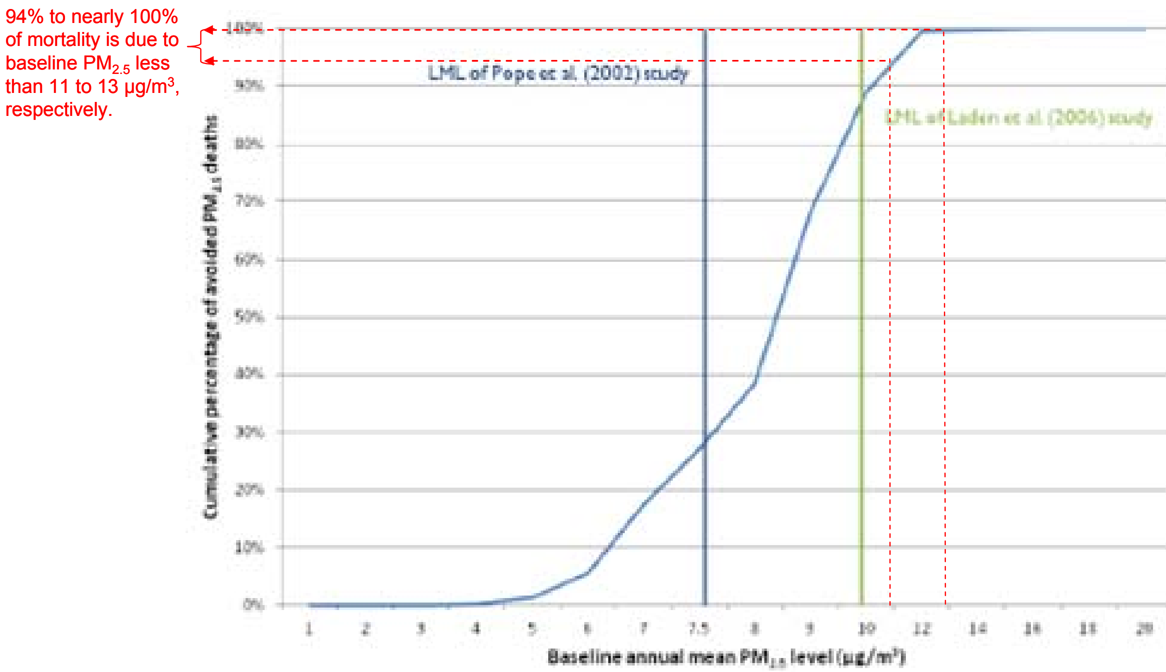
---

[48] Figure copied from EPA (2011a), Figure C-2. However, the figure in the RIA is presented for a $PM_{2.5}$ concentration-response slope that is not the one EPA uses to calculate its upper bound estimate of lives saved from the EGU MACT due to $PM_{2.5}$ co-benefits. That is, the text in EPA (2011a) explaining the derivation of the figure indicates that it is based on a $PM_{2.5}$ concentration-response slope from Krewski *et al*. (2009). EPA's current upper bound estimates of lives saved from $PM_{2.5}$ is based a concentration-response slope from Laden *et al.* (2006). Since the 2005 $PM_{2.5}$ levels in each county in the map would not change (they are historical data), the risk range for the scale can readily be recalculated for the Laden *et al*. slope, as done in this paper. Smith (2011) explains how this adjustment is made.

zero co-benefits from $PM_{2.5}$ reductions in areas already below the LML, EPA has created a reservoir of perhaps over 100,000 deaths that it can tap into as co-benefits from new non-PM regulations.

The extent to which this inflationary extrapolation enhances co-benefits estimates can be seen in Figure 6, which is taken from the RIA for the Final EGU MACT RIA.[49] This figure reports (on the vertical axis) the percentage of EPA's estimate of the EGU MACT's total $PM_{2.5}$ mortality co-benefits (*i.e.*, the 11,000 lives saved) that is attributable to ambient $PM_{2.5}$ concentrations at or below the level reported on the x-axis. It shows that nearly all of those 11,000 deaths are in populations that are in areas that are already in attainment with the current $PM_{2.5}$ annual NAAQS of 15 $\mu g/m^3$.[50] Under current EPA policy, all of those estimated deaths would be deaths of people living in areas that are protected with an "adequate margin of safety" from $PM_{2.5}$ risks.

Figure 6. Copy of Figure 5-15 from EPA's RIA for the Final EGU MACT Rule Showing that 94% to Nearly 100% of the $PM_{2.5}$ Co-Benefits in that RIA Are Due to Changes in Exposures to Annual Average Ambient $PM_{2.5}$ that Will Still Be Deemed Safe by EPA after Revising the $PM_{2.5}$ NAAQS.



---

49 EPA (2011c), Figure 5-15.

50 This fact can be inferred from the figure in the following way. The blue S-shaped curve in Figure 6 indicates on the vertical axis the percent of the RIA's $PM_{2.5}$ co-benefits estimate that is attributable to baseline $PM_{2.5}$ exposures at or below the $PM_{2.5}$ concentration on the horizontal axis. This is known as a "cumulative distribution." The point on the horizontal axis where the S-shaped curve just reaches 100% indicates the level of baseline $PM_{2.5}$ at or below which *all* (*i.e.*, "100%") of the estimated $PM_{2.5}$ co-benefits occur. As one can see, the vertical reading on the blue S-shaped curve is about 100% at 15 $\mu g/m^3$, which means that about 100% of EPA's estimated $PM_{2.5}$ co-benefits from the EGU MACT would be based on reductions in annual average $PM_{2.5}$ exposures that are already below the health-protective level of the current $PM_{2.5}$ standard.

Figure 6 also shows that if EPA had not extrapolated below the LML, about 89% of the estimated upper bound co-benefits of the EGU MACT would have been estimated as zero.[51] This is confirmed in the RIA, which reports that of the 11,000 estimated avoided premature deaths, only 1,200 are in areas where to baseline $PM_{2.5}$ concentrations are above the LML.[52]

The 15 μg/m^3 annual $PM_{2.5}$ NAAQS is under review now, and EPA staff (with CASAC's concurrence) has stated that it will consider revising the annual $PM_{2.5}$ NAAQS to somewhere in the range of 11 to 13 μg/m^3.[53] EPA's reluctance to set the annual $PM_{2.5}$ NAAQS anywhere below 11 to 13 μg/m^3 would appear to reveal the extent to which EPA does not itself feel that risk estimates below that range are credible; if it did view them as credible estimates, surely EPA and CASAC would be compelled to propose a lower $PM_{2.5}$ NAAQS.

Dotted red lines have been added to Figure 6 to show that between 94% and nearly 100% of the 11,000 $PM_{2.5}$ mortality benefits that EPA has estimated from the Final EGU MACT are attributed to estimated $PM_{2.5}$ concentrations below levels that will be deemed protective of the public health with an adequate margin of safety even if EPA revises the annual $PM_{2.5}$ NAAQS to a level within its recommended range of 11 μg/m^3 to 13 μg/m^3.[**] If those concentrations are safe, then it is not appropriate for EPA to be calculating them as co-benefits justifying non-PM regulations such as the EGU MACT rule. Thus those estimates are non-credible from a scientific standpoint.

Further, the remaining <1% to 6% of estimated mortality reductions (*i.e.,* ~0 to ~660 avoided premature deaths out of EPA's estimated 11,000) that are attributable to baseline concentrations between whatever the new $PM_{2.5}$ NAAQS level may be and the upper end of the x-axis (*i.e.*, at about 15 μg/m^3) should, if anything, be counted as direct benefits of the revised $PM_{2.5}$ NAAQS. They are overstated due to issues discussed above concerning the use in chronic exposure studies of recent ambient data rather than average ambient concentrations experienced over the cohort's lifetime, and due to EPA's presumption that there is no uncertainty in the causality of the statistical associations. However, even a more appropriately calculated lower estimate should not be considered a co-benefit for the EGU MACT or other non-PM regulation; it should be counted as a benefit of the $PM_{2.5}$ NAAQS. Placing them in the co-benefits category is tantamount to double-counting them, will be explained in Section 7.

---

[51] The LML for the upper bound is at the green vertical line in the figure.

[52] EPA (2011c), Table 5-20, p. 5-101.

[53] EPA, (2010a), p. 2-106.

[**] Note: A previous version of this report erroneously stated that the lower bound of the range was 84%.

7. EPA's Baselines and Reporting of Benefit and Costs Estimates for a Single Year Cause Double-Counting

This paper has already shown that:

- Co-benefits have no support in BCA theory,
- Use of $PM_{2.5}$ co-benefits in RIAs is undercutting the more general, practical objectives of RIAs,
- EPA's current calculations of $PM_{2.5}$ risks are unsupported by data or scientific principles, and
- The resulting magnitude of EPA's risk estimates are *prima facie* non-credible.

These points should give any thoughtful person reason to call for a stop to the practice of using co-benefits as the primary benefit justification for new rules, and to call for a stop to the estimation of $PM_{2.5}$ risks below the range of observed associations. However, there is yet another significant concern that merits discussion in this paper: EPA may be double-counting many of the $PM_{2.5}$ benefits as it moves from one RIA to the next.

EPA has argued that it does not double-count the $PM_{2.5}$ benefits because it includes all existing regulations in the baseline of emissions for each of its RIAs for another rule. If EPA were doing so thoroughly and consistently, double-counting would not be a concern. However, this is not the actual case.

First, many RIAs are being prepared simultaneously. In 2010, 6 final major CAA-related RIAs and at least 7 proposed RIAs were released for CAA-related rulemakings. In 2011, 7 final and at least 4 proposed CAA-related RIAs were released. This creates a constant source of confusion and potential for double-counting. For example, the RIA for the Proposed EGU MACT rule applied the Proposed CATR rule in *its* baseline, while the RIA for the Final EGU MACT rule applied the Final CSAPR rule in *its* baseline (simply because the CSAPR rule was finalized in the interim between the proposal and finalization of the EGU MACT rule). This change of baseline appears to be the primary reason why the EGU MACT rule's estimated $PM_{2.5}$-related co-benefits for mortality fell from 17,000 to 11,000 when the RIA for the final rule was released. This reveals the extent to which double-counting can occur due to seemingly small differences in what specific rules are included in an RIA's baseline. Moreover, *neither* of the EGU MACT RIAs' baselines included compliance with other existing regulations that have yet to be fully implemented, such as the new 1-hour SO_2 NAAQS, the new NO_2 NAAQS or even the 2006 daily or annual $PM_{2.5}$ NAAQS themselves. In fact, there is a very small amount of co-benefit in the RIA for the Final EGU MACT that is due to reduction of baseline $PM_{2.5}$ exceeding the 15 $\mu g/m^3$ annual NAAQS level.[54] Small as that amount is, it is direct evidence that double-counting can and does occur across all CAA RIAs as a group.

[54] See EPA (2011c), Figure 5-14, p. 5-100.

Clearly the development of an RIA's baseline plays a critical role in the estimates of benefits (and costs) of a rule. The significance of the baseline in determining the benefit and cost comparisons of an RIA has been pointed out by other reviewers of RIAs.[55] However, only one of the previous RIA critiques reviewed in this study has addressed the question of how a baseline affects $PM_{2.5}$ co-benefits. In a review of proposed and final RIAs for the first mercury rule, which was under development during the period 2001-2005, O'Neill takes issue with the fact that coincidental $PM_{2.5}$ reductions from mercury regulation did not appear in the RIA for the mercury rule proposal released in 2004 (*i.e.*, the proposal for what became the Clean Air Mercury Rule, CAMR, which was finalized in 2005). The reason the co-benefits did not appear in the proposed CAMR's RIA was because by the time that rule had been proposed, another new rule that was designed specifically to reduce those same $PM_{2.5}$ levels also was in its final stages (*i.e.*, the Clean Air Interstate Rule, CAIR). As a result, the CAIR rule was incorporated into the baseline for the final CAMR rule's RIA, and what might have once appeared to be co-benefits of CAMR were actually recognized as direct benefits of CAIR. O'Neill also criticizes the fact that EPA chose the single year 2020 to assess the incremental benefits of CAMR, which was the point in time at which the CAIR rule would have been fully implemented. The choice of year as well as the choice of placing CAIR in the baseline had the effect of attributing all of CAIR's benefits to CAIR, rather than allowing any of them to appear as co-benefits from CAMR.

One reasonable response to O'Neill's criticism is that since CAIR was a rule specifically designed to control $PM_{2.5}$, any $PM_{2.5}$-related benefits that might be derived from CAIR should rightfully appear as direct benefits in the RIA for CAIR. In fact, one could contend that they never should have been viewed as co-benefits of the CAMR (or any other possible non-PM rule) as long as the $PM_{2.5}$ NAAQS was in place, because throughout the period when the first mercury rule was being crafted, one could fully anticipate that the $PM_{2.5}$ NAAQS would require implementation. Even if CAIR had not been in development stages at that same time, any non-PM RIA, such as a mercury RIA, should have assumed full implementation of the $PM_{2.5}$ NAAQS anyway. That would have had the same effect as the simple and appropriate act of moving the $PM_{2.5}$-related benefits estimates off of the mercury rule's co-benefits ledger and onto the direct benefits ledger of a $PM_{2.5}$ rulemaking.

The point raised by O'Neill does highlight how the baseline can alter whether $PM_{2.5}$ changes will be counted as co-benefits to justify a non-PM rule or not. However, it does not address double-counting, which is another concern that arises from EPA's choices of RIA baselines. It is nearly impossible to keep the baselines straight when multiple regulations are in the proposal stage at the same time. However, a simple prescription can be applied to EPA's current practice that would help minimize the problem. If any RIA will be accounting for co-benefits from a pollutant that it does not directly address, such as those from $PM_{2.5}$ in a NESHAP rulemaking, then the baseline for that RIA should include "existing" rules, even if not fully implemented yet. It should also explicitly

[55] See, for example, Morgenstern in Chapter 3 of Morgenstern (1997) and O'Neill in Chapter 6 of Harrington *et al.* (2009).

incorporate any reasonably anticipated future standards and/or rulemakings that will deal with that pollutant before allowing any co-benefits from that pollutant to be counted in some unrelated RIA. This may be an uncertain task, but it can certainly be handled by at least considering two baselines:

> Baseline A: Include only the present level of current standards, but ensure that all of them are simulated as attained at their respective attainment deadlines.
>
> Baseline B: Incorporate reasoned assumptions regarding levels of new regulations that are known to be on the verge of modification, even if not yet promulgated or even proposed, and accounting for their future attainment deadlines. (For example, Baseline B would incorporate a reasoned estimate of the most stringent potential level of a tightened $PM_{2.5}$ NAAQS level that may be implemented within the next decade.)

This recommendation conforms with OMB guidance for performing RIAs, which states "When more than one baseline is reasonable and the choice of baseline will significantly affect estimated benefits and costs, you should consider measuring benefits and costs against alternative baselines."[56] Morgenstern also has highlighted the value of considering multiple baselines to highlight the role it plays in RIA findings.[57]

In neither of the alternative baselines should $PM_{2.5}$ co-benefits be calculated based on extrapolation of the concentration-response relationship below the data range over which its slope has been estimated. Indeed, the limit for extrapolation should not be based on the *most recent* LML among the cities in the database; the calculation of risks should be curtailed at a level reflective of the concentrations that the individuals in the cohort experienced on average across their lives.

Another change that is required in order to mitigate double-counting is that EPA stop reporting its benefits and cost estimates for a single year. Regulatory compliance costs and benefits should be considered on a present value basis. EPA's practice of reporting the costs and benefits for a single year can be misleading, especially if the baseline of emissions is declining after the single year selected. For example, $PM_{2.5}$, SO_2, and NO_2 can all be expected to keep declining after 2016 even in the absence of an EGU MACT rule because there are specific standards for each off those pollutants that will take effect between now and 2020. However, in the RIA for the EGU MACT, EPA reports its $PM_{2.5}$ co-benefits only for 2016, at a point in time where $PM_{2.5}$ levels should be on a steady decline through 2019 (which is the latest attainment date for the 2006 $PM_{2.5}$ NAAQS). Thus, there must be a declining trend in baseline risks, and hence the EGU MACT's $PM_{2.5}$ co-benefits soon will be much smaller than EPA reports in the RIA for the single year, 2016. In contrast, the annual costs that EPA reports for that rule will <u>not</u> be declining. Choosing 2016 as the single year for reporting the benefits and costs from the EGU MACT gives an overstated impression of the size of the benefits relative to their

---

[56] OMB (2003), p. 15.

[57] Morgenstern in Chapter 3 of Morgenstern (1997), p. 35.

costs. In fact, it is tantamount to double-counting of co-benefits, because the reported "annual co-benefits" in 2016 includes mortality and morbidity risks that will be gained (and attributed to) the $PM_{2.5}$ and other existing rules just a couple of years later. If benefits and costs <u>are</u> reported for only a single year, that year should be selected as one in which all other regulations in the baseline will be fully implemented.

8. Summary and Conclusions

The key findings of this paper, which is based on review of the benefit and cost evidence in RIAs for major CAA-based rules dating back to 1997, are:

- EPA is relying heavily on coincidental "co-benefits" from $PM_{2.5}$ reductions to create the impression of a benefit-cost justification for many air regulations that are not intended to address $PM_{2.5}$.
- Consideration of co-benefits for a separately-regulated pollutant is not supported by benefit-cost analysis (BCA) theory, and EPA's excessive reliance on them undercuts the broader practical value of RIAs, which is to provide structured and transparent information to help avoid and reduce redundant and ineffective regulations.
- In 2009, EPA vastly increased the levels of mortality risks that it attributes to $PM_{2.5}$ (and hence inflated its estimates of $PM_{2.5}$ benefits and co-benefits) simply by starting to assign risks down to background levels of $PM_{2.5,}$ below the most recent of the lowest measured levels (LMLs) in the epidemiological studies. This created non-credible estimates of risks from ambient exposures that are well within the safe range established by the $PM_{2.5}$ NAAQS.
- Identifying an appropriate lower bound below which risk estimates are not scientifically supported is not as simple as identifying the most recently-observed LML among cities in a chronic exposure epidemiological study. The exposure level to attribute to the observed mortality differences could be much earlier in time, given that such studies track mortality outcomes dating several decades back, based on people whose lifetime exposures date back to well before 1950.
- The decision to inflate the $PM_{2.5}$ risk estimates by presuming risks continue at an unchanged rate down to background has its greatest impact on co-benefits estimates because – for rules that do not address $PM_{2.5}$ directly – a much greater share of their incremental reduction of $PM_{2.5}$ will occur in areas that are already in attainment with the $PM_{2.5}$ NAAQS (and thus have $PM_{2.5}$ levels that EPA has deemed safe).
- Poor choices of baselines and EPA's practice of reporting benefits and costs for only a single year leads to double-counting of the $PM_{2.5}$-related benefits and co-benefits.

Based on the above observations, several recommendations and conclusions follow for aligning RIA methods with BCA principles, and for improving the quality and usefulness of RIAs that EPA produces. These include:

- Baselines in RIAs should incorporate implementation of all reasonably anticipated standards, even if formal rules to implement them are not yet in place. Estimates of benefits from $PM_{2.5}$ reductions will thus remain the direct benefits of $PM_{2.5}$-specific rules, and double-counting will be avoided. Any temporary benefits from early introduction of $PM_{2.5}$ reductions via a non-$PM_{2.5}$ rule should be identified as temporary only, and not reported as the co-benefits in a single, "snapshot" year, which implies those benefits would be permanent.
- Co-benefits from a pollutant that EPA already regulates under separate rulemakings should not be allowed to serve as a component of the total benefits reported in the Executive Summary of RIAs for rules that target different public health or welfare concerns. The current practice of doing so subverts the practical values of preparing RIAs, leads to unnecessary regulatory complexity, and incentivizes use of less credible methods of risk estimation. Co-benefits should not be reported as part of the total benefits estimates in an RIA, nor should they be included in public announcements of the benefits of a new regulation.
- EPA should stop using its scientifically non-credible method of extrapolating $PM_{2.5}$ risks below the LML. If EPA does persist in producing estimates of benefits or co-benefits from changes in concentrations below the LML, those estimates should be kept clearly separated from all other $PM_{2.5}$-related mortality benefits estimates, not be added to any other PM-related benefits estimates, and should be accompanied by a clear statement that there is no scientific evidence about the shape or existence of any concentration-response function in that range of ambient $PM_{2.5}$ concentrations.
- For benefits estimates based on $PM_{2.5}$ concentrations above the LML, EPA should be offering quantitative estimates of the uncertainties associated with its risk estimates, *taking account of the expanded confidence interval for estimates nearing the LML*. Confidence ranges based only on the statistical error of the slope estimate are not an appropriate measure of the statistical confidence of its predicted changes in health risk for reductions in $PM_{2.5}$, especially those well below the average $PM_{2.5}$ in the underlying epidemiological study.

In all, EPA's use of co-benefits in its RIAs should end for several reasons. It scares the public into believing that large numbers of people die prematurely were it not for implementation of new rules on pollutants for which EPA has not actually identified any current public health risk. EPA's use of co-benefits also gives EPA a shield to justify building a complex web of rules when EPA could (and is already obligated to) provide almost all of those purported health-protective benefits with just a single rule, if warranted: the $PM_{2.5}$ NAAQS. If large effects below the level of the $PM_{2.5}$ NAAQS were deemed credible, the appropriate policy remedy would be to tighten the $PM_{2.5}$ standard. The fact that EPA does not take this simple, streamlined approach hints at the degree to which the Agency realizes that its co-benefits calculations do not reflect true public health risks. But finally, promoting the goal of further $PM_{2.5}$ risk reductions by way of rules for totally different categories of emissions is just bad policy. This cannot possibly result in a cost-effective path to addressing a nation's clean air needs.

References

Arrow K. D., M. L. Cropper, G. C. Eads, R. W. Hahn, L. B. Lave, R. G. No11, P. R. Portney, M. Russell, R. Schmalensee, V. K, Smith, and R. N. Stavins. 1996. "Is There a Role for Benefit-Cost Analysis in Environmental, Health and Safety Regulation?" *Science*. Vol. 272, pp. 221-222.

EPA. 2011a. *Regulatory Impact Analysis of the Proposed Toxics Rule: Final Report*. March. Available at http://www.epa.gov/ttnecas1/regdata/RIAs/ToxicsRuleRIA.pdf.

EPA. 2011b. *Regulatory Impact Analysis of the Final Transport Rule.* June. Available at http://www.epa.gov/airtransport/pdfs/FinalRIA.pdf.

EPA. 2011c. *Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards*. EPA-452/R-11-011. December. Available at http://www.epa.gov/ttnecas1/regdata/RIAs/matsriafinal.pdf.

EPA. 2010a. *Policy Assessment for the Review of the Particulate Matter National Ambient Air Quality Standards*. EPA-452/R-11-003. Office of Air Quality Planning and Standards, Research Triangle Park, N.C. April. Available at: http://www.epa.gov/ttnnaaqs/standards/pm/data/20110419pmpafinal.pdf.

EPA. 2010b. *Quantitative Health Risk Assessment for Particulate Matter*. EPA-452/R-10-005. Office of Air Quality Planning and Standards, Research Triangle Park, N.C. June. Available at: http://www.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf.

Executive Order 12291. 1981. "Federal Regulation." 46 *Fed. Reg.* 13193, February 17. Available at: http://www.archives.gov/federal-register/codification/executive-order/12291.html.

Executive Order 12866. 1993. "Regulatory Planning and Review." 58 *Fed. Reg.* 51735, October 4. Available at: www.whitehouse.gov/omb/inforeg/eo12866.pdf.

Executive Order 13563. 2011. "Improving Regulation and Regulatory Review." 76 *Fed. Reg.* 3821, January 18. Available at: http://www.regulations.gov/exchange/sites/default/files/doc_files/President%27s%20Executive%20Order%2013563_0.pdf.

Hahn R. W. and P. M. Dudley. 2007. "How Well Does the US Government Do Benefit-Cost Analysis?" *Review of Environmental Economics and Policy*. Vol. 1(2), pp. 192-211.

Harrington, W., L. Heinzerling, and R. D. Morgenstern (eds.) 2009. *Reforming Regulatory Impact Analysis*. Resources for the Future, Washington DC. April.

Krewski D., R. T. Burnett, M. Goldberg, K. Hoover, J. Siemiatycki, M. Jerrett, M. Abrahamowicz, and W. H. White. 2000. *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality.* Special Report. Health Effects Institute, Cambridge, Massachusetts. July.

Krewski D., M. Jerrett, R. T. Burnett, R. Ma, E. Hughes, Y. Shi, Y, *et al*. 2009. *Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality*. HEI Research Report Number 140. Health Effects Institute, Boston, MA. May.

Laden, F., J. Schwartz, F. E. Speizer, and D. W. Dockery. 2006. "Reduction in Fine Particulate Air Pollution and Mortality." *American Journal of Respiratory and Critical Care Medicine*. Vol 173, pp. 667-672.

Morgenstern, R. D. (ed.) 1997. *Economic Analyses at EPA: Assessing Regulatory Impact*. Resources for the Future, Washington, DC.

OMB. 2003. *Circular A-4, Regulatory Analysis*. Available at: http:/www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/a-4.pdf.

Pope, C. A., III, R. T. Burnett, M. J. Thun, E. E. Calle, D. Krewski, K. Ito, G. D. Thurston. 2002. "Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to fine Particulate Air Pollution." *JAMA*. Vol. 287(9), pp. 11332-1141.

Smith, A. E. 2011. *Technical Comments on the Regulatory Impact Analysis Supporting EPA's Proposed Rule for Utility MACT and Revised NSPS (76 FR 24976)*. Prepared for and submitted to EPA EGU MACT Docket by Utility Air Regulatory Group (Attachment 13 in Docket Reference EPA-HQ-OAR-2009-0234-17775). August 3. Available at: http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2009-0234-17775.

Appendix A.

Sources of Cost and Benefit Information on CAA RIAs since 1997 that Were Reviewed in this Study

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
7/12/1997	1997	Ozone NAAQS *(To revise the 0.12 1hr standard to a 0.08 8hr standard)*	Ozone	Final RIA. See pp.13-2 for cost, pp. 12-64 for other co-benefits, pp. 12-1 for total benefits. Full attainment (F/A) numbers were estimated by scaling partial attainment (P/A) numbers for target benefits, PM co-benefits and PM mortality rates.	http://www.epa.gov/ttn/oarpg/naaqsfin/ria.html
7/16/1997	1997	$PM_{2.5}$ NAAQS *(To implement the first $PM_{2.5}$ standard at 15/65 annual/daily averages, supplementing the PM_{10} standard)*	$PM_{2.5}$	Final RIA. F/A numbers provided. Target benefit estimate comes from: low- 19.8-4.3 = 15.5; high- 109.7-8.1 = 101.6. Cost: pp.13-2. Other co-benefits: pp.12-64. Total benefits: pp.13-2. Mortality rates: see pp.12-43 for P/A numbers. F/A estimated by 15.5/14.5 * 3300 = 3528 for low; 101.6/96.1 * 15,600 = 16493 for high.	http://www.epa.gov/ttn/oarpg/naaqsfin/ria.html
8/14/1997	1997	Hospital/ Medical/ Infectious Waste Incinerators NSPS and EG	Many pollutants	Final rule FR. See pp. 29 for cost and benefits. All quantified benefits are PM.	http://www.gpo.gov/fdsys/pkg/FR-1997-09-15/pdf/97-23835.pdf#page=1
9/22/1997	1997	Highway Heavy-Duty Engines and Diesel Engines	NO_x, HC	Final RIA. See pp. 97 for cost.	http://www.regulations.gov/#!searchResults;rpp=10;po=0;s=EPA-HQ-OAR-2003-0012-0949
10/27/1997	1997	Pulp & Paper NESHAP	HAPs, VOC, TRS	Final rule FR. See pp. 120 for cost, pp. 126 for benefits. Included air related numbers only. Identified negative co-benefits (due to SO_2, CO, PM, NO_x increases).	http://www.gpo.gov/fdsys/pkg/FR-1998-04-15/pdf/98-9613.pdf#page=1
12/16/1997	1997	Locomotive Emission Standards	NO_x, PM	1998 Regulatory support document. See pp. 120 for NPV (7% discount rate) of the total cost, no annualized figure provided.	http://www.regulations.gov/#!searchResults;rpp=10;po=0;s=EPA-R03-OAR-2009-0956-0038

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
8/14/1998	1998	National VOC Standards for Architectural Coatings	VOC	Proposed rule and notice of public hearing FR. See pp. 6 for cost.	http://www.gpo.gov/fdsys/pkg/FR-1996-06-25/pdf/96-16009.pdf#page=1
8/27/1998	1998	Non-Road Diesel Engines	NO_x, HC	Final RIA. See pp. 72 for cost.	http://www.epa.gov/nonroaddiesel/frm1998/nr-ria.pdf
9/2/1998	1998	Revised NO_x Std: New Fossil-Fuel-Fired Steam Generating Units	NO_x	Insufficient information.	http://www.gpo.gov/fdsys/pkg/FR-1997-07-09/pdf/97-17950.pdf#page=1
9/23/1998	1998	NO_x SIP Call & Section 126 Petitions	NO_x	RIA. Ranges quoted are for low to high assumption sets. See pp. ES-3 for cost, pp. ES-6 for total benefits, pp. 4-50 for a breakdown of benefits, pp. 4-23 for mortality rates. All ozone related benefits are target benefits.	http://www.epa.gov/ttn/oarpg/otag/sipriav2.zip
3/1/1999	1999	Phase II Emission Stds for New Nonroad Spark-Ignition Non-Handheld Engines <19 kW	HC, NO_x	Final RIA. See pp. 7-15 for fuel savings (0.2 billion per year), pp. 7-13 for cost (0.132 billion) for a net cost savings of 0.0907.	http://www.epa.gov/otaq/equip-ld.htm
4/22/1999	1999	Regional Haze Rule	Visibility	RIA. See pp. 9-48 and 9-51 for benefits, pp. 10-20 for cost, pp. 9-55 and 9-61 for mortality rates. Reported 1.0 dv/10years levels, ranges quoted for benefits and mortality rates are the low and high ends across Case A and Case B. Total benefit is calculated accordingly.	http://www.epa.gov/ttnecas1/regdata/RIAs/rhria.zip
4/30/1999	1999	Final Section 126 Petition Rule	NO_x	RIA. See pp. ES-3 for cost, pp. ES-11 for benefits, pp. ES-7 for mortality rates.	http://www.epa.gov/ttnecas1/regdata/RIAs/126fn0.zip
12/21/1999	1999	Gasoline Sulfur Control Requirements	NO_x, PM	Final FR. See pp. 88 for benefits and mortality rate, pp. 86 for cost.	http://www.gpo.gov/fdsys/pkg/FR-2000-02-10/pdf/00-19.pdf#page=1

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
3/1/2000	2000	Phase 2 Emission Stds for New Nonroad Small Spark Ignition Handheld Engines <19 kW	HC, NO_x	Final RIA. See pp. 110 for annualized cost (.234-.284) and fuel savings (0.094).	http://www.epa.gov/otaq/equip-ld.htm
7/28/2000	2000	Control of Emissions from 2004 and Later Model Year Highway Heavy-Duty Engines	Many pollutants	RIA. See pp. 89 and 106 for cost.	http://www.regulations.gov/#!searchResults;rpp=10;po=0;s=EPA-HQ-OAR-2003-0012-0950
10/19/2000	2000	Protection of Stratospheric Ozone Reductions	Stratospheric O_3	RIA. See pp. 4 for cost.	http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2008-0009-0012
12/21/2000	2000	Heavy-Duty Engine & Diesel Fuel Sulfur Control Reqm 2007	NO_x, PM	Final RIA. See pp. xvi for cost and benefits, pp. xvii for mortality rates.	http://www.epa.gov/oms/highway-diesel/regs/exec-sum.pdf
9/13/2002	2002	Emissions from Nonroad & Recreational Spark-Ignition Engines	NO_x, VOC, CO, PM	Insufficient Information.	http://www.gpo.gov/fdsys/pkg/FR-2001-10-05/pdf/01-23591.pdf#page=1
8/27/2003	2003	PSD & NSR: Routine Maintenance and Repair	all	Insufficient Information.	http://www.epa.gov/fedrgstr/EPA-AIR/2003/October/Day-27/a26320.htm
2/26/2004	2004	Stationary Reciprocating Internal Combustion Engine NESHAP	HAPs	RIA. See pp. ES-5 for cost, pp.8-40 for mortality rates (50% NO_x emission reduction), pp. 8-45 for benefits. Assuming the social cost of 0.255 on pp. ES-7 is a typo. Mortality rates are prorated assuming 25% NO_x emission reduction. Ozone and PM_{10} benefits are regarded as "other benefits".	http://www.epa.gov/ttnecas1/regdata/RIAs/RICERIA-finalrule.pdf
2/26/2004	2004	Plywood & Composite Wood Products NESHAP	organic HAPs	RIA. See pp. ES-1 for cost.	http://www.epa.gov/ttnecas1/regdata/RIAs/pcwp-finalruleRIA.pdf

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
2/26/2004	2004	Automobile & Light-Duty Vehicle Manufacturing NESHAP	HAPs	RIA. See pp. ES-5 for cost. Did mention ozone and PM co-benefits from VOC reduction, but did not quantify.	http://www.epa.gov/ttnecas1/regdata/RIAs/autolightdutyRIAfinaltotal.pdf
2/26/2004	2004	Industrial Boilers & Process Heaters NESHAP	HAPs, HCl, metals	RIA. See pp.ES-1 for cost, pp. 10-45 for mortality rates and benefits.	http://www.epa.gov/ttnecas1/regdata/RIAs/indboilprocheatfinalruleRIA.pdf
5/7/2004	2004	Non-Road Diesel Rule	PM, NO_x, HAPs	RIA. See pp.9-42 to 43 for mortality rates and benefits, pp. 9-52 for costs. Other co-benefits include 2.5-3.4 (pp. 9-27) reductions in unpleasant odors, and 2.15 PM welfare benefits.	http://www.epa.gov/nonroad-diesel/2004fr.htm#ria
3/10/2005	2005	Clean Air Interstate Rule	NO_x,SO_2 *(SO_2 as precursor of amb. $PM_{2.5}$)*	RIA. See pp. 1-2 for benefits and cost, pp. 1-4 for mortality rates.	http://www.epa.gov/cair/pdfs/finaltech08.pdf
3/15/2005	2005	Clean Air Mercury Rule	Hg	RIA. See pp. 11-14 for target benefits, pp.7-13 for cost, pp.12-8 for $PM_{2.5}$ co-benefits and mortality rates.	http://www.epa.gov/ttn/ecas/regdata/RIAs/mercury_ria_final.pdf
6/15/2005	2005	Clean Air Visibility Rule/BART Guidelines	Visibility	RIA. See pp. 1-3 for cost and benefits, pp. 1-5 for mortality rates.	http://www.epa.gov/oar/visibility/pdfs/bart_ria_2005_6_15.pdf
3/15/2006	2006	Inclusion of Delaware and New Jersey in CAIR	NO_x,SO_2 *(SO_2 as precursor of amb. $PM_{2.5}$)*	Insufficient Information.	http://www.gpo.gov/fdsys/pkg/FR-2005-05-12/pdf/05-5520.pdf#page=1
3/15/2006	2006	Sec. 126 from NC to Reduce Interstate Transport of PM & O3; FIPs to Reduce Interstate Transport of PM & O3; Revisions to CAIR; Revisions to Acid Rain Program	NO_x,SO_2 *(SO_2 as precursor of amb. $PM_{2.5}$)*	Insufficient Information.	http://www.gpo.gov/fdsys/pkg/FR-2005-08-24/pdf/05-15529.pdf#page=1

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
6/28/2006	2006	Stationary Compression Ignition Internal Combustion Engine NSPS	many	RIA. See pp. 1-2 for cost, pp. 6-4 for benefits. Direct PM benefit is recorded as target benefit. Benefits from NO_x and SO_2 are recorded as PM co-benefits. Premature mortality prevention accounts for 90% of the total benefit, but cannot be quantified (pp.6-5). Benefits are quoted at 3% discount rate (pp.6-4).	http://www.epa.gov/ttnecas1/regdata/RIAs/ci_nsps_ria_reportfinal06.pdf
9/21/2006	2006	$PM_{2.5}$ NAAQS *(To revise from 15/65 annual/daily averages, to 15/35)*	$PM_{2.5}$	RIA. See pp. ES-9 to 10 for costs and benefits, pp. 5-100 for mortality rates.	http://www.epa.gov/ttnecas1/regdata/RIAs/Executive%20Summary.pdf http://www.epa.gov/ttnecas1/regdata/RIAs/Chapter%205--Benefits.pdf
2/8/2007	2007	Control of HAP from mobile sources	HAPs	Final RIA. See pp. 12-20 for mortality rate (Pope et al. only), pp. ES-10 for PM benefits, pp. ES-11 for cost.	http://www.epa.gov/otaq/regs/toxics/fr-ria-sections.htm
3/28/2007	2007	Clean Air Fine Particle Implementation Rule	$PM_{2.5}$	Insufficient Information.	http://www.gpo.gov/fdsys/pkg/FR-2005-11-01/pdf/05-20455.pdf#page=1
2/14/2008	2008	Control of Emissions form New Locomotives & Marine Diesel Engines <30 L per Cylinder	PM, NO_x	RIA. See pp. 6-52 for cost and benefits, pp. 6-44 for PM mortality, pp. 6-46 for a breakdown of benefits.	http://www.epa.gov/oms/regs/nonroad/420r08001a.pdf
3/12/2008	2008	Ozone NAAQS *(To revise the 0.08 8hr standard to 0.075 8hr standard)*	Ozone	RIA. See pp.ES-3 for cost and visibility benefits, pp. 6-62 for target benefits, pp. 6-48 for mortality rates, pp. 6-64 for PM co-benefits.	http://www.epa.gov/ttnecas1/regdata/RIAs/452_R_08_003.pdf

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
8/18/2008	2008	Control of Emissions form Non-road Spark-Ignition Engines & Equipment	VOC, NO_x, PM,CO	Final rule FR. See pp. 122 for mortality rates, pp. 124 for a breakdown of benefits, pp. 128 for cost and total benefits. Target benefit is all PM; other benefits include visibility and ozone benefit.	http://www.gpo.gov/fdsys/pkg/FR-2008-10-08/pdf/E8-21093.pdf#page=1
10/15/2008	2008	Lead (Pb) NAAQS	Pb	RIA. See pp. ES-11 for cost and benefits.	http://www.epa.gov/ttnecas1/regdata/RIAs/finalpbria.pdf
12/10/2008	2008	Petroleum Refineries NSPS	SO_2, NO_x, PM, VOC	RIA. See pp. 7-6 for benefits, pp. 7-12 for cost. Direct benefit is PM benefit, PM 2.5 co-benefits include benefits from reductions in PM precursors.	http://www.epa.gov/ttnecas1/regdata/RIAs/finalpetroleumrefineriesnspsria43008.pdf
9/16/2009	2009	GHG Mandatory Reporting Rule	GHGs	Final rule FR. See pp. 105 for cost.	http://www.epa.gov/climatechange/emissions/notices.html
12/17/2009	2009	Control of Emissions from New Marine Compress'n-Ign Engines >30 L per Cylinder	NO_x	Final rule FR. See pp. 69 for benefits and cost, pp. 67 for PM and Ozone ("other") benefit, pp. 65 for mortality rates.	http://edocket.access.gpo.gov/2010/pdf/2010-2534.pdf
2/17/2010	2010	Reciprocating Internal Combustion Engines NESHAP - Compression Ignition	Organic, metal HAPs	RIA. See pp.1-1 for cost, pp.7-1 for $PM_{2.5}$ co-benefits, and pp.7-8 for mortality rates.	http://www.epa.gov/ttnecas1/regdata/RIAs/CIRICENESHAPRIA2-17-10cleanpublication.pdf
3/31/2010	2010	EPA/NHTSA Joint Light-Duty GHG Emission Stds & CAFES	GHGs	Final FR. See pp. 213 for benefits and cost, pp. 206 for PM benefits, pp. 205 for mortality rates,	http://www.gpo.gov/fdsys/pkg/FR-2010-05-07/pdf/2010-8159.pdf#page=1
5/12/2010	2010	Greenhouse Gases PSD and Tailoring Rule	GHGs	RIA. See pp.18 for cost. No benefits quantified.	http://www.epa.gov/ttnecas1/regdata/RIAs/riatailoring.pdf

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
6/2/2010	2010	SO_2 NAAQS *(To set a 75 ppb 1-hr standard)*	SO_2	See pp. ES-9 for cost and benefits, pp. 5-30 for mortality rates. Negative cost indicates regulatory relief benefit. Numbers quoted are for Step 1, 25000 tpy.	http://www.epa.gov/ttnecas1/regdata/RIAs/fso2ria100602full.pdf
8/6/2010	2010	Portland Cement Manufacturing Industry NSPS & NESHAP Amendment	HC, HAPs, PM	RIA. See pp. 1-2 for cost, pp. 6-1 for $PM_{2.5}$ co-benefits, pp. 6-15 for mortality rates. All benefits of the rule are from NESHAP portion. NESHAP does not target $PM_{2.5}$ or PM_{10} mass, but all the benefits of the NESHAP (and of the NESHAP + NSPS) are $PM_{2.5}$ ambient concentration. Therefore, all are co-benefits.	http://www.epa.gov/ttnecas1/regdata/RIAs/portlandcementfinalria.pdf
8/10/2010	2010	Existing Stationary Compression Ignition Engines NESHAP	HAPs	Final RIA. See pp. 7-10 for mortality rates, pp. 7-9 for benefits, pp. 1-1 for costs.	http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2008-0708-0571
2/21/2011	2011	Industrial, Comm'l, and Institutional Boilers NESHAP	HAPs	Final FR. See pp. 27 for benefits and mortality rates, pp.29 for cost.	http://www.gpo.gov/fdsys/pkg/FR-2011-03-21/pdf/2011-4493.pdf#page=1
2/21/2011	2010	Indus'l, Comm'l, and Institutional Boilers & Process Heaters NESHAP	HAPs	RIA. See pp.1-1 for cost, pp.6-1 for $PM_{2.5}$ co-benefits pp. 6-8 for mortality rates.	http://www.epa.gov/airquality/combustion/docs/boilerria20100429.pdf
2/21/2011	2011	Comm'l & Indus'l Solid Waste Incineration Units NSPS and Emission Guidelines	CO, Pb, HAPs	RIA. See pp. 1-1 for cost, pp. 1-2 for benefits, pp. 5-10 for mortality rates.	http://www.epa.gov/ttnecas1/regdata/RIAs/CISWIRIAfinal110221_psg2.pdf
7/1/2011	2011	Cross State Air Pollution Rule (CSAPR)	NO_x,SO_2 *(SO_2 as precursor of amb. $PM_{2.5}$)*	RIA. See pp.1 for mortality rates, pp.2 for cost, table 1-3 on pp. 6 to 7 for benefits. Other co-benefits include visibility (4.1) + social cost of carbon (0.6) = 4.7. Sum up all the remaining items to get target benefits.	http://www.epa.gov/airtransport/pdfs/FinalRIA.pdf

Concluded Date	Year of Document Used	RIA Name	Target Pollutant	Document Type / Page References	URL
8/8/2011	2011	Control of GHG from Medium & Heavy-Duty Vehicles	GHGs	Final RIA. See pp. 9-45 for benefits and cost, net cost = 24.7 (technology cost) - 166.5 (fuel savings), pp. 8-86 for PM benefit and pp.8-81 for mortality rates. Benefit range is derived from different assumptions for social cost of carbon in 2012.	http://www.epa.gov/otaq/climate/documents/420r11901.pdf
9/6/2011	2010	Reconsideration of Ozone NAAQS	Ozone	RIA. F/A (75 ppb) numbers quoted. See pp. S1-4 for cost, pp.3-11 for mortality rates and benefits, pp.3-6 for visibility. Target benefit refers to ozone benefit here.	http://www.epa.gov/ttnecas1/regdata/RIAs/s1-supplemental_analysis_full.pdf
12/16/2011	2011	EGU MACT Rule	Hg, HAPs	RIA. See p. ES-2 for cost; pp. ES-6/7 for direct benefits, $PM_{2.5}$ co-benefits, & social cost of carbon. SCC is quoted at 3% discount rate. See p. ES-5 for mortality counts.	http://www.epa.gov/ttnecas1/regdata/RIAs/matsriafinal.pdf
N/A	2011	Mercury Cell Chlor Alkali Plant Mercury Emissions NESHAP	Hg	RIA. See pp.1-2 for cost and total benefit, pp. 5-1 for $PM_{2.5}$ co-benefits, pp. 5-11 for mortality rates, and pp. 5-16 for the social cost of carbon (other co-benefits).	http://www.epa.gov/ttnecas1/regdata/RIAs/mercurycell.pdf
N/A	2011	Oil and Natural Gas Industry NSPS & NESHAP Amendment	VOC, SO_2, HAPs, Methane	RIA. See pp.1-4 and pp. 1-6 for costs.	http://www.epa.gov/ttnecas1/regdata/RIAs/oilnaturalgasfinalria.pdf
N/A	2011	Sewage Sludge Incineration Units NSPS & Emission Guidelines	Hg	RIA. See pp. 3 for cost and benefit, pp. 5-11 for mortality rates.	http://www.epa.gov/ttnecas1/regdata/RIAs/ssiria110201.pdf

Enclosure 2

NERA
ECONOMIC CONSULTING

Technical Comments on EPA's Regulatory Impact Analysis for the Proposed Repeal of the Clean Power Plan

Prepared for:

Utility Air Regulatory Group

American Coalition for Clean Coal Electricity

April 26, 2018

Authors[*]

Anne E. Smith, Ph.D., Managing Director

Scott J. Bloomberg, Associate Director

* The opinions expressed herein do not necessarily represent the views of NERA Economic Consulting or any other NERA consultants.

NERA Economic Consulting
1255 23rd Street NW
Washington, DC 20037
Tel: +1 202 466 3510
Fax: +1 202 466 3605
www.nera.com

Disclaimer

This report relies in large part upon public information and data. Unless otherwise indicated, NERA Economic Consulting has not independently verified this information and data, but assumes for purposes of this exercise that they are reliable. However, we make no representation as to the accuracy or completeness of such information. This report may contain predictions, which are subject to inherent uncertainties. NERA Economic Consulting accepts no responsibility for actual outcomes.

The opinions in this report are expressed only for the purpose stated herein and as of the date of this report. Unless separately contracted to do so, NERA Economic Consulting assumes no obligation to revise or update this report to reflect changing events or conditions.

Any decisions made in connection with any 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

List of Figures and Tables

I. INTRODUCTION AND EXECUTIVE SUMMARY

This report comments on technical aspects of EPA's October 2017 Regulatory Impact Analysis ("RIA") for the proposed repeal of the 2015 Clean Power Plan ("CPP"). The October 2017 RIA is referred to herein as the "CPP Repeal RIA" or "this RIA." Like all RIAs, this RIA is designed to describe the benefits and costs of a proposed regulatory action, provide estimates of those deemed quantifiable, and document the basis for those estimates. In part because the proposed regulatory action at issue is the repeal of a regulation that was promulgated recently but has never been implemented, it relies significantly on the estimated benefits, costs, and modeling presented in the RIA for that underlying rule—the final CPP (which were documented in the RIA that we will refer to herein as the "2015 CPP RIA").

As a preliminary matter, we find that this RIA's analysis methods and its presentation of results create a very useful document for policymakers tasked with determining whether the proposed action is sound public policy, consistent with the intended scope and purpose of RIAs. As such, it serves as a good model for future air regulation RIAs, albeit we recommend several additional elements in our comments herein that we believe will further enhance its utility in policy deliberations. Below is an outline of the full contents of these technical comments on the RIA, while the remainder of this section provides a high level summary of its key findings and our recommendations for further improvement:

- Overview of this RIA's contents and findings, and their relationship to the 2015 CPP RIA's findings (Section II);
- Criteria pollutant co-benefits (Section III);
- Social cost of carbon ("SCC") (Section IV);
- Corrections to estimates of annual compliance costs (Section V.A);
- Annual versus present value comparisons of benefits and costs (Section V.B); and
- Specific suggestions for additional analyses useful to conduct for the final (Section VI).

Because EPA's RIAs for other types of regulations adopted under the Clean Air Act ("CAA") often use similar methodologies, many points in these technical comments will likely be relevant for RIAs for future rulemakings.

A. This RIA Is More Robust, Expansive, Complete, and Transparent

We applaud EPA's efforts in the CPP Repeal RIA to provide transparency and an in-depth analysis and explanation of potential sensitivities that might influence outcomes of the proposed regulatory action. This RIA: (a) provides exceptionally detailed estimates of the potential benefits and costs of the proposed action; (b) provides new types of sensitivity analyses for fine particulate matter ($PM_{2.5}$) co-benefits; (c) provides estimates of potential climate benefits in both domestic and global terms; (d) analyzes the proposed action's potential net benefits using a range of discount rates consistent with RIA guidance; and (e) thoroughly describes the uncertainties associated with the CPP and its proposed repeal. As we will explain in the full body of these comments, each of these is an important component of the desired policy-relevant content of an RIA, and thus helps make it a useful resource document for policymakers and for policy deliberations generally.

The CPP Repeal RIA also provides new types of analyses to comply with Executive Order 13771 signed on January 30, 2017, including the present values of estimates of avoided regulatory compliance costs, forgone benefits, and net benefits. As these comments will further explain, the presentation of present values also expands the decision-relevant content of this RIA, and would be a beneficial addition even if not needed to meet requirements of Executive Order 13771.

In addition to the enhanced information provided in the CPP Repeal RIA, it announces EPA's plan to perform updated modeling using the Integrated Planning Model ("IPM") and also to potentially perform updated full-scale gridded photochemical air quality modeling to support the air quality benefits assessment. Such updated analyses would further expand available relevant information, and we provide suggestions for such modeling in these comments as well.

In summary, by transparently identifying a wide range of potential cost and benefit outcomes, this RIA enables policymakers to develop for themselves a broad as well as nuanced understanding of the issues and uncertainties associated with the proposed regulatory action of repealing the CPP. This will help ensure this complex policy decision is well-informed and substantiated by robust analysis.

B. Key Changes in the CPP Repeal RIA

Consistent with this regulatory proposal being a repeal of the rule for which the 2015 CPP RIA was prepared, comparisons of the two documents are unavoidable. The most salient change is the necessary reversal of labeling of benefits and the costs between the two RIAs. That is, what was a benefit of the CPP is now a forgone benefit in this RIA; what was a cost of the CPP is now an avoided cost in this RIA. This reversal of labeling can be confusing to readers attempting to make a cross-comparison, but ultimately, as we show, it has no substantive impact on the respective net benefit conclusions of the two RIAs under the same assumptions about uncertain outcomes. More important in an RIA is how it serves the objective of providing a range of potential net benefit outcomes that reflect broad uncertainties about the potential benefits and costs of a regulatory action. To that end, this RIA provides substantial disaggregation of its benefit and cost estimates, provides estimates of benefits and costs for many alternative set of assumptions ("sensitivity cases"), and provides extended evaluation of uncertainties in both benefits and costs. The points below summarize key details that this RIA provides, and our key recommendations for improvement.

Avoided Costs

1. The CPP Repeal RIA helpfully disaggregates two different forms of economic impact (*i.e.*, avoided compliance costs and the value of forgone energy efficiency savings) that were presented as one aggregated (*i.e.*, net) cost estimate in the 2015 CPP RIA. By disaggregating these impacts, policymakers can see that there are two large but offsetting phenomena behind what appeared in the 2015 CPP RIA as a relatively small net compliance cost. Given that these two types of dollar impacts are borne by different entities in the economy, and that their estimation is subject to different sources and degrees of uncertainty, such disaggregation better informs policymakers of both distributional and uncertainty aspects of the estimated overall net benefits of the action.

2. We recommend that EPA include additional measures of dollar impacts on consumers beyond just electricity rates and bills, as the ones reported now are incomplete. For example, it would be useful to show total spending on energy services, which would include changes in spending on non-electric sector natural gas and consumer direct spending (non-rebated) on energy efficiency.

Forgone Co-Benefits

1. We recommend that future EPA RIAs, to the extent they estimate co-benefits of reducing criteria pollutants that are not the subject of the proposed action, follow the lead of the CPP Repeal RIA by excluding such estimates from the primary benefit-cost analysis summary tables. Criteria pollutants are already controlled under the stringent legal requirements of CAA Section 109, and keeping the co-benefits estimates separate will enable policymakers to focus on the goals of the proposed regulation in question. Co-benefits can be addressed as sensitivity cases, in the manner done in this RIA.

2. The CPP Repeal RIA provides additional information on the uncertainty of the potential level of co-benefits by including sensitivity analyses showing the effect on forgone $PM_{2.5}$ co-benefits of using different assumptions about the air quality level above which criteria pollutants' risks may benefits occur. Specifically, the RIA now includes information showing the implications of the possibility that there are no forgone co-benefits in locations where air quality levels are 1) already below the current $PM_{2.5}$ National Ambient Air Quality Standard ("NAAQS"), and/or 2) below the lowest measured levels ("LML") of the epidemiological studies on which risk relationship assumptions are based.

3. We recommend that when co-benefits are incorporated into secondary summaries of potential net benefits (such as Table 4-2 of the CPP Repeal RIA), net benefits estimates for all alternative co-benefits sensitivity cases be presented in a single table so that the degree of sensitivity can be more readily understood by a reader.

4. The uncertainty and inconsistency issues that have been raised for $PM_{2.5}$ risk estimates apply equally strongly to those for ozone. We therefore recommend that each co-benefit sensitivity case be revised to include an adjustment to the ozone risk calculation that is directly analogous to the adjustment being made to the $PM_{2.5}$ risk calculation.

5. We note that there is a large change in the confidence associated with the two available estimates that impose a cutpoint 1) at the NAAQS, and 2) at the LML. Given that there is also a large change in the associated forgone co-benefits estimates, an additional sensitivity case between these two cutpoints would provide useful information about whether there is significant non-linearity in the sensitivity over this important interval in potential cutpoint values. We therefore recommend that EPA include at least one more cutpoint sensitivity case for the forgone co-benefits, which would be at a cutpoint that is just slightly below the NAAQS level, such as at 10 $\mu g/m^3$ for $PM_{2.5}$.

6. We endorse the Agency's stated intention to conduct new co-benefits sensitivity estimates using full photochemical grid modeling. In the event such modeling is not conducted, however, we recommend that EPA continue to use the existing photochemical grid modeling (of the Proposed CPP scenario, which was used to develop cutpoint sensitivities for this RIA) to recompute the benefit-per-ton values to reflect more logically-consistent estimates of forgone co-benefits at the different cutpoints. It is our conclusion that a more logically-consistent incorporation of cutpoints into the benefit-per-ton estimates (in the manner described in detail in Section III.E) will have more quantitative impact than revising the photochemical modeling of the control scenario to more precisely reflect the Final CPP's limits.

7. We recommend that county-level maps of projected SO_2 and NO_x emissions reductions ($PM_{2.5}$ and ozone precursors) and/or projected changes in air quality across the U.S. be presented to provide more information about the distribution of estimated co-benefits. If these are compared to projected baseline concentrations of $PM_{2.5}$ and ozone in the same compliance year, they can provide more insight to readers about why co-benefits are sensitive to cutpoint assumptions.

Forgone Climate Benefits

1. We concur with the decision to report domestic and non-U.S. climate benefits separately and provide additional rationales to support this decision.

2. We provide reasons why a discount rate higher than the consumption rate of interest – which results in lower estimates of potential forgone climate benefits – is reasonable to include in a sensitivity analysis of SCC. Related to this point, we recommend inclusion of an additional sensitivity case using a 5% discount rate.

3. We recommend supplemental ways to address concerns with intergenerational equity that do not require *ad hoc* adjustments to the discount rate, and provide an example of one such supplemental evaluation.

4. We recommend that EPA better communicate the timing of forgone climate benefits using the government's SCC modeling, which shows that most of the benefits are actually projected to occur after 2080.

5. We recommend that sensitivity analyses to additional non-scientific (*i.e.*, "framing") assumptions that strongly affect forgone climate benefits estimates be reconsidered in developing SCC values for use in future RIAs. These include: 1) the effect of choice of time horizon on confidence in the resulting climate impact estimates; and 2) the appropriate choice of baseline future (long-term) emissions projections when valuing near-term incremental emission reduction actions.

C. Despite the Improvements Noted in This RIA, Three of Its Analysis Methods Systematically Understate the Net Benefits of Repealing the CPP

The analysis of and communication about the uncertainties in the calculations of components of net benefits in the CPP Repeal RIA is commendable. Nevertheless, we have also identified three methodological concerns that lead to systematic understatement of the potential net benefits of repealing the CPP. That is, the understatement exists in all of the alternative net benefits estimates that can be derived from information in this RIA. These three aspects of the computations that we recommend be corrected are described below.

1. **The potential net benefits of CPP repeal are understated by several billion dollars in 2020 and 2025 because the RIA improperly understates the avoided costs of energy efficiency improvements in those years under the CPP.** The 2015 CPP RIA's cost analysis assumed that consumers would undertake certain energy efficiency measures to comply with the rule, subsidized by utility co-funding (*e.g.,* rebates). That RIA estimated that regulated utilities would recoup their outlays for those subsidies over a period of 20 years, adjusting electricity rates upwards in 2020 and 2025 by only annualized amounts of the outlays that would actually be expended in those years. In fact, cost recovery for such energy efficiency programs is fully embedded in the next year's electricity rates, and the 2015 CPP RIA should have reported the estimated *actual* dollar expenditures in the 2020 and 2025 compliance years when reporting CPP compliance cost for those years. The RIAs' use of only an *annualized* portion of that spending improperly assumes that society spreads those costs over the investments' useful life, and thereby omits a substantial portion of that actual cost from the calculations of net societal benefits in individual years. The CPP Repeal RIA does not correct this error initiated in the 2015 CPP RIA, and thus it substantially understates the net benefits from repealing the CPP in the years 2020 and 2025 in every alternative net benefit estimate.

2. **The potential net benefits of repeal (when including consideration of co-benefits) are significantly understated because the RIA calculations overstate forgone $PM_{2.5}$ co-benefits in the "cutpoint" sensitivity cases.[1]** When calculating co-benefits estimates for a given assumed cutpoint, EPA simply zeroes out all risks estimated for populations living in areas below that cutpoint concentration. This is intended to indicate the sensitivity of the risk estimates to the possibility that the presumed health effects concentration-response relationship does not continue down to zero, but may cease to exist at some ambient concentration.[2] The various assumed cutpoints are intended to represent alternative possibilities on where the risk relationship might cease, with decreasing confidence attributed to the risk estimates with lower assumed cutpoints. For such sensitivity cases, logical consistency would also suggest that risk would only start to rise above zero as concentrations rise above the cutpoint where the concentration-response relationship is assumed to begin to exist.[3] Thus, estimates of risks for populations living in locations above the assumed cutpoint should also be decreased as a result of a cutpoint assumption (and increasingly so for higher cutpoint assumptions). However, the CPP Repeal RIA's sensitivity cases leave the risks estimated in locations above the assumed cutpoints at exactly the same level as in the zero cutpoint case. This is logically inconsistent with the notion that the concentration-response relationship may not continue below the cutpoint, and results in an overstatement of forgone co-benefits in each of the cutpoint cases (which is particularly large for the higher-confidence co-benefits cases). Hence it also results in understatement of the net benefits of repealing the CPP when including co-benefits in a net benefits calculation.

3. **The RIA further understates the potential net benefits of repeal (when including consideration of co-benefits) by not including ozone risk uncertainties analogous to those for $PM_{2.5}$ in its cutpoint sensitivity cases.** When calculating co-benefits estimates for different cutpoint concentrations (as described in the prior point), EPA makes the adjustment only to the forgone $PM_{2.5}$ co-benefits, even though a substantial portion of the

[1] EPA uses the term "cutpoint" to refer to an ambient pollutant concentration below which the risk models are programmed to assume zero risk to human health. That is, although a non-zero risk is calculated down to zero concentrations using EPA's assumed concentration-response functions, EPA's cutpoint risk calculations then simply zero-out the risks estimated in any locations where baseline concentrations are less than the assumed cutpoint concentration.

[2] This uncertainty regarding whether the concentration-response relationship continues to exist at low ambient concentrations has been a central feature of Administrators' justifications for setting the $PM_{2.5}$ and ozone NAAQS levels through past NAAQS review cycles (CPP Repeal RIA at p. 50; for additional detail, see also Smith, 2016, pp. 1738-1739).

[3] That is, if population-wide health risk is assumed to be zero at and below a given cutpoint concentration, one should not expect population-wide health risk to instantly jump to a non-trivial level when the ambient concentration is only trivially higher than that cutpoint value, yet this is what EPA's cutpoint sensitivity cases assume. A logically-consistent risk model involving a cutpoint would assume public health risks only start to rise above zero as exposures exceed the cutpoint level where risks are assumed to be zero, with the amount of risk elevation being determined by the degree to which the exposure level exceeds that cutpoint concentration (*i.e.*, by the location's ambient concentration *minus* the cutpoint).

reported forgone co-benefits is attributed to ozone. Ambient ozone risk estimates face analogous issues in the confidence with which they are calculated at lower ozone concentrations. By failing to include ozone cutpoints in its co-benefits sensitivity cases, EPA further overstates forgone co-benefits in every one of the cutpoint cases, and thus further understates the net benefits of repealing the CPP when including co-benefits in a net benefits calculation.

D. Next Steps

The CPP Repeal RIA announces EPA's plan to develop additional refinements of its modeling of this regulatory action. We have four suggestions for additional analyses that would further the objective of understanding the impacts of the CPP repeal and the uncertainties regarding those impacts. These are listed below, and discussed in more detail in later sections of this document.

1. To help EPA better quantify the ranges of potential avoided compliance costs and forgone emission reductions, we suggest several new IPM runs. The categories of our recommendations include: 1) general updates (*e.g.*, database of generators, changes in electricity demand projections, natural gas supply/demand fundamentals, coal supply/demand fundamentals, and new technology costs and characteristics); 2) economic and technological change uncertainties (*e.g.*, natural gas supply, new technology costs and characteristics, and electricity demand); and 3) demand-side energy efficiency cost and availability.

2. We recommend evaluating at least one mass-based and one rate-based policy case using a computable general equilibrium model to gain a better understanding of whether the compliance costs based on the IPM model may be understated or overstated.

3. We endorse the Agency's expressed intention to conduct refined co-benefits sensitivity estimates using photochemical grid modeling in future iterations of the CPP Repeal RIA. However, we also note that the corrections to the co-benefits sensitivity cases described in point 2 of the prior section can still be corrected even if one is limited to results from the existing photochemical grid modeling.

4. We also recommend that the photochemical grid modeling outputs (or, more specifically, the air quality grids that are BenMAP inputs) be made available to the public to support comments on that additional work. This recommendation stands whether EPA continues to rely on prior modeling or conducts new model runs.

II. SUMMARY OF KEY CHANGES IN RIA ESTIMATES AND APPROACH

A. Comparing Methods and Results in the 2015 CPP and 2017 CPP Repeal RIAs

Unsurprisingly, the most salient change in the CPP Repeal RIA compared to the 2015 CPP RIA is a reversal of the benefits and costs of the regulatory action, consistent with the idea that the proposed regulatory action is to repeal the 2015 regulatory action. Most of the changes simply redefine what the 2015 CPP RIA characterized as benefits as costs or forgone benefits in the CPP Repeal RIA, and what was characterized as costs in the 2015 CPP RIA as benefits or avoided costs in the CPP Repeal RIA.

To better understand this reversal, we present Table 1, which identifies the key elements of the benefit-cost comparison, and how they are categorized in the two RIAs. The only item for which EPA did not undertake a simple reversal is demand-side energy efficiency ("DSEE"). In the 2015 CPP RIA, the total cost of compliance with the CPP and the value of energy savings from DSEE measures that consumers (with subsidies from utilities) were projected to undertake in response to the CPP were reported as a single aggregate value, leaving it impossible to understand the relative magnitude of either one. Given that DSEE measures were a "negative cost," this aggregation had the further effect of making the total CPP emissions reduction cost seem smaller than its actual estimate. In the CPP Repeal RIA, EPA makes the case that the value of these energy savings from DSEE would have been more properly characterized as a benefit of the CPP rather than as a negative cost, and should have been reported separately from any other cost or benefit component to allow the policymaker to understand the relative magnitudes of each. In the CPP Repeal RIA, EPA thus moves the value of energy savings from DSEE to the benefit side of the ledger from the cost side of ledger. Had this been done in the 2015 CPP RIA, however, the estimated <u>net</u> benefits of the CPP would have remained the same—the total costs of the rule would have been higher (because they would not have been reduced by the DSEE's "negative costs"), but the total benefits would have increased by the same amount. Thus, EPA's decision to recharacterize energy savings from DSEE as a benefit of the CPP rather than as a negative cost does not affect the estimated net benefits of the CPP's repeal (nor of the CPP), but doing so provides policymakers with substantially more insight about the underlying components of benefit-cost comparison.

Since this adjustment has no impact on the net benefits in either the 2015 CPP RIA or the CPP Repeal RIA, we do not give it further attention in these comments. Our view is that it should be calculated and reported as a separate, disaggregated element of the costs and benefits in an RIA. We therefore applaud the CPP Repeal RIA for having provided quantitative information on the magnitude of this element of regulatory impact by estimating it and reporting it as the qualitatively-separate impact category that it is. The improvement in transparency provided by this step is more important than whether the CPP Repeal RIA labels it an avoided cost or a forgone benefit.

Table 1. Labeling of Concepts in the Two RIAs

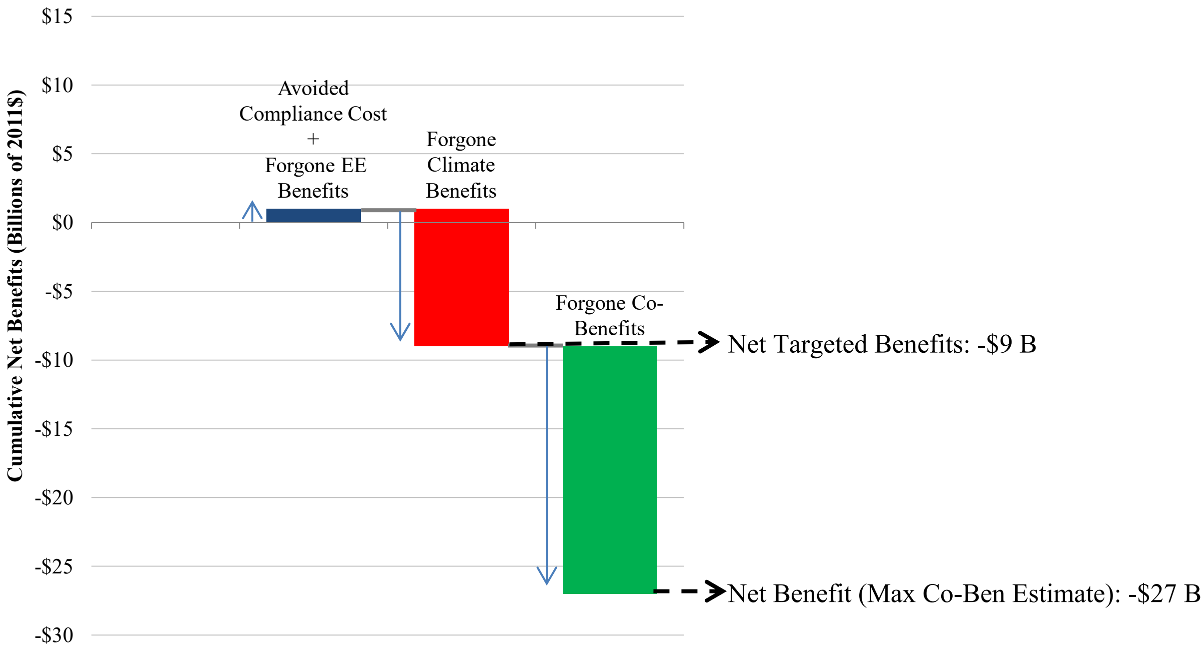
Line Item	2015 CPP RIA	CPP Repeal RIA
Societal Value of Climate Impacts from Changes in CO_2 Emissions	Benefit	Forgone Benefit ("Cost")
Societal Value of Health and Welfare Impacts from Coincidental Changes in Criteria Pollutant Levels	Co-Benefit	Forgone Co-Benefit ("Cost")
Change in Total Power Sector Generating Costs (CPP Policy Case – Base Case)	Cost	Avoided Cost ("Benefit")
Demand-Side EE Expenditures (DSEE)	Cost	Avoided Cost ("Benefit")
Value of Energy Savings from DSEE	Cost (a negative cost)	Nets this item out of 2015 CPP RIA's estimate of Change in Total Power Sector Generating Costs and includes it as a Forgone Benefit
Monitoring, Reporting, and Recordkeeping Costs	Cost	Avoided Cost ("Benefit")

Figure 1 is provided below to graphically illustrate the similarities and differences of the two RIAs' benefit-cost analysis ("BCA") calculations by comparing their component elements which, when added together, translate into net benefits. Figure 1 shows estimates from the rate-based case for 2025. (A comparable figure for the mass-based option in 2025 is provided in Appendix A.) To keep Figure 1 simple for purposes of comparison, the figure presents costs and benefits based on only the 3% discount rate and only the maximal (high) estimate of criteria pollutant co-benefits.

Figure 1(A) presents each of the 2015 CPP RIA's component element estimates exactly as reported in the document, *except* that the sign of each respective estimate has been reversed from that in the 2015 CPP RIA. This allows the estimates to be interpreted from the perspective of repealing rather than promulgating the final CPP and to be compared directly to the estimates in the CPP Repeal RIA, which are shown in Figure 1(B). We do this solely to facilitate the visual comparison of the same component elements in the CPP Repeal RIA.

Figure 1. Cumulative Net Benefits of Repeal as Benefit/Cost Components Are Sequentially Added (Rate-Based Option, 2025 Compliance Year, 3% Discount Rate, Maximum Forgone Co-Benefits)

(A) 2015 CPP RIA (Data Stated in Terms of CPP Repeal)



(B) CPP Repeal RIA

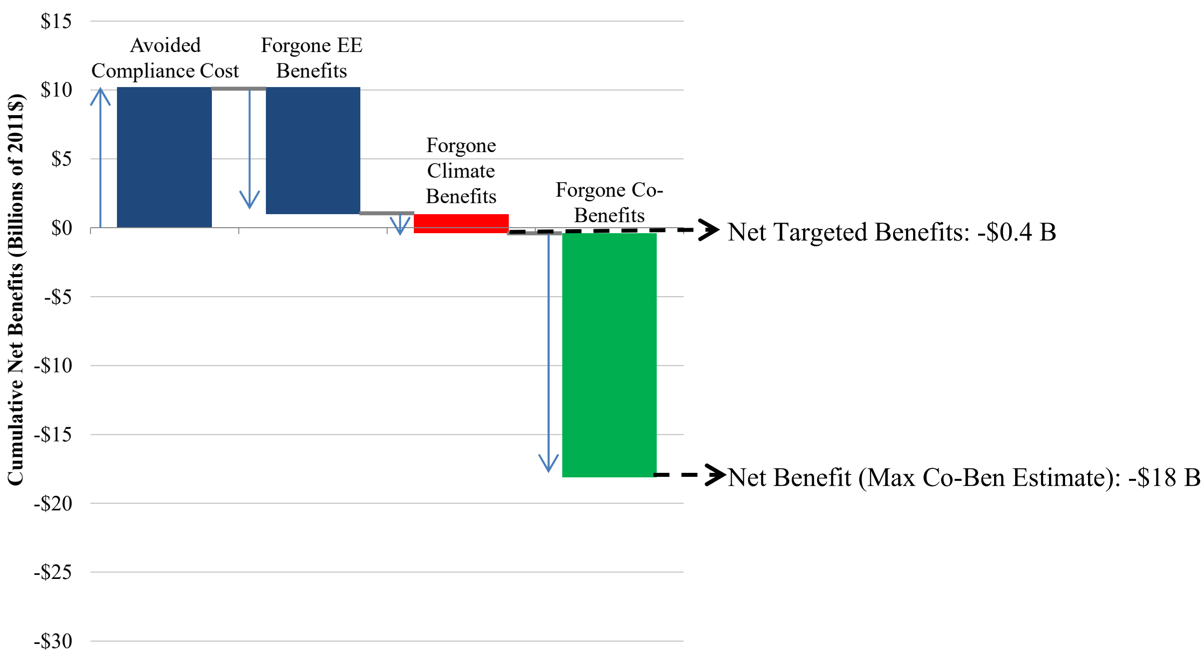


Figure sources: (A) 2015 CPP RIA, Table ES-9; (B) CPP Repeal RIA, Tables 1-1, 1-3, 1-5, and 3-6.

The figure above is called a "waterfall diagram," which shows the cumulative effect on the net benefits of the action when including, sequentially, each of the component elements represented by the bars from left to right. For example, estimated avoided compliance costs (inclusive of forgone EE benefits) are shown in the first bar of Figure 1(A). The estimates of each forgone benefit component (first forgone climate benefits, then forgone co-benefits) are then shown as the vertical lengths of the two subsequent bars, each of which adds to the cumulative net benefit associated with all preceding bars. The net "*targeted*" benefits (*i.e.*, the net benefits of reducing the pollutant targeted by the action, CO_2) can be seen in the figure by looking at the cumulative net benefit just before addition of the bar representing forgone co-benefits of reducing other pollutants that were not targeted by the action (*e.g.*, -$9 billion in the 2015 CPP RIA and -$0.4 billion in the CPP Repeal RIA).

The cumulative net benefit when also including the RIA's maximum forgone co-benefits estimate (which is the same in both RIAs—$17.7 billion for this particular case) is indicated by the bottom of the rightmost bar (*i.e.*, -$27 billion in the 2015 CPP RIA and -$18 billion in the CPP Repeal RIA). In other words, the CPP RIA and the CPP Repeal RIA project identical CPP net avoided costs ($1 billion) and identical maximum net forgone co-benefits from reducing non-targeted criteria pollutants (about $18 billion), while the CPP Repeal RIA projects $8.6 billion less in forgone climate benefits from the CPP than did the 2015 CPP RIA (the difference in the height of the red bars). The only change between the two RIAs that explains the difference of about $9 billion in their targeted net benefits and in their maximal net benefits (including co-benefits), is due to the revised core estimate of forgone climate benefits. (The basis for this revision is discussed in Section IV.)

Thus, comparison of panels A and B in Figure 1 makes apparent the two key changes in this RIA. The first is that the total cost of the CPP in the 2015 CPP RIA has now been disaggregated into its two components (*i.e.*, total spending to comply with the CPP and the value of energy savings from DSEE measures), as discussed above. The second is that the SCC values are estimated differently, which affects the magnitude of the estimated climate benefits. These two changes are discussed individually below. A third change that is not shown in Figure 1 is that this RIA presents several alternative estimates for air quality impacts. This change is also discussed below, along with an enhancement of the figure illustrating how these alternative air quality impact estimates also can be placed on such a figure (see Figure 2).

1. Disaggregation of Total CPP Costs

As noted above, the 2015 CPP RIA presented the total estimated costs of complying with the CPP as an aggregated total that netted the energy savings (*i.e.*, negative costs) from DSEE programs against the estimates of what electric utilities and consumers would have to spend to reduce emissions to comply with the rule. Because of that, it was impossible to discern from the 2015 CPP's RIA how much of the apparently small estimated cost of the CPP (*i.e.*, the first bar, in blue, in Figure 1(A)) is direct spending that was estimated to be necessary to comply with the rule versus what amount was the value of energy savings from the DSEE investments. EPA's decision to disaggregate these two components is a significant analytical refinement of the CPP Repeal RIA that is shown in Figure 1(B).

In Figure 1(B), the total cost that is represented as one dark blue bar in the 2015 CPP RIA is now presented by the first two bars (both also shown in blue). The first bar is avoided direct compliance spending and the second blue bar is the forgone value of energy savings from DSEE. They move in opposite directions, but their net effect is a positive benefit in the CPP Repeal RIA that has the same magnitude as in the 2015 CPP RIA. In other words, using the same underlying data, EPA in its 2017 RIA showed that the costs of complying with the CPP were estimated to be \$10.2 billion, and that the estimated benefits of implementing energy efficiency measures were \$9.2 billion. The cumulative net benefit after the second bar in Figure 1(B) is thus equal to the small positive amount of the single blue bar in Figure 1(A), or +\$1.0 billion.[4]

There are clear merits to this change in how information is presented in the CPP Repeal RIA. It is more transparent, revealing that behind the relatively small estimate of cost in the 2015 CPP RIA is a much larger direct cost offset by a similarly large DSEE-based savings. Given that these are entirely different types of regulatory impacts, it is appropriate to present them separately. It is certainly helpful to see how the components affecting "pocket books" compare to each other, but more importantly, these two offsetting regulatory impacts are borne differently by different groups in the economy. Thus, this information is very helpful for better understanding the distributional implications of the regulation's impacts that almost always lie behind any regulatory net benefit estimate.

Another merit to this additional information lies in the fact that there are different sources and degrees of uncertainty in the estimation of each component. Until they are disaggregated, it is not possible to assess the uncertainty (or perform sensitivity analyses) of the final net benefit estimate. Such sensitivity analyses have not been provided, but would be useful in future RIAs.

There has been some public discussion about the merits of calling DSEE-related energy savings a benefit or a cost. The CPP Repeal RIA justifies its choice of labeling as necessary to be consistent with the accounting conventions used by the Office of Management and Budget ("OMB") as noted by the OMB Guidance for Implementing Executive Order 13771.[5] A comparison of the two panels in Figure 1 should make it apparent the choice of labeling is really not relevant to the net benefit result. Whether one calls it a forgone benefit or an avoided negative cost, it will still function as an offsetting force to the avoided cost of compliance in the CPP Repeal RIA. (The same can be said of its role in offsetting compliance costs in the 2015 CPP RIA.) **The two components of cost impact have been disaggregated in the CPP Repeal RIA, and such disaggregation of fundamentally-different types of financial impacts should**

[4] 2015 CPP RIA, Table ES-5.

[5] CPP Repeal RIA, p. 33. EPA's rationale, consistent with OMB Guidance, is that DSEE reduces the total electricity that customers would need to purchase, and hence represents a savings to customers.

be emulated in any future RIA that contains such different types of impacts in its cost or benefit modeling.

2. Revisions to Estimates of Climate Impact Value

Another key modification in the CPP Repeal RIA is to the estimate of the CPP's climate benefit (which in this RIA becomes the estimate of forgone climate benefits from repealing the CPP). EPA has not changed its estimate of the CO_2 emission reductions from the CPP, nor has it changed the fact that it calculates estimated climate benefits by multiplying that tonnage estimate by one of several available estimates of the SCC, which is stated as a present value of future climate impacts per ton of incremental change in CO_2 emissions. What EPA has changed in the CPP Repeal RIA is the geographic scope of climate impacts that are accounted for in its core estimate of the SCC value. While retaining the same SCC modeling methods, the CPP Repeal RIA estimates climate benefits by focusing only on the impacts projected to occur in the U.S., rather than including impacts that would occur in other nations, as EPA did in the 2015 CPP RIA. Thus, for any choice of discount rate, the CPP Repeal RIA's domestic SCC value is a subset of (and thus smaller than) the global SCC values used in the 2015 CPP RIA.

The merits of using a domestic rather than global SCC value in an RIA for a U.S. regulatory decision are discussed in detail in Section IV of these comments. The implications of this choice for the net benefits of the proposed CPP repeal can be seen by comparing the red bars for climate impacts in the two panels of the figure. Climate impacts have much less overall role in determining net benefits in the CPP Repeal RIA (Figure 1(B)) than they did in the 2015 CPP RIA (Figure 1(A)).

While the CPP Repeal RIA uses a domestic SCC for its core net benefits estimates, it also reports net benefits using the global SCC values as a sensitivity case, consistent with the new general approach of providing more information for policymakers. The 2015 CPP RIA, in contrast, presented net benefits using only the global SCC value.

3. Air Quality Impacts

In the CPP Repeal RIA, EPA does not change the way it estimates the CPP's maximal potential co-benefits of reducing non-CO_2 emissions. The base estimate of air quality impacts (forgone health co-benefits) is the same as the estimate of air quality co-benefits in the 2015 CPP RIA, and thus the heights of the (maximal) air quality impacts bars are the same in panels A and B of Figure 1. However, this RIA provides additional information by including several sensitivity analyses that estimate benefits of reducing fine particulate matter ("$PM_{2.5}$") below the lowest measured levels ("LMLs")[6] and below the level of the annual $PM_{2.5}$ NAAQS.

[6] Each epidemiological study used to estimate association between pollutant concentrations and health risk relies on observations of how health risk varies as pollutant concentrations vary over a range of values. The lowest concentration observed in a given study is its LML. Any association detected in such a study can only be said to

In both sensitivity cases, EPA assumes that the benefits fall to zero when $PM_{2.5}$ levels fall below the LML and the NAAQS, respectively. In the LML case, this is because there is no evidence at all that the association continues to exist below the LML. In the NAAQS case, this is because the NAAQS by law is set at a level that is protective of public health and thus reducing emissions below that level by law should not yield public health benefits.[7] These sensitivity cases, which are illustrated in Figure 2, indicate the degree of uncertainty in net benefits associated with these co-benefit uncertainties.[8]

As seen in Figure 2, with the additional information included in the CPP Repeal RIA, one can now evaluate cumulative net benefits in three additional ways: 1) including only co-benefits estimated for populations living in areas where $PM_{2.5}$ is above NAAQS, and 2) also including co-benefits estimated for populations with exposures below the NAAQS but above the LML, and 3) also including the lowest-confidence category of co-benefits, which are those estimated in populations whose ambient $PM_{2.5}$ exposures are already below even the lowest level measured in any of the epidemiological studies. The last of these was the only net benefits case provided in the 2015 CPP RIA. The merit of providing net benefits estimates under a range of co-benefit sensitivity cases is discussed in more detail in Section III of these comments, and some suggestions are provided for improving the RIA's presentation of those uncertainties.

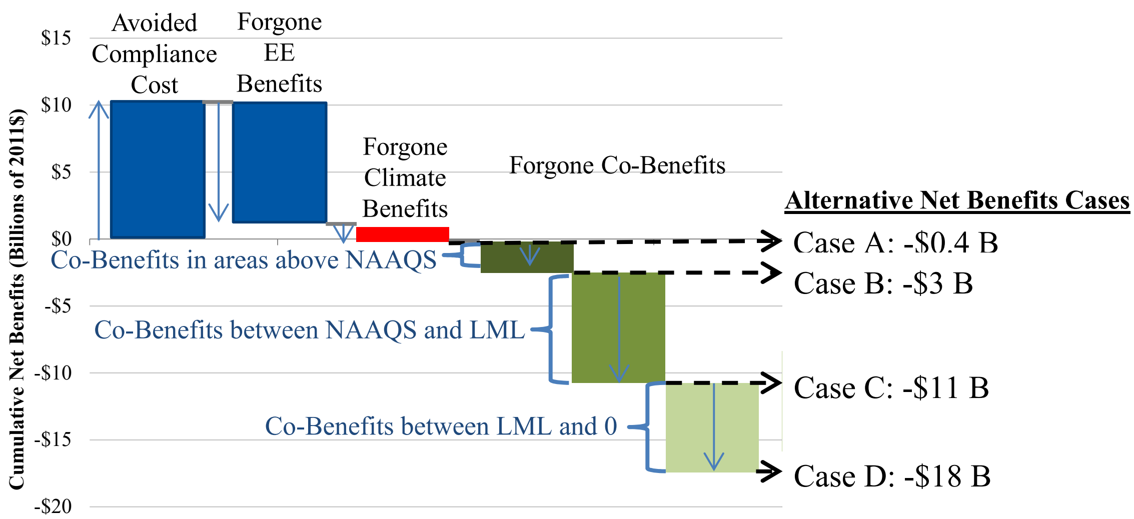
---

apply to concentrations within that observed range, and continuation of the association below a study's LML is unknown.

[7] The NAAQS are not set as low as the LMLs because uncertainty about the continuation of the observed association becomes a concern somewhere between the central mass of the observations (which are near their mean or average) and the 10^{th} to 25^{th} percentile of the observed data, which are above the LML, or 0^{th} percentile of the observations (78 *Federal Register* 3086, January 15, 2013 at 3159).

[8] The comparable figure for the mass-based option is provided in Appendix A.

Figure 2. Alternative Potential Estimates of Net Benefits of Repeal for CPP Repeal RIA's Co-Benefit Sensitivity Cases (Rate-Based Option, 2025 Compliance Year, 3% Discount Rate)



LEGEND

Case A: Includes targeted benefits (*i.e.*, excludes all forgone co-benefits)
Case B: Includes only high-confidence co-benefits estimates (*i.e.*, includes co-benefits only in areas above the NAAQS)
Case C: Also includes lower-confidence co-benefits (*i.e.*, in areas with concentrations attaining the NAAQS and as low as the LML)
Case D: Also includes co-benefits for which there is no observational evidence of a health effects relationship (*i.e.*, in areas with concentrations below the LML)

B. Merits of CPP Repeal RIA in Context of Objectives for RIAs Generally

To summarize from the prior section, the difference in the ranges of absolute net benefits shown in panels (A) and (B) of Figure 1 are due entirely to showing the climate impacts by using a domestic SCC value instead of a global one.[9] The main difference is thus in a judgment about the policy-relevance of U.S. versus non-U.S. impacts of a U.S. regulation, and thus which estimates to emphasize in net benefits summaries, rather than any computational differences in the method of calculating the value of climate impacts. A sensitivity case that computes climate impacts in the same manner as in the 2015 CPP RIA is provided in Appendix C of the CPP

[9] While attention has been given in public discussion of this RIA to the change in how one *qualitatively* describes a certain regulatory impact (*i.e.*, value of DSEE savings), the prior section has shown it to be irrelevant to the ultimate question of the numerical net benefits of either the final CPP or the proposed repeal of the CPP.

Repeal RIA (starting at p. 168) for 2020 and 2030, and these too could be incorporated into illustrations of net benefits sensitivities.[10]

Technical or theoretical arguments in favor of some of the alternative emphases are discussed in Sections III through V below, along with comments about how the RIA's estimates and their communication can be further improved. First, however, we comment on how the CPP Repeal RIA's methods of presenting alternative possible cost and benefit estimates helps meet the objectives for RIAs generally.

Executive branch agencies have been required to complete RIAs for regulatory proposals and final rules since 1981, though the primary currently-applicable requirements date to Executive Order 12866, adopted in 1993. Throughout the history of RIAs, their most basic objective has been to inform policymakers about positive and negative implications of a regulatory decision. A central, but not sole, feature of RIAs is BCA, which leads to evaluation of whether a regulation will have positive net benefits. Discussion of the distributional impacts of the component elements of benefits and costs, economic impacts, and other concerns such as employment and small business impacts is also expected in a thorough RIA.

Pursuant to Executive Order 12866, OMB in 2003 developed guidance for agencies preparing RIAs in what is referred to as Circular A-4.[11] EPA has prepared its own guidance, generally following that of OMB, but with more detail about methodologies that are most relevant to environmental policy issues (EPA, 2010). These guidelines, and other papers and articles about the RIA requirements (see, for example, Dudley *et al*., 2017 and NERA, 2011) all concur that a sound RIA must present the relevant information in a transparent and balanced manner so that readers (which include policy makers and the interested public or stakeholders) can understand how estimates were derived and the uncertainties associated with those estimates. The objective of an RIA is not to resolve uncertainties, but instead to highlight the role of uncertainties in the overall conclusions about the potential merits of a new regulation.

The CPP Repeal RIA's provision of multiple alternative BCA comparisons enhances the degree of transparency in how uncertainties of CPP-related impacts (both costs and benefits) are communicated. The CPP Repeal RIA strives to reflect the range and sensitivities to key uncertainties that were known, but not reported or discussed in a quantitative manner in the 2015 CPP RIA. The CPP Repeal RIA highlights these uncertainties with respect to forgone climate benefits and also forgone air quality co-benefits by presenting sensitivity analysis results for each. For the forgone climate benefits, the CPP Repeal RIA presents these values based on a domestic SCC and a global SCC; for the forgone air quality co-benefits, the CPP Repeal RIA presents these values based on three different levels where $PM_{2.5}$ benefits would fall to zero

[10] Appendix C of the CPP Repeal RIA does not report global values for 2025 specifically (it does so only for 2020 and 2030, which bound 2025), but if it had presented the 2025 global impacts estimates as well, they would match the global value of forgone climate impacts reflected in the red bar of Figure 1(A).

[11] See https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf.

(which are 1) only at zero a $PM_{2.5}$ concentration, 2) when $PM_{2.5}$ concentrations are lower than the LML, and 3) when $PM_{2.5}$ concentrations are below the annual $PM_{2.5}$ NAAQS level, or "in attainment").[12] In contrast, the 2015 CPP RIA made certain preferred assumptions, and left readers no information about how much those assumptions affect the cost, benefit, or net benefit estimates. While it was possible for a technically-sophisticated reviewer to conduct her or his own sensitivity analyses to alternative assumptions, a good RIA should not leave that exercise to the reader.

Although the CPP Repeal RIA has filled in many of those blanks, it does (necessarily) make judgments about which assumptions to treat as core assumptions rather than as sensitivity analyses. When doing so, however, it directly provides alternative estimates so that others who might disagree with those judgments can emphasize the alternatives instead. In other words, the CPP Repeal RIA does not attempt to resolve uncertainties, but instead it seeks to enable readers to see the full range of net benefit estimates that result from those uncertainties.

It is difficult to imagine a rational case for providing less information on quantitative impacts of key sources of uncertainties. At best, one might argue that extensive new information can be difficult to assimilate. This, however, would be an argument for better communication and synthesis of the results, not for fewer sensitivity cases. In later sections of these comments, we suggest ways to summarize those many alternative net benefit estimates that might be useful for policymakers.

Prior comments on RIAs such as NERA (2011) have argued that the common method of RIAs to compare costs and benefits at single points in time (such as for a first compliance year) should be replaced by comparisons of the present values of a projected multi-year stream of costs and benefits. The CPP Repeal RIA also opens the door to this possibility by reporting present values. Although the present value analysis is provided ostensibly to meet a new requirement under Executive Order 13771, we recommend that this analysis become more central to the BCA portion of the RIA as well. Additionally, in conducting a present value analysis, one should present timelines of cost accrual and benefit accrual, allowing readers to understand the extent to which costs may precede benefits (or vice versa), and the likely payback period associated with each new regulation. This issue becomes particularly relevant for regulations addressing greenhouse gas emissions, as is discussed in more detail in Section IV.C of this document. The CPP Repeal RIA has taken the first analytical steps necessary to consider net benefits on a present value basis, and to provide associated timelines. **We recommend that if EPA finalizes the proposed repeal of the CPP, the RIA for that final action should implement characterization of the timeline of net benefits more fully, as we discuss in more detail in later sections of these comments.**

[12] Although it could have, the CPP Repeal RIA has not included analogous cutpoint assumptions for ozone-related co-benefits. In these comments, we recommend that EPA incorporate ozone co-benefits into its cutpoint sensitivity cases in the next RIA.

The key message a reader likely inferred from the presentation of costs and benefits in the 2015 CPP RIA was that the net benefits of implementing the final CPP would have almost certainly been positive (*i.e*., benefits would have exceeded compliance costs). Stated in terms of a repeal of that rule, this would mean that the net benefits of repeal of the CPP would almost certainly be negative. Although negative net benefits from CPP repeal are among the potential outcomes estimated in the CPP Repeal RIA, such a result is not the only possibility, which can be understood better in light of this RIA's provision of new information on the impacts of important uncertainties, and other enhancements we identified above. Having access to this more nuanced understanding of the uncertainty in an RIA's net benefits estimates is an important step towards achieving the balance and transparency that are desired traits in an RIA that can provide sound guidance to complex policy decisions.

III. CO-BENEFITS FROM REDUCED EMISSIONS OF CRITERIA POLLUTANTS

The CPP Repeal RIA estimates forgone health co-benefits associated with forgone reductions of the criteria pollutants ("CPs") $PM_{2.5}$ and ozone that are projected to occur in achieving compliance with the CPP. The method by which these forgone benefits are calculated is identical to that in the 2015 CPP RIA, using a "benefits-per-ton" ("BPT") shortcut approach. However, these co-benefits are presented in a different manner in the CPP Repeal RIA – one that helps readers understand the degree to which the original estimates are subject to uncertainties that go beyond statistical variance, and which relate to lack of confidence in the continued existence of the concentration-response ("C-R") functions at lower and lower baseline ambient concentrations.

Specifically, the forgone co-benefits estimates are presented for a full range of potential scientific realities: no attenuation in risk down to zero ambient concentration (which is the method used for the 2015 CPP RIA's only set of co-benefits estimates); counting only those $PM_{2.5}$ co-benefits that occur in areas where $PM_{2.5}$ is above the LMLs of the epidemiological studies underlying the risk estimates; and counting only those $PM_{2.5}$ co-benefits that occur in areas where $PM_{2.5}$ is above the current annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$. Additionally, the CPP Repeal RIA presents results in a manner that is forthcoming regarding the degree to which co-benefits, rather than benefits from the pollutant targeted by the rule, drive the prospects for the proposed action to have a positive net benefit outcome.[13]

The Agency seeks comments on its selected method of presenting forgone co-benefits in this way (p. 51), on its approach for characterizing these uncertainties (p. 94), and on how best to use empirical data to characterize the increasing uncertainty in a quantitative manner (p. 8).

The way these sensitivities are used to provide information about scientific uncertainties is a very helpful step in the direction of greater transparency and should be continued, for the reasons outlined below. We also provide several suggestions for developing the alternative sensitivity estimates of co-benefits in a more robust manner. In addition, we provide suggestions for clearer synthesis and communication about the sensitivity in RIA results.

A. Background on Use of Criteria Pollutant Co-Benefits

The growing use by EPA of co-benefits from coincidental reductions of CPs associated with projected compliance with non-CP regulations was first documented and discussed at length in NERA (2011), focusing specifically on $PM_{2.5}$ co-benefits. The 2011 NERA study conducted a review of air RIAs dating back to the time of the first $PM_{2.5}$ risk analysis in 1997 (which was

[13] In the case of the CPP Repeal RIA, the target pollutant is CO_2, and a "positive net targeted benefit" would occur if the estimated avoided cost of rescinding the CPP is less than the estimated forgone benefits from reductions of CO_2 without any consideration of CP co-benefits that are not targeted by the action.

applied for the first $PM_{2.5}$ NAAQS rulemaking) and found that $PM_{2.5}$ co-benefits had become an increasingly important component justifying findings of benefits greater than costs in RIAs for all sorts of non-$PM_{2.5}$ regulations. Indeed, $PM_{2.5}$ co-benefits accounted for more than half of the non-$PM_{2.5}$ RIA's regulatory benefits in almost all RIAs reviewed over the entire period, and after 2009, $PM_{2.5}$ co-benefits usually accounted for all, or more than 99%, of total benefits in those RIAs.

In effect, the ease with which $PM_{2.5}$ co-benefits could overwhelm estimated costs of most non-$PM_{2.5}$ regulations appeared to be undermining the Agency's motivation to develop methods for quantifying the health and welfare impacts of other air pollutants, particularly those regulated under CAA Section 112 as air toxics. This fact alone suggested a detrimental impact on one of the important roles of RIAs, which is to provide a well-documented analysis of the merits of each new regulation – which surely should be focused primarily on the effects of the pollutant being regulated, rather than on the co-benefits of another pollutant that is already subject to its own, quite stringent, regulatory framework.

NERA (2011) also made a number of other observations regarding EPA's reliance on $PM_{2.5}$ co-benefits. It described how the Agency had changed its assumptions for estimating such co-benefits in a manner that greatly increased its estimates of population-wide risk from current levels of ambient $PM_{2.5}$ at approximately the same time co-benefits started to become the central form of benefit reported in most non-$PM_{2.5}$ RIAs. That is, in about 2009 EPA started to assign mortality risk due to $PM_{2.5}$ down to zero concentration, instead of to the LML in the underlying epidemiological studies. (This is the calculation that the CPP Repeal RIA calls "full range of ambient $PM_{2.5}$ concentrations" and which produces the highest estimate of forgone co-benefits.) As NERA (2011) showed, this single change in the co-benefit calculation more than tripled the quantity of annual deaths "attributable to $PM_{2.5}$" associated with then-current ambient concentrations – a reservoir of potential co-benefits that each new regulation that might coincidentally reduce a $PM_{2.5}$ precursor could tap.

The CPP Repeal RIA's approach for presenting a series of alternative estimates of $PM_{2.5}$ co-benefits is a very positive development because it provides information enabling readers to see the impact of this assumption, and also to estimate net benefits using alternative assumptions in which they have greater confidence. The CPP Repeal RIA does this in a balanced manner that does not give particular emphasis to any one of the assumptions.[14]

B. Reasons to Exclude Criteria Pollutant Co-Benefits Altogether

The CPP Repeal RIA notes (at p. 47, footnote 28) that inclusion of co-benefits is consistent with RIA guidance from OMB (2003) and EPA (2014), and does not question the appropriateness of including $PM_{2.5}$ and ozone co-benefits in non-CP RIAs. However, NERA (2011) provides a theoretical analysis demonstrating that the inclusion of co-benefits from already-regulated

[14] In later sections, we provide recommendations for how to make these insights more accessible to readers.

pollutants (particularly those regulated as CPs) in a benefit-cost optimization for another targeted pollutant can lead to overregulation of the targeted pollutant from an overall societal BCA perspective. Furthermore, if CPs are truly regulated under CAA Section 109 to the point where there is no confidence that the C-R relationship continues to exist at lower concentrations than the selected NAAQS level, then the *expected value* of co-benefits from incremental reductions of those CPs below their NAAQS level will be close to zero, if not exactly zero.[15] The latter assumption is consistent with the forgone co-benefits sensitivity case that the CPP Repeal RIA labels "$PM_{2.5}$ benefits fall to zero below NAAQS," in which co-benefits are only counted if they occur in locations with $PM_{2.5}$ concentrations above the NAAQS.[16]

For these reasons, **the OMB and EPA guidance to include co-benefits in RIAs should be reconsidered for the specific case of CP co-benefits**: a strong case can be made to exclude estimates of co-benefits associated with CPs based on the stringent legal requirements under which they are already controlled under CAA Section 109. The stringency of NAAQS levels is reinforced by the requirement that NAAQS be reviewed every five years and updated as appropriate to address the latest scientific evidence, and by the detailed implementation requirements and timelines for CPs. At the same time, it remains appropriate to include ancillary benefits from co-reductions of other pollutants or other environmental conditions that are not already regulated, or that face regulatory constraints that, in contrast to the NAAQS, are far less stringent from the perspective of permissible remaining public health risk.

Although we present a strong case for eliminating CP co-benefits from non-CP RIAs altogether in the future, we consider it a very good first step to separate the assessment of co-benefits from the main BCA summary table, such as in Table 4-1 (p. 71 in the CPP Repeal RIA). We recommend, for purposes of improved clarity, that when co-benefits are then incorporated into the summary of net benefits (as is done in the format of Table 4-2, p. 73, in the CPP Repeal

---

[15] From the perspective of legal interpretation of CAA Section 109, its requirement that NAAQS be set at a level that is "requisite" to protect the public health with an adequate margin of safety does not imply that NAAQS literally achieve "zero risk." EPA Administrators have based their determinations of "requisite" on identifying a concentration level at which their confidence in the continuation of the C-R relationships (which provide the evidence of risk to the public health) below that level becomes too low to warrant a yet-lower level for the NAAQS. This use of subjective confidence allows one to reconcile the statement that a NAAQS is not a "zero risk" standard with the statement that it is requisitely protective of the public health; the use of subjective confidence is also consistent with the notion that the expected value of incremental risk is exceedingly low, if not zero, even though application of the C-R functions below that NAAQS level – as if one does has 100% confidence in their continuation -- will obviously produce positive estimates of incremental risk. Whether the expected value of incremental co-benefits below the NAAQS is zero or merely *de minimis* from a public health perspective, it is much lower than the values that are calculated using the C-R functions that have been used in the current and earlier RIAs.

[16] The fact that the co-benefits in the RIA for this sensitivity case are not very close to zero (see Table 3-11, p. 52) is because EPA has not applied a similar assumption of zero benefits below the NAAQS for the calculation of ozone co-benefits. Our replication of EPA's sensitivity analysis calculations in that table shows that the $PM_{2.5}$ co-benefits are reduced from the "full range" estimate by about 99.6%, and almost all of the reported forgone co-benefits in the "$PM_{2.5}$ benefits fall to zero below the NAAQS" sensitivity case are therefore due to ozone co-benefits, even though the ozone risk calculations face analogous uncertainties to those of $PM_{2.5}$. We therefore recommend that EPA include comparable cutpoints for ozone as for $PM_{2.5}$ in its forgone co-benefits sensitivity cases in the final rule RIA.

RIA), that the results be presented for each of the alternative co-benefits computations, from omitting co-benefits entirely (*i.e.*, the net benefit values in Table 4-1), through "zero below NAAQS," to "zero below LML," to "full range." This will help a reader understand the implications of the sensitivity cases in terms of the very large uncertainty about net benefits when co-benefits are given consideration. If this had been done in the RIA for the MATS rule, there would have been a much better and more transparent communication to the public and policymakers that could have reduced the risk of performing the kind of "end run around" that Chief Justice Roberts identified when he noted the "disproportionate nature" of the $PM_{2.5}$ co-benefits in that rulemaking.[17]

C. Reasons for Assigning Low Confidence to Many of the Co-Benefit Estimates

The approach used to characterize co-benefits uncertainties addresses another concern with $PM_{2.5}$ benefits and co-benefits calculations that has been identified in the literature. Smith (2016) compared the rationales used by the Administrator in choosing NAAQS levels for $PM_{2.5}$ and ozone with the assumptions being made in the RIAs associated with those decisions and noted that the two were inconsistent. While the rationales indicated that the levels of the NAAQS had been set where uncertainty in continued public health risk was deemed too great to warrant a tighter standard, the RIAs have been assuming that estimates of risks below the standard were every bit as certain as those for exposures above the standard. Smith (2016) calls for the risk estimates to be broken into their components of decreasing confidence levels rather than to present them as a single combined risk estimate. This recommendation focused on the use of CP risk estimates even when they are the targeted benefit of an RIA, such as in RIAs for new NAAQS decisions, but would also apply to CP co-benefits estimates (if they are to continue to be used in non-CP RIAs).

Bloomberg (2016) pointed out that the overall confidence level in CP co-benefits estimates will continue to decline over time due to ever-declining ambient concentration levels across the U.S. Thus, the confidence level associated with total co-benefits reported in an RIA for a rule such as the CPP, which was to be implemented in the mid-2020s, would be even lower than the co-benefits reported in an RIA such as for the MATS rule, which was implemented in the mid-2010s, when U.S. ambient $PM_{2.5}$ and ozone concentrations were projected to be generally higher.

The range of sensitivity assumptions of $PM_{2.5}$ co-benefits estimates spans from estimates that can be viewed as having "highest confidence" (because they are associated with concentrations above the NAAQS) down to those with "lowest confidence" (because they assume C-R relationships continue to exist to the lowest concentrations modeled, even below the LMLs of the associated studies). However, **we recommend that EPA also include at least one more sensitivity case, which would be at a cutpoint that is just slightly below the NAAQS level**, such as at 10 $\mu g/m^3$ for annual $PM_{2.5}$. We recommend this additional sensitivity case because

[17] See oral arguments in *Michigan v. EPA*, pages 61-62, transcript available at: https://www.supremecourt.gov/oral_arguments/argument_transcripts/2014/14-46_1b5p.pdf.

there is a large change in the confidence associated with the sensitivity cases that impose a cutpoint at the NAAQS (at 12 μg/m^3) versus at the LML (as low as 5 μg/m^3). There is also a very large change in estimated $PM_{2.5}$ co-benefits between these two sensitivity cases.[18] An additional sensitivity case that is slightly below the NAAQS level would provide helpful insight about whether the very small co-benefits in the "highest confidence" (NAAQS cutpoint) estimate rise quickly to the larger co-benefits estimates in the "lower-confidence" (LML cutpoint) case or whether those co-benefits start to rise only after the cutpoint has been reduced far below the NAAQS level.

D. A Comparable Sensitivity Analysis Should Be Applied to the RIA's Ozone Co-Benefits Estimates

The CPP Repeal RIA's approach for calculating and presenting co-benefits estimates goes far in the direction of revealing the declining confidence levels of different components of the co-benefits. In particular, the co-benefits in the "zero below NAAQS" case should be viewed as being the estimate for which there is good confidence (*i.e.*, are calculated in a manner consistent with the Administrator's more recent judgment about the scientific evidence on health effects). One concern with the manner in which EPA has implemented this approach in the CPP Repeal RIA is that it has re-calculated *only the $PM_{2.5}$* co-benefits for alternative confidence levels. This has resulted in almost all of the remaining co-benefit estimate being due to ozone co-benefits,[19] because the ozone co-benefits have not been similarly revised. However, the uncertainty and inconsistency issues that have been raised for $PM_{2.5}$ benefits estimates apply equally strongly to those for ozone.

Thus, **we strongly recommend that when EPA refines its analysis for future RIAs, a parallel adjustment be made to the ozone co-benefits as is made to the $PM_{2.5}$ co-benefits for each sensitivity case.**

E. Correction Needed in Computation of Co-Benefits Under Alternative Cutpoint Levels

Although the CPP Repeal RIA has made good progress in the decision to present a range of co-benefits estimates for different cutpoints in the continuation of the C-R function, there is a logical inconsistency in how these alternative calculations are being made for risks above the assumed cutpoint. Specifically, the sensitivity cases are simply estimating the fraction of risks

---

[18] The $PM_{2.5}$ co-benefits estimate in the NAAQS cutpoint case is far smaller than one may guess from the results presented in the CPP Repeal RIA, which combine ozone with $PM_{2.5}$ co-benefits. If these were presented in a disaggregated manner by type of pollutant, it would become apparent that the $PM_{2.5}$ co-benefits are nearly zero in the NAAQS cutpoint case, and almost all of the co-benefit value reported for that sensitivity case is due to ozone. We recommend that ozone be included in the sensitivity cases too (see Section III.D).

[19] We have replicated most of this RIA's co-benefit calculations for the sensitivity cases, and we find that 98% to 99% of the co-benefits in the "zero below the NAAQS" case are ozone co-benefits, which have not had any adjustment relative to their "full range" values.

that are occurring in populations residing in areas with concentrations below the selected cutpoint, and zeroing out that subset of the population-wide risk estimate. However, if the cutpoint is to be viewed as the point at which one loses confidence that the C-R function continues to yet-lower concentrations, then the relative risk per unit of pollutant would only start to accrue *from that cutpoint*.

The logically-consistent way to calculate the risk if the C-R relationship is assumed not to continue below some cutpoint is not to only zero-out the estimated portion of the risk that occurs below that cutpoint, but to also recalibrate the relative risk that exists for populations that reside in areas with concentrations above that cutpoint. For example, if the C-R relationship is assumed to end at an LML of 8 $\mu g/m^3$, then 8 $\mu g/m^3$ becomes the starting point from which incremental exposure creates incremental (relative) risk. Thus, exposures at 10 $\mu g/m^3$ would be subjected to the increase in risk associated in an incremental exposure of 10 minus 8, or 2 $\mu g/m^3$ rather than 10 $\mu g/m^3$. This means that current estimates of the $PM_{2.5}$ co-benefits in each sensitivity case in the CPP Repeal RIA are overstated—and greatly so for the highest cutpoint case. The higher the cutpoint assumption, the more the relative risk for exposures above that cutpoint is reduced, and hence the higher the overstatement.

This may seem like a minor detail but it will in fact have a very large impact on the sensitivity of co-benefits that are currently presented. This point was made in UARG's comments to the docket for the proposed ozone NAAQS, based on the technical report of Smith and Glasgow (2015). In that proposed rule, a similar cutpoint analysis was presented for ozone risks associated with different NAAQS levels. Smith and Glasgow (2015) demonstrated how the sensitivity was much more pronounced when risk above the cutpoint level was recalibrated to start relative to the cutpoint level.[20] Appendix B of these comments provides a copy of the relevant sections of Smith and Glasgow (2015).

Thus, **we strongly recommend that every one of the co-benefits sensitivity calculations be revised to compute incremental risk <u>relative to the cutpoint point</u> rather than by simply zeroing out those risks that are calculated below the cutpoint point.**

When cutpoints are applied to the ozone co-benefits estimates as well, the method of recalibration of risk relative to the selected cutpoint should also be applied to those sensitivity cases.

F. Avoiding Limitations of Benefit-per-Ton Approach

The BPT approach for estimating $PM_{2.5}$ and ozone benefits was developed to make it exceptionally easy for the Agency to produce co-benefits estimates. Whatever its merits may be, this device instantly created a barrier for the Agency and for public commenters to develop

[20] This calculation of relative risk starting from the cutpoint is also the method used in the sensitivity analysis of $PM_{2.5}$ benefits at different confidence levels that appears in Smith (2016).

estimates of the sensitivity of co-benefits to alternative assumptions about where the C-R relationship might end. This is a particularly problematic situation given that uncertainty on this specific matter has routinely been used by the Administrator to justify the choice of NAAQS level for these two pollutants.[21] NERA identified this problematic aspect of the BPT approach in its report on the proposed CPP RIA co-benefits prepared for the Virginia Legislature (NERA, 2015). Using a cutpoint of 10 $\mu g/m^3$ (a level substantially more stringent than the current NAAQS), NERA (2015) performed a very rough approximation of the geographical relationship of projected $PM_{2.5}$ and ozone precursor emission reductions and areas in attainment with the current $PM_{2.5}$ and ozone standards to estimate that only about 2% of the overall $PM_{2.5}$ co-benefits were likely to be in counties with $PM_{2.5}$ above 10 $\mu g/m^3$. We note that this is stated in terms of counties rather than population, and the roughness of the estimation approach reflects our lack of access to the underlying data on which the BPT estimates were originally calculated.[22]

In preparing the CPP Repeal RIA, the Agency has also identified this problem and developed some rough approximations for working around it for its sensitivity cases. In doing so, the Agency has had the advantage of being able to return to the modeling data that it used for its CPP BPT estimates in 2015. From these data, EPA has obtained direct estimates of the percentage of the modeled avoided premature mortalities in its CPP Option 1 case that resided in areas above the relevant LMLs and NAAQS. It then reduced each respective BPT estimate by that fraction (see footnote 36 on p. 51, and Table 5-2 on p. 95 of the CPP Repeal RIA) to calculate the reduced $PM_{2.5}$ mortality and co-benefits for its two sensitivity cases. With this approach, EPA reports that 0.4% of the avoided premature mortalities upon which the BPT estimates were calculated were in areas projected to be exceeding the annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$. The Agency seeks comment on how best to use the available empirical data to develop such sensitivity estimates (p. 8), and we provide our responses below.

First, just as we have applauded the effort to provide sensitivity estimates in the CPP Repeal RIA, **we also endorse the Agency's expressed intention to conduct refined co-benefits sensitivity estimates using photochemical modeling in future iterations of the CPP Repeal RIA. We also recommend that the photochemical modeling outputs (or, more specifically, the air quality grids that are BenMAP inputs) be made available to the public to develop comments on that additional work.**

However, even if new photochemical modeling is not conducted, we have several recommendations for refining the sensitivity calculations already prepared:

[21] See footnote 2, and discussion regarding points made in Smith (2016) in Section III.C regarding this.

[22] NERA (2015) also provides a detailed explanation of how the BPT approach relates to the standard health risk calculation of BenMAP, and why this eliminates the ability to tailor BPT-based benefits estimates to account for location-specific differences in relative risk from pollutant concentrations. We recommend pp. 7-13 of that report to readers who would like more explanation of this BPT issue than is provided in the CPP Repeal RIA.

- As stated above, the same types of cutpoints that are applied to $PM_{2.5}$ should also be applied for ozone. For example, in the "zero below NAAQS" case, ozone co-benefits should be included only to the extent they occur above the current ozone NAAQS. At present the significant sensitivity of $PM_{2.5}$ co-benefits in this case is masked by the fact that ozone co-benefits remain at their "full range" value, and become almost all of the co-benefits estimate reported for that case. LML levels can also be defined for ozone for the "zero below LML" calculations.

- The error in the computation of sensitivity to alternative "cutpoints" described in Section III.E can be roughly corrected even without full new photochemical modeling. This can be done using the existing projection for the proposed CPP Option 1 and Baseline air quality projections to recompute BPT in the original manner, after first subtracting the cutpoint value (either the LML or the NAAQS, depending on the sensitivity case) from the projected air concentration in each location in the modeling domain.

G. Suggestions for Improving Synthesis and Communication of Impacts on Net Benefits of Sensitivity Cases

We note that a valuable aspect of EPA's present approach is that the Agency does not make any attempt to resolve the question of which sensitivity case is more valid. A "best estimate" is inappropriate for purposes of educating the public about the implications of including co-benefits in the net benefit calculation, and for communicating how much the associated uncertainty can affect results, if one does wish to incorporate co-benefits at all. Transparency and an unbiased presentation are best served by simply providing the alternative estimates, explaining what they represent, and letting each reader draw his or her own conclusion about what to emphasize. Public discussion can thus also proceed without the ability of one party or another to dodge the issue of what assumptions they are giving greatest weight to.

In the interests of doing this, **we recommend the adaptation of Tables 4-1 through 4-4 in the CPP Repeal RIA to a more condensed format such as our Table 2 below.**[23] For the Rate-Based Option, Table 2 summarizes the net benefits in the CPP Repeal RIA under all of the combinations of discount rate and co-benefits sensitivity cases.[24]

Each row within a cell of Table 2 shows the effect of incrementally adding more and more of the uncertain forgone co-benefits from $PM_{2.5}$ (as previously noted, the CPP Repeal RIA does not address the uncertainty in the ozone co-benefits, but should). The first row in each cell, labeled "No Co-Benefits," shows net targeted benefits (by year and discount rate, as indicated in row and column headers). This estimate provides an appropriate BCA evaluation for regulatory action if one decides that $PM_{2.5}$ and ozone co-benefits are inappropriate to include given that they are

[23] It would be perhaps even more helpful to find a way to represent these sensitivity ranges in a graphical format to supplement the tabular format provided here.

[24] The comparable table for the Mass-Based Option is provided in Appendix A (see Table 8).

already stringently regulated under the CAA. The remaining three entries in each cell below that reflect the impact of allowing for consideration of co-benefits, but showing the implications of allowing co-benefits estimates that have varying degrees of perceived credibility (or "confidence" in the words of the EPA Administrator).

The second row in each cell (labeled "Cutpoint at NAAQS") shows the effect on net benefits when including only co-benefits of the highest confidence level (*i.e.*, those associated with exposures above the NAAQS level). The third row includes co-benefits estimated for populations facing even very low current $PM_{2.5}$ exposures, as low as the LML observed in the associated epidemiological study data set. The Administrator has declared such low confidence in risk estimates based on exposures within this range as to not warrant setting the NAAQS at any level within this range. The fourth row within each cell (labeled "No cutpoint") includes risk estimates for all populations, including those living in locations that have cleaner air than any that were observed in the associated epidemiological studies. The resulting net benefits estimates on this last row of each cell thus have the lowest confidence levels of all.

Naturally, the estimates of the net benefits of repeal become increasingly smaller (increasingly negative in some cases) as less and less credible estimates of co-benefits are included in the calculation. A table such as this is useful for summarizing the sensitivity of the net benefits of the rule to the inclusion of co-benefits, and to alternative limits that are placed on the credibility of co-benefits estimates, if they are to be considered at all.

With the net benefits estimates for all the sensitivity cases (in Tables 4-1 through 4-4 in the CPP Repeal RIA) consolidated into this single table, one can more readily infer the extent to which the acceptance of co-benefits estimates in the policy evaluation affects one's view of its potential to be net beneficial.[25] When either discount rate is used, net benefits can become negative, but generally only when co-benefits are both included in the evaluation, and are based on the lower-confidence assumptions about the continuation of the C-R function to levels far below the NAAQS. As one would expect, the potential that net benefits will be negative is somewhat larger for the 3% discount rate than for the 7% discount rate cases.

The important insight made clearer by providing a condensed summary such as the above is that whether the repeal of the CPP will result in net benefits is not a certainty, and depends heavily not just on whether one believes CP co-benefits are appropriate to include in a climate RIA, but also on how willing one is to believe in the unabated continuation of the $PM_{2.5}$ and ozone C-R relationships to levels far below their respective NAAQS levels.

[25] We reiterate that the co-benefits sensitivity cases should be revised to include analogous cutpoints for ozone, which will reinforce this statement. If the cutpoint sensitivities for both are computed to calculate risk relative to the cutpoint, these results will also be reinforced.

Table 2. Sensitivity of Net Benefits of CPP Repeal to Inclusion of Increasingly Uncertain Forgone Co-Benefits (Rate-Based Option)

		Discount rate case[26]	
		3%	**7%**
2020	No co-benefits Cutpoint at NAAQS Cutpoint at LML No cutpoint	$2.1 $1.5 to $2.0 $0.9 to $1.5 $0.3 to $1.4	$2.9 $2.4 to $2.8 $1.8 to $2.3 $1.2 to $2.3
2025	No co-benefits Cutpoint at NAAQS Cutpoint at LML No cutpoint	($0.4) ($3.1) to ($1.1) ($10.5) to ($7.3) ($18.1) to ($7.8)	$4.7 $2.1 to $4.0 ($4.6) to ($1.6) ($11.5) to ($2.0)
2030	No co-benefits Cutpoint at NAAQS Cutpoint at LML No cutpoint	$5.7 $0.7 to $4.2 ($13.5) to ($7.6) ($28.3) to ($8.6)	$14.0 $9.2 to $12.7 ($3.6) to $2.0 ($16.9) to $1.1

The temporal aspect of the potential for negative net benefits revealed in the above tables is of some interest, because, as the CPP Repeal RIA notes (at p. 11), there is an issue of what regulations take place first in terms of the net benefits of the next regulation. Given that the co-benefits come from pollutants that are subject to NAAQS, and may be more stringently regulated by the later dates, some of those forgone co-benefits may occur "anyway" as a result of direct regulation of those CPs that would occur even without the CPP. Indeed, the lower the cutpoint considered reasonable (which is what drives up the forgone co-benefits), the more likely it is that those $PM_{2.5}$ reductions will occur anyway by the years 2025 and 2030 – and thus should not even be considered as forgone co-benefits for the CPP.

H. Suggestions for Providing Insight About Geographical Distribution of Co-Benefits

As the results of the cutpoint sensitivity analyses show, many of the $PM_{2.5}$ co-benefits are apparently occurring in areas that have low $PM_{2.5}$ concentrations from the start. Clearly the best way to demonstrate this would be to perform full photochemical air modeling and graph both baseline $PM_{2.5}$ and estimated mortality reductions as overlays. However, some geographical

[26] The discount rate affects both the forgone climate benefits and the avoided compliance cost estimates (as can be seen in CPP Repeal RIA Table 4-1

insight can be gained even from the current outputs of IPM model runs, as illustrated with the figures below.

NERA obtained the detailed IPM model output files from the IPM model runs that were used to estimate compliance costs and associated emissions reductions. (These are the same for both the original and CPP Repeal RIA.) These files identify the generating units that are projected to have SO_2 and NO_x reductions as a result of CPP implementation, the total of which is used to calculate the RIAs' co-benefits using the BPT approach.[27] We assigned each unit to its county, and mapped the projected reductions across the U.S. at the county level. Figure 3 maps the counties in which the SO_2 tons of reduction associated with the mass-based option are projected to occur. Figure 4 does the same for the associated NO_x tons reduced.

These files tell us where IPM has projected the reductions in generation will occur– which itself injects an unknown amount of uncertainty into the total tons of reduction, given that the reduction in SO_2 and NO_x per unit of reduced CO_2 will vary depending on which units are projected to reduce their generation to comply with the CPP. Whatever may be the uncertainty in total tons, it is unsurprising that there is a fair amount of overlap in where SO_2 and NO_x reductions occur, given that compliance with the CPP is mostly achieved by reduction of utilization of certain electricity generating units rather than reduction in those specific pollutants.

Another interesting feature is that some counties are projected to experience an increase rather than decrease in emissions. This reflects the fact that as some plants close down, others in other locations may generate more. Thus, the maps tell us that estimated co-benefits of the CPP were not necessarily positive for all people in all parts of the U.S. These distributional differences in where co-benefits are likely to be concentrated, and possibly also negative, would be useful to report in interests of transparency.

We recognize that the location of emissions reductions are not the same as the locations of air concentration changes, given that $PM_{2.5}$ and ozone are formed as the result of secondary chemical reactions in the atmosphere following emission of their precursors such as SO_2 and $NO_{x.}$ Nevertheless, a rough first approximation of where the concentration changes will occur may be possible to infer from these maps of where the emissions reductions are projected to occur. **We therefore recommend that such maps be presented in the co-benefits section of the RIA, particularly if photochemical modeling of these specific emissions reductions has not been done. In the latter case, the better alternative would be to provide the maps of the projected changes in air quality results.**[28]

[27] The two files for 2025, EPA (2015f) and EPA (2015g), were submitted by EPA to the CPP Docket, EPA-HQ-OAR-2013-0602.

[28] It would appear that EPA could do this with current results, as it seems that its analysis of the BPT for the 2015 CPP RIA was based on 2015 modeling of the predicted changes in tons from the proposed CPP's Option 1 case. While those reductions are not going to be identical to the results of the final CPP's compliance projections, they will nevertheless be very informative about the general geographic pattern of where the air quality changes are

Figure 3. Location of 2025 IPM-Projected SO_2 Reductions (Mass-Based Option)

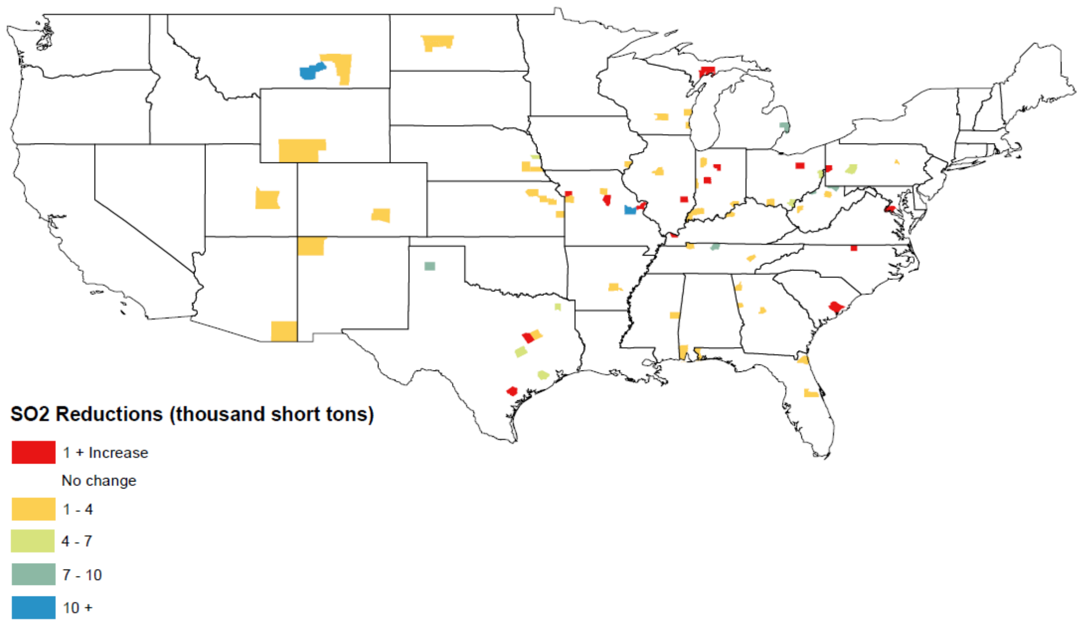
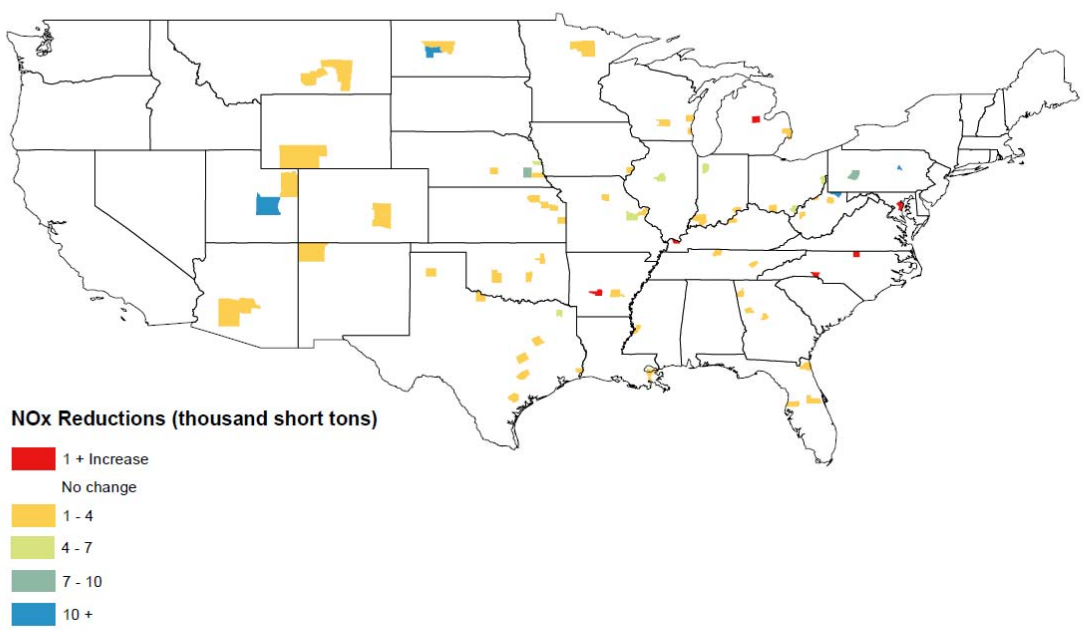


Figure 4. Location of 2025 IPM-Projected NO_X Reductions (Mass-Based Option)



---

occurring, and should be provided if EPA does not proceed with its intention of conducting more specific air quality modeling.

Finally, it would be useful if the RIA were to provide maps showing the distribution of baseline $PM_{2.5}$ and ozone levels in each of the modeled years. An ability to compare the projected locations of the emissions changes (or better, the air quality changes) from CPP compliance with baseline projection of concentrations in each compliance year analyzed would help readers gain insight on why co-benefits are so sensitive to using a cutpoint in the co-benefit calculations. This would also help readers understand what is inside the BPT approach's black box.

IV. SOCIAL COST OF CARBON

The pollutant targeted by the CPP was CO_2, and therefore, the targeted benefits of that rule were those associated with the impact to climate change. RIAs for rules that target greenhouse gases have often relied on a concept known as the SCC to estimate the net economic value of climate impacts associated with each incremental ton of CO_2 emitted.[29] While the use of SCC to assess climate benefits in RIAs dates back about a decade, the U.S. government's quantitative SCC estimates have varied over time as both climate assessment models and philosophies regarding the appropriate non-scientific ("framing") assumptions to apply when running those models have evolved.[30] Both assumptions about scientific phenomena and analysis framing assumptions have been shown to have extremely large impacts on the SCC estimates, and this has made every attempt to develop an SCC value for use in policy evaluations highly controversial.

The CPP Repeal RIA focuses on SCC estimates that have been calculated with a wider range of alternative values considered for two of at least four important framing assumptions that were adopted during the previous Administration (and included in the 2015 CPP RIA). Given the high degree of sensitivity of SCC estimates to alternative values for these two framing assumptions, and the complete absence of such estimates in the 2015 CPP RIA, the range of potential net benefits is substantially altered in the more recent RIA. The two framing assumptions that are treated differently are:

1. *The geographic scope of climate impacts that is considered relevant for comparison to compliance costs*. The 2015 CPP RIA assumed that the CPP's U.S. compliance costs should be compared to the rule's estimated impacts of global damages, including those projected to occur outside of the U.S. (2015 CPP RIA, p. 4-4), and it did not report the U.S.-specific component of the global impact at all. The CPP Repeal RIA gives primary emphasis to U.S.-specific impacts, while still providing estimates of global impacts separately.

[29] Like the estimates of criteria pollutant co-benefits discussed in Section III, the SCC is a dollar per ton estimate. The U.S. government's SCC estimates are stated in dollars per metric ton of CO_2 emitted and vary with the year in which the ton is emitted.

[30] Framing assumptions are assumptions that have no objective or testable basis, and which instead reflect ethical and other value judgments of the decision maker that are unavoidable in the analysis of the impacts of a particular decision. Examples of framing assumptions in the SCC are the choice of geographical and temporal scope to incorporate into the climate damage calculations, the baseline conditions projected to occur in the far future, and the relative weight to assign to future vs near-term impacts. None of these judgments are fixed in the climate models that are used, but all have significant impact on the estimates that any given climate model will produce. There is no single correct way to set such framing assumptions. Decision analysis practice suggests that such judgments should be tailored to the context of the decision that is being informed, including the relative balance deemed acceptable between estimates based on assumptions that have strong empirical support vs. those that involve significant extrapolation beyond the available data. As a result, completely different SCC values may be appropriate for different decisions and for different decision makers.

2. *The discount rate that is used to apply different relative weight to consumption changes that occur in the future versus now*. The 2015 CPP RIA used discount rates from 2.5% to 5%. The CPP Repeal RIA continues to use the 2.5% and 3.0% discount rates, and expands the range to include 7%, while giving primary emphasis to results for discount rates of 3% and 7%.[31]

The CPP Repeal RIA notes that both of these framing assumption changes have been made to comply with the requirements of Executive Order 13783, which withdraws the prior Administration's SCC technical support documents (*i.e.*, IWG, 2010, 2013a, 2013b, 2015) and requires that future SCC values adhere to guidance about framing assumptions expressed in OMB's Circular A-4 (OMB, 2003, pp. 42-43). The bases for both of the above framing assumption choices are discussed in more detail in Sections IV.A and IV.B below, respectively. Although we will not discuss them in as much detail, **we also note here that there are yet other important framing assumptions implicit in RIAs' climate benefits estimates that we recommend also be reconsidered in developing SCC values for use in future RIAs**. Two important ones include:

- ***The choice of time horizon over which impact estimates are made which affects the confidence one can place in the resulting SCC estimates***. At present the models give equal credence to an estimate of economic impact that occurs in 2250 as it does to an estimated impact that occurs in 2050. While discounting diminishes the relative effect of a later impacts, it does not (and should not be used to) assign lower confidence to outcomes projected in the far future. The enormous uncertainty in climate impact estimates, particularly those that SCCs ascribe to the far future, is discussed and characterized quantitatively in many studies, including NERA (2014a), Smith (2014), and Smith (2015). (The effect of longer time horizons on confidence in the SCC results is not dissimilar to the effect that assuming lower cutpoints on $PM_{2.5}$ risk impacts has on resulting co-benefits estimates.)

- ***The choice of baseline future emissions against which to value the impact of an incremental ton in the near term***. The estimate of the SCC of a ton emitted in a given year, such as 2025, is affected by the total amount of baseline greenhouse gases assumed to be emitted *after* that year until the end of the time horizon. The government's current method of calculating its SCC values averages SCC estimates from five alternative baseline projections of future emissions that are assumed by the SCC-estimating models to be invariant to any emissions control decisions made as a result of the resulting SCC

[31] In its reporting of estimated climate benefits, the 2015 CPP RIA included estimates using the 95th percentile of damages using a 3% discount rate. From a decision analysis perspective, a comparison of "worst case" benefits to "best case" costs without also considering the other ends of both distributions is not an appropriate method for accommodating risk aversion into an evaluation. The CPP Repeal RIA has dropped this SCC estimate without discussion. We would recommend that the next RIA give a more explicit discussion of the reasons for excluding this type of net benefit calculation.

estimate.[32] Four of these five baseline projections assume no long-term emissions reduction efforts, even if the resulting elevation in estimated near term SCC values associated with those no-future-control assumptions do motivate actions to decrease emissions now (and in the future). A more logically-coherent approach for estimating SCC values to guide near-term reduction decisions would assume that future (long-term) emissions would also be reduced consistent with continued use of the SCC through the end of the model horizon. Doing so would imply lower baseline emissions in at least four of the five baseline projections now used by the U.S. government, which, in turn, would imply lower average estimates of SCC than those currently adopted.[33]

Finally, in Section IV.C we make a recommendation for how the RIA can improve its communication and transparency about the temporal nature of the climate impact estimates, which have a uniquely long-term dimension relative to the estimated costs or other estimates to which they are being compared. This recommendation would not alter any SCC calculation *per se*, but would alter their presentation. The recommendation is consistent with Circular A-4 guidance calling for transparency in communications of results (p. 17, Section E.4).

A. Geographic Scope of Climate Impact Estimates

The SCC estimates developed by the previous Administration (IWG, 2010, 2013a, 2013b, 2015) embodied a judgment that all climate impacts experienced worldwide should be included when evaluating costs and benefits of U.S. policies affecting U.S. CO_2 emissions. This was deemed the appropriate perspective even if the policy measures were unilateral and would impose costs only on the U.S. economy. Consistent with that perspective, the 2015 CPP RIA compared estimates of global climate impacts to estimates of the costs of complying with the CPP in the U.S. That RIA did not provide any information on the portion of global impacts that might be expected to accrue domestically in the U.S.

For the CPP Repeal RIA, additional SCC estimates have been calculated reflecting domestic climate impacts alone. Because these were computed in the same manner and with the same assumptions as the global SCC estimates calculated by the prior Administration (p. 162 of the Current RIA), they indicate the portion of the 2015 CPP RIA's climate impact estimates that

---

[32] Each baseline projection also assumes future levels of gross domestic product ("GDP"), and population. The government adopts the simple average of all the alternative SCC estimates for a given discount rate as "the" SCC value for that discount rate.

[33] One of the five baselines used in current SCC estimation process (called the "Fifth Scenario") assumes future emissions levels low enough to stabilize global atmospheric concentrations at 550 ppm. This one baseline is not inconsistent with the notion of using SCC estimates to motivate control measures today. Notably, it also produces lower SCC estimates than any of the other four baselines. Until the U.S. government adopts SCC-estimating models that endogenously adjust future emissions levels to be consistent with near-term SCC-based reduction efforts, a case might be made to use SCC values based solely on that "Fifth Scenario" baseline, rather than continuing the present practice of giving it only 20% weight, compared to the 80% weight assigned to SCC estimates are based on internally-inconsistent future emissions baselines.

could have been attributed to impact on the U.S. The primary results reported in the various net benefits summary tables in Sections 1 and 4 of the CPP Repeal RIA reflect only domestic impacts, but quantitative results using the respective global SCC values are reported in Appendix C of the RIA. Thus, unlike the 2015 CPP RIA, the CPP Repeal RIA provides estimates for both domestic and global forgone climate benefits.

The CPP Repeal RIA points to OMB guidance in Circular A-4 as the justification for its emphasis on domestic benefits (pp. 42-43). There are sound reasons for OMB's guidance to have called for non-U.S. benefit (or forgone damage) estimates to be reported separately from U.S. damages. This fact is briefly noted in a footnote in Appendix C (CPP Repeal RIA, fn. 83, p. 168), which merits greater prominence:

> *While Circular A-4 does not elaborate on this guidance, the basic argument for adopting a domestic only perspective for the central benefit-cost analysis of domestic policies is based on the fact that the authority to regulate only extends to a nation's own residents who have consented to adhere to the same set of rules and values for collective decision-making, as well as the assumption that most domestic policies will have negligible effects on the welfare of other countries' residents (EPA 2010; Kopp et al. 1997; Whittington et al. 1986). In the context of policies that are expected to result in substantial effects outside of U.S. borders, an active literature has emerged discussing how to appropriately treat these impacts for purposes of domestic policymaking (e.g., Gayer and Viscusi 2016, 2017; Anthoff and Tol, 2010; Fraas et al. 2016; Revesz et al. 2017). This discourse has been primarily focused on the regulation of greenhouse gases (GHGs), for which domestic policies may result in impacts outside of U.S. borders due to the global nature of the pollutants.*

The points that are made in the papers cited in this quotation deserve a more thorough discussion in the final RIA, possibly in the form of a technical support document to accompany that RIA. We recommend that such an extended discussion be developed. In its absence, we briefly expand below on the key elements of the justification for emphasis on domestic benefits in the case of a global externality such as climate change.

A common thread in the literature supporting emphasis on domestic benefits in a policy that is known to have non-domestic spillover effects is tied to the concept of legal standing. This in turn is tied to the fact that standing has usually been granted only in the presence of reciprocal effort on the part of the other nations. Reciprocal effort is important because it implies something akin to a joint optimization. Without joint optimization, results of a unilateral benefit-cost policy optimization that considers the other nations' benefits leads to outcomes that are detrimental to the individual nation's interests. Thus, the societal rationality that BCA promises is lost.

Another way of explaining the theoretical reasons for considering only domestic benefits in a BCA is noted in some of the papers cited in the CPP Repeal RIA's footnote 83 (p. 168). The conclusion that a BCA will lead to societal welfare enhancement is founded on a principle called the Kaldor-Hicks "potential compensation principle" ("PCP"). The PCP addresses concerns with distributional effects of a policy (*i.e.*, the potential that the costs of the policy may be distributed more heavily on some citizens than their share of its benefits). According to the PCP, a policy can be treated as welfare-enhancing as long as the value of its benefits can be redistributed by that society in such a way that all those absorbing its costs will be individually compensated. The policy need not actually achieve this compensation, but only identify that the society making the decision to implement that policy be able, potentially, to do so through other policy mechanisms available to it. The PCP is the basis for the conclusion that a policy that is estimated to have positive net benefits will enhance societal welfare.

The difficulty with including non-domestic benefits in a net benefit calculation for a unilateral national policy decision is that national authority for potentially redistributing benefits does not extend to the benefits accruing outside of that nation. If the non-domestic benefits are necessary for net benefits to be positive, then the PCP fails, and that net benefits estimate cannot be viewed as necessarily welfare-enhancing. In other words, the underlying social welfare properties of BCA are lost when non-domestic benefits are automatically included in the calculation, and thus it is important to *separate* estimates of non-domestic benefits from domestic benefits. It is acceptable to include non-domestic benefits as additional justification supporting a policy, but a first principle remains that the domestic-only net benefit calculation be positive. Policies that are likely to produce positive net benefits only when including some or all non-domestic benefits should be avoided or otherwise demand much stronger evaluation of off-setting considerations such as the existence of reciprocity.

A common counterargument to the above arguments is that the U.S. needs to account for global impacts in order for its assessments of climate policies to be consistent with a global optimization of climate risk management. A related argument is that the U.S. needs to do this to demonstrate leadership in global climate policy development, thus encouraging other countries to undertake similarly aggressive action. It would be appropriate to include global damages in valuations of U.S. policies that are to be part of a global policy package (*i.e.*, when actions in other major-emitting nations are also being set to be optimal with respect to the same global damage estimates). However, that is a different decision context than the one-by-one consideration of unilateral U.S. policies that are not part of a global optimization package. Even if the CPP were to be viewed as part of a U.S. commitment under the Paris Agreement, it is not correct to view it, or the other countries' national commitments under the Paris Agreement, as consistent with a global climate control optimization. A fundamental concept underlying that Agreement is the voluntary nature of the commitments that each country is willing to contribute when considering its own domestic conditions. As a result, each nation's commitment reflects what it considers the best it can contribute within the time frame of concern – a set of domestically-affordable actions rather than a set of actions possible within each nation that would have global benefits greater than their domestic costs.

Thus, even if the U.S. ultimately remains a party to the Paris Agreement, it would not be inconsistent for the U.S. to focus primarily on the domestic benefits of its own domestic policy decisions, while leaving room in the analysis results to give some recognition (for altruistic purposes) to the additional incremental benefits that other nations may accrue as a result of the U.S.'s domestic spending. This is the basis for the Circular A-4 guidance to report domestic benefits separately from non-domestic benefits. The amount of recognition to decide to grant to non-domestic benefits in a final policy judgment could be tied to the amount of reciprocal consideration of global benefits that appears to be entering into other nations' levels of "ambition" in reducing their own carbon emissions.

B. Discounting Far-Future Climate Impact Estimates

The SCC estimates used in the 2015 CPP RIA were based on discount rates of 2.5%, 3% and 5% per year. Citing the requirement of Executive Order 13783 to rely on guidance of Circular A-4 for updated estimates of the SCC, the CPP Repeal RIA provides additional climate impact estimates based on new SCC calculations using a 7% discount rate. The primary net benefit estimates include a 3% and 7% discount rate estimate. Appendix C of the CPP Repeal RIA reports the comparable climate benefits estimates for 2.5%, reflecting Circular A-4 guidance to also consider estimates with a lower discount rate in cases involving very long time horizons, such as climate change. No specific estimates are provided in the CPP Repeal RIA for the 5% discount rate, possibly because a discount rate between 3% and 7% is not mentioned in Circular A-4. However, it is clear that estimates for that discount rate would lie within the range provided in the primary tables.

The CPP Repeal RIA notes that the 3% discount rate is intended by Circular A-4 to reflect the consumption rate of interest while the 7% rate is intended to reflect the capital rate of interest (p. 166). Circular A-4 requires that both discount rates be used in RIAs, and does not suggest that some types of regulations could be evaluated using only one or the other of the rates.[34] The argument for omitting an estimate based on 7% provided by developers of the initial ranges of SCC estimates[35] is that the models being used to estimate the monetary value of climate damages have already converted all damages into consumption-equivalent units, and therefore only the consumption rate of interest should be used in converting far future climate damages into a present value. The reason SCC estimates based on 5% were provided rather than just 3%, as advised by Circular A-4, was that it reflected the IWG's view on uncertainty regarding the consumption rate of interest. They described this range as generally being 3% to 5%, while a lower rate of 2.5% could be justified by concerns about growth rate uncertainty and/or ethical issues (IWG, 2010, p. 23).

---

[34] Circular A-4 also allows for a sensitivity analysis using an unspecified lower (but positive) discount rate for regulatory actions that would have "important" intergenerational cost or benefit impacts (OMB, 2003, p. 36).

[35] This group is often referred to as the Interagency Working Group ("IWG").

1. Reasons to Consider a Discount Rate Higher Than the Consumption Rate of Interest for Discounting the IWG's SCC Results

Certainly the order to follow Circular A-4 guidance on discount rates provides a direct reason to provide sensitivity analyses based on 7%. On a more directly theoretical basis, if one accepts the IWG's view that the consumption rate of interest may be as high as 5% (as did the IWG), an argument for considering the sensitivity of the SCC to discount rates that exceed 5% is the following:

- The SCC calculations being used by the U.S. government are conducted in the absence of any consideration of costs to achieve the incremental tons of reduction that are simulated. That is, the consumption impacts of an incremental change in emissions are estimated by the models that the U.S. government has adopted, while those models do not include any accounting for the consumption impacts of the investment that would be required to achieve that incremental emissions change.

- The present value of benefits from a ton of carbon reduction is thus estimated in a vacuum that ignores any opportunity cost associated with achieving that reduction. Instead, that SCC estimate is compared to a separately-derived estimate of the cost of carbon-reducing action(s) to determine whether to mandate such control measure(s). If, as a result of this *ex post* SCC-to-control cost comparison, a control action is required, the cost of that control action will have its own incremental impact on future consumption levels, which will be in the opposite direction of the improved future consumption reflected in the SCC estimate. That offsetting incremental reduction in future consumption levels is not accounted for in the U.S. government's method of estimating SCC. In other words, any control actions motivated by use of an SCC estimate will cause an endogenous adjustment of the future consumption levels that are an important determinant of the value of the SCC in the first place, and that adjustment is not accounted for by any of the SCC models that have been used by the U.S. government.

- The dollars spent on the incremental ton of emission reduction in a given year will have an opportunity cost thereafter that is equal to the real rate of return on capital, which is recognized to be higher than the consumption rate of interest. While it would require a complex analysis to directly incorporate that opportunity cost of capital into the U.S. government's SCC estimates, the effect of doing so would be equivalent to a slight reduction in the baseline future consumption path upon which the SCC's consumption impacts are computed. It would thus reduce the SCC value, and would do so in a manner that is mathematically similar to a slight increase in the consumption rate of interest (whatever it may be assumed to be for a given SCC calculation).

In summary, it is appropriate that the SCC be estimated using a range of discount rates that reflects the range in the estimated consumption rate of interest plus some adder to reflect the long-run opportunity cost of the control cost on the long-run consumption path that is independent of how climate impacts also reduce it. If the consumption rate of interest does lie in the range of 3% to 5%, the appropriate discount rates to use for estimating present values from the U.S. government's versions of SCC-estimating models should be somewhat above 3% to somewhat above 5%. For this reason, **we recommend that the RIA also present estimates of forgone climate benefits based on 5**%, as well as the 3% and 7% mandated by Circular A-4.

The concept of an endogenous opportunity cost of capital is more properly captured in the standard version of the DICE model, rather than the version adapted by the IWG for its own SCC estimation process. That standard version does not estimate damages in a vacuum independent of the cost of control, but rather includes both costs and climate benefits to determine the socially-optimal level of investment in climate control (Nordhaus, 2017).[36] An optimal real rate of increase in the price of carbon is generated by the standard DICE model. Professor Nordhaus notes that the goods discount rate is endogenously determined, and model parameters for assumptions such as intergenerational discounting (which are unobservable) should be calibrated to produce near-term savings rates and rates of return on capital (which are observable) that are consistent with those actually observed (Nordhaus, 2007, 2017). Based on this logic, Nordhaus's preferred discount rate in a model that estimates an optimal SCC by balancing the consumption impacts of spending to control emissions against those of resulting climate outcomes is between 4% and 5% (Nordhaus, 2017, Table 3). In earlier analyses, he calibrated to consumption discount rates of over 5%, and showed how this discount rate could be reconciled with an assumed rate of time preference across generations as low as 0.1% (Nordhaus, 2007, p. 698-700).

The sensitivity of net benefits estimates to the discount rate assumption is greatly reduced when domestic benefits are applied (see for example, CPP Repeal RIA Table 1-5, plus the sensitivity results reported on p. 167 for a 2.5% discount rate). However, it remains a significant source of sensitivity if non-domestic benefits are to be given any weight in decision making (as can be seen by replacing the domestic climate benefits in Table 1-5 with the global climate benefits estimated for 3% and 7% that are reported on p. 168).[37] For this reason, absent any easy empirical resolution to the appropriate discount rate range to use, it is useful to consider from first principles one of the key elements of the debate about discount rates in the context of climate change benefits estimates, which we discuss in the next section.

---

[36] To perform its own "DICE" calculations that it considered "harmonized" with FUND and PAGE model runs, the IWG has removed this optimization feature from the versions of DICE that it has used (IWG, 2010, p.7, fn.3).

[37] At 3%, global benefits reverse the finding of positive net benefits from repealing the CPP, whereas at 7% they do not.

2. Reasons Not to Consider Discount Rates Lower Than the Consumption Rate of Interest for Discounting the IWG's SCC Results

The most commonly-articulated argument in favor of discount rates as low as or lower than 3% for far-future climate impact estimates is a concern that the present generation will make decisions that unethically ignore the implications of their current consumption on that available to future generations. Circular A-4 acknowledges this concern and that a sensitivity analysis with a rate of interest lower than 3% would be permissible as a sensitivity case, reflecting some views that this concern might be addressed by lowering the discount rate below empirically observed levels. However, Circular A-4 also suggests that one possible way to address concerns with intergenerational equity would be:

> *… to follow the same discounting techniques described above*[38] *and supplement the analysis with an explicit discussion of the intergenerational concerns (how future generations will be affected by the regulatory decision). Policymakers would be provided with this additional information without changing the general approach to discounting.* (OMB, 2003)

In other words, rather than using a discount rate lower than 3% to "adjust for" concerns with intergenerational equity, one might perform the present value analysis using 3% and 7%, then directly report on the degree of inequity that is implicit in the analysis. In this section, we provide an example of how this can be done using the same model results that produce the SCC values used in U.S. government RIAs.[39]

The principle that the consumption ("welfare") of future generations should be given fair consideration when society makes decisions today that may have very long-term consequences is not controversial. However, the prescription that the way to accomplish this is to use a discount rate that is lower than, and inconsistent with, empirical evidence of current societies' consumption rate of interest is not the only approach that economists/philosophers have suggested for ethically accounting for future generations.

Mishan (1977) analyzes intergenerational welfare and growth models, as well as theories of intragenerational welfare, to assess economic criteria for intergenerational comparisons. The paper shows that any number of possible intergenerational distributions can be derived from the models, but also makes the case that "no economic criterion can produce acceptable answers to the distribution problem – whether at a point of time or over time – since the problem is basically an ethical one." (Mishan, 1977, p. 304). Recognizing the ethical issue is one of personal opinion, Mishan suggests he believes most people would agree on one premise with respect to intergenerational ethics:

---

[38] In the context of this quote, the techniques "above" are to estimate net benefits using 3% and 7% discount rates.

[39] This example and discussion is taken from Smith (2015).

> *For whatever be our view of the fundamental factors explaining differences in existing incomes, we are likely to agree that an equal per capita real consumption for all generations is an eminently fair arrangement …In sum, the ethical appeal of equality of per capita consumption over generational time is independent of a belief in the justice of an equal division of the product in any existing society, and is far more compelling.* (Mishan, pp. 300-301).[40]

In brief, economic analysis offers no way to sort among prescriptive formulas. It is thus false to view the common prescription of adjusting the discount rate to lower levels than is descriptive of existing society's consumption rate of time preference as the only ethical way to handle the question of fairness to future generations. In fact, studies have shown that the approach of addressing this concern through lowered discount rates creates analytic problems. Two such problems were noted by Farrow and Viscusi (2011): time inconsistency and infinite benefits. Nordhaus (2007) further demonstrates that an overly low discount rate in an SCC-estimating integrated assessment model ("IAM") produces nonsensical implications for savings rates. (Nordhaus, 2007, p. 700)

The quote from Mishan suggests alternative ways to give consideration to the welfare of future generations than titrating the empirically-observed consumption rate of interest to a normatively-prescribed lower level. If Mishan is correct that most would agree that we should manage existing societal decisions so that future generations will have at least our level of real consumption, then we can look to the consumption projected by the IWG's IAM model runs to determine how well different emissions regulations meet that objective. Table 3 presents the real per capita consumption in each of the five IWG baseline scenarios using the IWG's version of the DICE model for current time (2020), and then in 2100, 2200, and 2300. These consumption paths are the endogenous ones that DICE calculates, given the climate impacts associated with each scenario's respective projection of emissions.[41] Table 3 shows that even after absorbing the impacts of temperature change, all of the IWG scenarios are projecting that future generations will be far wealthier and have far higher real consumption than is the case in the present. In fact, by 2100, real consumption is projected to be three to five times higher than real global consumption today. By 2300, when the largest amount of climate impact (with unreduced baseline emissions) is projected to occur, real consumption is projected to be between 7 and 25 times higher than we have today. Thus, the scenarios that the IWG has used to compute the SCC of a ton of emission today are also implying that any cost we incur today will reduce our generation's lower consumption in order to add to the much higher projected baseline consumption ("welfare") of future generations.

[40] This philosophical stance originates with Rawls (1971).

[41] In other words, the damage function in the model decreases the raw IWG projections of GDP in light of the emissions projected and their projected impact on temperature. These calculations used the median value of the equilibrium climate sensitivity input assumption (*i.e.*, 3).

Table 3. Real Undiscounted Consumption per Capita Over Time IAM Scenarios (Baseline Emissions)

	IMAGE	MERGE	MESSAGE	MiniCAM	5th scenario
Real global consumption per capita					
2020	$ 9,194	$ 7,427	$ 8,595	$ 7,613	$ 8,171
2100	$ 37,133	$ 22,892	$ 26,912	$ 36,671	$ 31,106
2200	$ 125,365	$ 43,798	$ 53,759	$ 134,827	$ 90,555
2300	$ 169,660	$ 49,239	$ 63,872	$ 187,494	$ 122,001
Consumption relative to 2020 consumption					
2100 relative to 2020	4	3	3	5	4
2200 relative to 2020	14	6	6	18	11
2300 relative to 2020	18	7	7	25	15

Source: NERA runs of DICE model using median equilibrium climate sensitivity (ECS=3)

Table 4 considers the impact on future consumption of eliminating emissions. In these analyses, NERA set all manmade emissions after 2010 to zero in each of the same five respective IWG socioeconomic scenarios. The result is that future generations' real consumption does rise; relative to 2020 real consumption, future generations will be even better off than we are. In other words, the projected inequitable distribution of wealth over time – which favors future generations – is exacerbated by reductions in emissions. Furthermore, as discussed earlier in this subsection, the costs of those emissions controls are not included in these projected consumption levels; to the extent that they are more heavily borne in the near term than in the far future, inclusion of the costs of attaining the welfare of future generations shown in the table below may further tilt the balance in favor of future generations.

Table 4. Real Undiscounted Consumption per Capita over Time in IAM Scenarios (Zero Manmade Emissions from 2015 Onwards)

	IMAGE	MERGE	MESSAGE	MiniCAM	5th scenario
Real global consumption per capita					
2020	$ 9,202	$ 7,433	$ 8,603	$ 7,620	$ 8,177
2100	$ 38,466	$ 23,954	$ 27,726	$ 38,072	$ 31,458
2200	$ 140,133	$ 51,271	$ 58,024	$ 151,673	$ 92,610
2300	$ 202,420	$ 63,738	$ 71,653	$ 224,995	$ 126,239
Consumption relative to 2020 consumption					
2100 relative to 2020	4	3	3	5	4
2200 relative to 2020	15	7	7	20	11
2300 relative to 2020	22	9	8	30	15

Source: NERA runs of DICE model using median equilibrium climate sensitivity (ECS=3), and with manmade emissions set to zero in 2015 and all years thereafter.

In conclusion, it is possible to use the IAM models with reasonable estimates of discount rates based on empirical (behavioral) evidence on the consumption rate of interest, and to separately check that this does not result in unfair welfare outcomes of future generations. This can be done as long as the real consumption levels projected for the far future by the same model runs that estimate SCC do not fall relative to what those models assume is the real consumption level for current generations. This supplemental analysis more directly addresses the issue of intergeneration equity than *ad hoc* reductions of the discount rate to some level lower than empirical estimates of the consumption rate of interest.

If one were to contend that the IAM models do not properly account for the welfare of future generations by consideration of just their projected real consumption, then this would be an admission that any estimate of SCC from those models is also invalid. The welfare calculations implicit in each SCC estimate are based on nothing other than projections of changes in real consumption, now and in the far future.

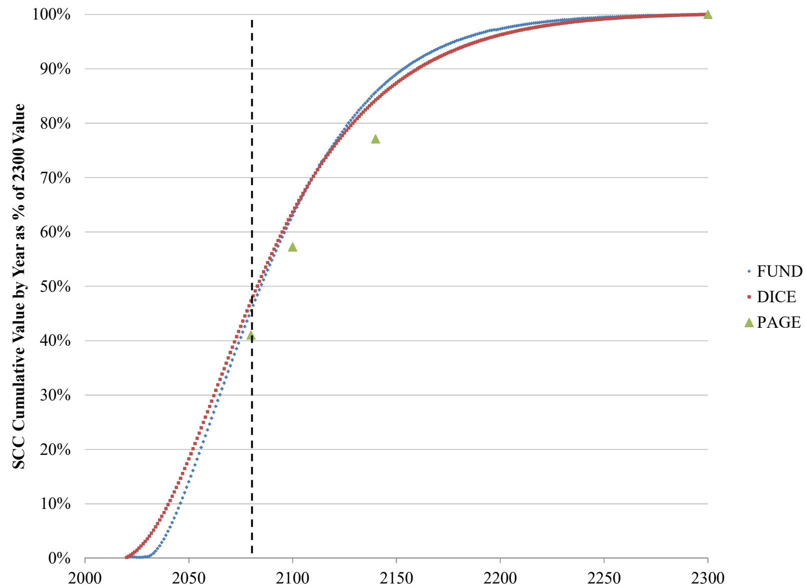
C. Communicating the Temporal Dimension of Net Benefit Estimates That Have a Large SCC-Based Component

When considering net benefits estimates that have a large SCC-based component, such as those in the CPP Repeal RIA, we recommend that EPA better communicate the timing of those SCC-based benefits. NERA has performed additional analysis and model runs of the IAMs (FUND, PAGE, and DICE) that EPA has used to set the SCC values to better understand the timing of the SCC benefits. Our estimates of what fraction of the total SCC value will have accrued cumulatively from the time of emission to 2300 are shown in Figure 5 (for the domestic SCC estimate) and in Figure 6 (for the global SCC estimate). In both cases, this is based on the SCC values using a 3% discount rate. As these figures show, about 50% of the domestic climate benefits would be realized by 2080, and less than 50% of the global SCC estimates.[42]

Evaluating the net benefits associated with the targeted pollutant (Table 1-5, p. 12 in the CPP Repeal RIA), there is only one combination of CPP implementation, year, and discount rate where the net benefits (for the targeted pollutant) of repealing the CPP are negative (*i.e.*, for rate-based implementation, 2025, and a 3% discount rate, which has an estimated net benefit of negative $0.4 billion in 2011 dollars). Using this worst case net benefits outcome, one can infer the net benefits would be highly unlikely to turn negative until after 2080. That is, if only 50% of the forgone climate benefit in that case ($1.4 billion, per Table 1-5) would be realized by 2080, this would imply only $0.7 billion in climate benefits by 2080. Assuming all the other costs and forgone benefits in that net benefit calculation are incurred before 2080, the net benefits by 2080 for that case would be positive $0.3 billion. Since all other cases in Table 1-5 have positive net benefits even through 2300, this adjustment would only reinforce those positive net benefit results.

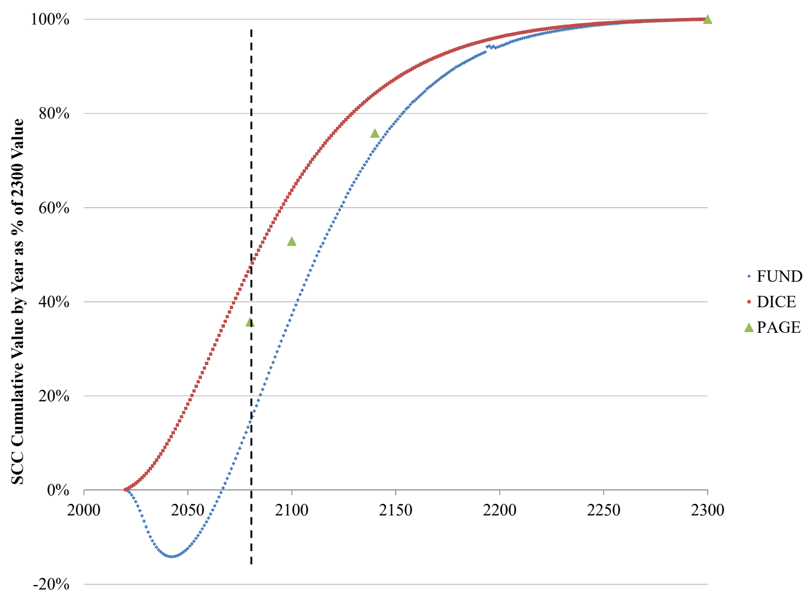
[42] NERA computed values to determine the SCC values over time using the three standard IAMs used by the EPA. For the FUND model, the values are standard outputs by year, averaged across 10,000 iterations and averaged across five baselines (MERGE, MESSAGE, IMAGE, MiniCAM, and 5th Scenario); for the PAGE model, values are averaged across 10,000 iterations and five baselines for separate model runs with terminal years of 2080, 2100, 2140, and 2300; and for the DICE model, values by year are averages across five baselines for a fixed climate sensitivity value of 3.

Figure 5. Cumulative Value of Domestic SCC through 2300 (2007$/metric ton, 2020 emission year)



Sources and notes: NERA analysis using IWG's versions of FUND, DICE, and PAGE models. Values from PAGE model are based on separate model runs with terminal years of 2080, 2100, 2140, and 2300.

Figure 6. Cumulative Value of Global SCC through 2300 (2007$/metric ton, 2020 emission year)



Sources and notes: NERA analysis using IWG's versions of FUND, DICE, and PAGE models. Values from PAGE model are based on separate model runs with terminal years of 2080, 2100, 2140, and 2300.

If one were relying on global, instead of domestic, climate benefits, the communication of the timing of the realization of benefits would become even more important. Based on the analysis contained in the CPP Repeal RIA (Table 1-5 and forgone global climate benefits on p. 168), the net benefits associated with the target pollutant would be negative in 2020 for a 3% discount rate (negative \$0.3 billion for rate-based and negative \$1.9 billion for mass-based). However, in both instances, less than 50% (and possibly significantly less) of the forgone global climate benefits of \$2.8 billion and \$3.3 billion, respectively, would be realized by 2080. Thus, by 2080, both the rate-based and mass-based implementations would still be registering positive net benefits. Another way to think about this is that the compliance costs associated with the CPP would not be "paid back" even by *global* climate benefits until after 2080—more than 60 years after those costs would have been incurred.

V. COSTS OF PROPOSED CPP REPEAL

Section II described how the benefits/avoided costs in the CPP Repeal RIA are based on the cost estimates in the 2015 CPP RIA. The CPP Repeal RIA also has additional observations based on a comparison of results with and without an implementation of the CPP included by the U.S. Energy Information Administration ("EIA") in its *Annual Energy Outlook 2017 ("AEO 2017")*. This additional comparison is discussed in Appendix C of these comments.

Table 5 contains a summary of the detailed annual avoided compliance costs presented in the CPP Repeal RIA, with DSEE costs presented for both 3% and 7% discount rates.[43] The total avoided compliance costs (3% discount rate) in 2025 for the mass-based policy are the same as those presented in Figure 1 (B) in Section II.A.

Table 5. Avoided CPP Compliance Costs from CPP Repeal RIA (Billions of 2011$)

	2020	2025	2030
Rate-Based			
Avoided power sector generating costs	$0.3	($15.7)	($18.0)
Avoided DSEE costs (3%)	$2.1	$16.7	$26.3
Avoided DSEE costs (7%)	$2.6	$20.6	$32.5
Additional generation costs absent demand reductions from EE	$1.2	$9.2	$18.8
Monitoring, reporting, recordkeeping	$0.07	$0.01	$0.01
Total avoided compliance cost (3%)	$3.7	$10.2	$27.2
Total avoided compliance cost (7%)	$4.2	$14.1	$33.3
Mass-Based			
Avoided in power sector generating costs	($0.8)	($13.7)	($21.2)
Avoided DSEE costs (3%)	$2.1	$16.7	$26.3
Avoided DSEE costs (7%)	$2.6	$20.6	$32.5
Additional generation costs absent demand reductions from EE	$1.2	$10.0	$19.3
Monitoring, reporting, recordkeeping	$0.07	$0.01	$0.01
Total avoided compliance cost (3%)	$2.6	$13.0	$24.5
Total avoided compliance cost (7%)	$3.1	$16.9	$30.6

Source and notes: CPP Repeal RIA, Tables 3-1, 3-2, 3-3, and 3-6, pp. 34-35, 41. Negative values denote avoided costs.

[43] We note that the so-called annual avoided DSEE costs are actually annualized costs, rather than first-year costs that we contend should be used instead. This issue is discussed further in Section V.A.2.

A. Presented Avoided Costs Are Not the Full Avoided Costs

The costs presented in the 2015 CPP RIA and the avoided costs in the CPP Repeal RIA both are missing some important information to allow individuals to understand how these costs will impact electricity consumers and industry participants. The market impacts, which do show economic impacts on electricity consumers and industry participants, still do not represent a full picture of the costs of the Final CPP (or the avoided costs of the proposed repeal of the CPP).

1. Market Impacts

Table 3-14 in the CPP Repeal RIA (Tables ES-11 and 3-22 in the 2015 CPP RIA) shows the changes in retail electricity prices and average electricity bills (relative to a case with the Final CPP). However, neither of these measures reflects the spending by electricity consumers on electricity services, which would also include consumers' direct (non-rebated) spending on DSEE. To take this example to an extreme, if electricity consumers could undertake sufficient DSEE projects to completely eliminate their electricity demand then their electricity bill would be $0, but their cost for electricity services would be exceptionally high because of their direct costs of DSEE undertaken to avoid having an electricity bill.

In addition, Table 3-14 in the CPP Repeal RIA (Table 3-18 in the 2015 CPP RIA) shows the change in the price of the Henry Hub natural gas spot price (relative to a case with the Final CPP), but this is not translated into a cost for consumers. Natural gas is purchased by households, commercial businesses and industry, and any avoided increase in the price of that fuel would also be an avoided cost of repealing the CPP that can be calculated by multiplying the change in the price by the quantity of natural gas purchased.[44] In NERA (2014b), NERA estimated this cost of non-electricity natural gas purchases (for the proposed CPP rather than the final CPP), which ranged from $15 billion to $144 billion (present value from 2017 through 2031, taken in 2014 using a 5% real discount rate, in 2013$).[45] This avoided cost is a direct impact of the repeal of the CPP, and should be included in any analysis to provide a more complete picture of the costs avoided by repealing the CPP. **We recommend that EPA include broader measures of economic impacts on consumers beyond just electricity rates and bills, as these are incomplete and potentially misleading.**

---

[44] The quantity of natural gas purchased would likely decrease (increase) somewhat given an increase (decrease) in the natural gas price, but a first order approximation of the economic impact can be estimated based on quantities purchased absent the policy. An analysis using a computable general equilibrium ("CGE") model of the entire U.S. economy, as EPA mentioned they are considering, could provide a more refined estimate of this cost because the non-electric sector natural gas demand in a policy scenario would be at equilibrium given changes in electric sector natural gas demand and natural gas prices.

[45] NERA Report, "Potential Energy Impacts of the EPA Proposed Clean Power Plan," included in comment submitted by Paul Bailey, Senior Vice President Federal Affairs and Policy, American Coalition for Clean Coal Electricity at https://www.regulations.gov/document?D=EPA-HQ-OAR-2013-0602-25764. Full NERA Report available at:
http://www.nera.com/content/dam/nera/publications/2014/NERA_ACCCE_CPP_Final_10.17.2014.pdf.

2. Under-Reporting of Demand-Side Energy Efficiency Costs

The reported avoided compliance costs of achieving DSEE (Tables 3-1, 3-2, and 3-3 in the CPP Repeal RIA) are $2.1 billion, $16.7 billion, and $26.3 billion for 2020, 2025, and 2030, respectively (with a 3% discount rate). These are the same costs in the 2015 CPP RIA (Table 3-3). However, these are not the full costs of the DSEE measures undertaken in those years.

The avoided costs/costs for DSEE reported in the CPP Repeal RIA and the 2015 CPP RIA are not the actual ("upfront") spending associated with the level of DSEE adopted in the reported year, but instead are annualized costs. In both the Original and CPP Repeal RIAs, EPA calculated costs of achieving DSEE improvements in two ways: 1) Annual first-year costs, and 2) Annualized costs.[46] DSEE is typically associated with an upfront cost, with benefits realized in the future over a number of years (EPA assumes an average life of 10.2 years). EPA properly reflected these as upfront costs when calculating the impact of DSEE costs on retail rates, but did not have the same treatment of these costs when presenting its avoided compliance costs in the CPP Repeal RIA (or compliance costs in the 2015 CPP RIA).

EPA has properly represented how benefits from DSEE accrue over time (based on its assumed EE expiration schedule), but it has not properly represented the avoided costs/costs of DSEE. Table 6 shows the DSEE costs for the two ways in which EPA has calculated such costs, and then shows that the approach used for determining avoided costs in the CPP Repeal RIA leads to a very large understatement of such avoided costs in 2020 and 2025 (with a small overstatement of costs in 2030).

Table 6. Comparison of Reported and Correct Timing of Avoided Costs of Achieving DSEE Improvements (Billions of 2011$)

	2020	2025	2030
Reported (Annualized)	$2.1	$16.7	$26.3
Correct (First-Year)	$18.1	$25.4	$25.3
Under (Over) Reporting	$16.0	$8.7	($1.0)

Such changes do not affect any other avoided costs or forgone benefits in the CPP Repeal RIA, so these understatements of avoided costs (and small overstatement in 2030) would directly translate to higher net benefits of repeal of the CPP in 2020 and 2025 (and slightly lower net benefits in 2030) if EPA had used the proper first-year DSEE costs instead of the annualized costs. (We also note that the analysis of avoided compliance costs using *AEO 2017* presents the DSEE costs as expenditures, equivalent to first-year costs.[47]) **We recommend that EPA properly report DSEE costs as first-year costs to accurately reflect the timing of when these**

[46] See EPA (2015b), Tables 32 and 33 (Total Rows).

[47] See further discussion of avoided costs from *AEO 2017* in Appendix B. Cost details for *AEO 2017* are included in: https://www.regulations.gov/document?D=EPA-HQ-OAR-2017-0355-0010.

costs will be incurred. This will greatly increase the net benefits of repeal estimated for 2020 and 2025.

B. Present Value vs. Annual Value

The CPP Repeal RIA purports to present avoided compliance costs and forgone benefits on an annual basis for 2020, 2025, and 2030 (*e.g.*, Tables 3-6 and 3-8). However, these comparisons of annual avoided compliance costs and forgone benefits in 2020, 2025, and 2030 are false comparisons because neither the avoided costs nor the forgone benefits are actually annual values for the stated years.

As was detailed in the previous section, the avoided costs of DSEE that are reported in 2020, 2025, and 2030 are not the actual costs that would be incurred in those years. The avoided costs in 2020 and 2025 are significantly understated (the reported avoided costs in 2030 are very similar to the avoided costs that would be incurred in that year).

As previously described in Section IV, the forgone domestic climate benefits are based on SCC values that do not represent avoided damages that actually occur in 2020, 2025, or 2030. Instead, the avoided U.S. CO_2 emissions in the individual years presented are multiplied by the *present value* of estimated avoided damages from that year through 2300. In fact, the estimated avoided damages in the year of the reduced CO_2 emissions are miniscule, with the highest incremental domestic SCC value in any year being less than \$0.02/metric ton (2007\$) in the FUND model.[48] Thus, the forgone climate benefits reported in 2020, 2025, and 2030 are likely to be misinterpreted by readers if more is not done to explain that they are present values, and to communicate about the timeline over which the forgone climate benefits would accrue. (More details of this timeline and how to estimate it for inclusion in the RIA are provided in Section IV.C).

Section 6 of the CPP Repeal RIA provides a present value analysis, something that was not provided in the 2015 CPP RIA. According to EPA, the present value analysis was done to comply with Executive Order 13771. The present value analysis included in the CPP Repeal RIA is for the years 2020 through 2033, with values presented from the perspective of 2016.

The exact manner in which the present value avoided costs were calculated in the CPP Repeal RIA (Table 6-1 in the CPP Repeal RIA) is unclear, particularly for DSEE and the approximate cost of additional generation required in the absence of the DSEE.[49] What is clear, however, is

---

[48] Incremental values are readily available for all years from the FUND model, but not from the PAGE model. Incremental values are also available from the DICE model, with the domestic SCC values assumed to be 10% of the global value. The highest incremental domestic SCC value in any year from DICE is less than \$0.04/metric ton (2007\$).

[49] It is unclear if the RIA uses the year-by-year DSEE costs that were included in spreadsheets for 3% and 7% discount rates (see EPA, 2015c and 2015d). It is also unclear if (and how) EPA might have recalculated the cost of additional generation required in the absence of DSEE, particularly if the year-by-year DSEE quantity and costs were included.

that the present value of avoided costs for DSEE for 2020 through 2033 is understated, as shown in Table 7, because of EPA's incorrect use of annualized costs. If the proper first-year costs had been used (as previously discussed), then the present value of avoided DSEE costs would have been approximately $75 billion higher.

Table 7. Annual Values for Avoided Demand-Side Energy Efficiency (2020-2033) and Present Value (Billions of 2011$)

Year	Annualized (EPA)	First-Year (Correct)
2020	$2.1	$18.1
2021	$4.7	$21.5
2022	$7.5	$24.3
2023	$10.6	$26.0
2024	$13.8	$27.3
2025	$16.7	$25.4
2026	$19.3	$25.3
2027	$21.5	$25.3
2028	$23.5	$25.3
2029	$25.2	$25.3
2030	$26.3	$25.3
2031	$27.4	$25.4
2032	$28.4	$25.5
2033	$29.4	$25.6
Present Value	***$175.9***	***$250.0***

While the CPP Repeal RIA did not show present values for the forgone benefits, if it had, those results may have suffered from similar issues of timing as was discussed in Section IV regarding the SCC.

VI. RECOMMENDATIONS FOR MODELING NEXT STEPS

The prior sections have detailed several adjustments that we recommend EPA implement, including:

- Refining health co-benefits analysis in the absence of air quality modeling,
- Presenting U.S. climate benefits and how they accrue over time,
- Suggesting additional sensitivities in calculating the SCC, and
- Reporting all spending for achieving DSEE improvements in the years where the spending actually occurs.

In this section we highlight our recommendations for next steps as they relate to modeling, with a particular focus on updated IPM runs of the U.S. electricity sector, consideration of using a CGE model to better capture secondary market impacts, and new air quality modeling that would allow for improved estimation of health co-benefits.

A. Updated IPM Runs

As previously described, the avoided power sector compliance costs in the CPP Repeal RIA are based on 2015 simulations of the IPM model including and excluding the CPP (separate evaluations of rate-based and mass-based implementations). The CPP Repeal RIA states:

> *EPA plans to do updated modeling using the Integrated Planning Model (IPM), which will be made available for public comment before any action that relates to the CPP is finalized. We plan to provide updated analysis of avoided costs, forgone benefits, and impacts.*[50]

EPA later specified five key uncertainties, two of which are directly applicable to IPM analysis – 1) economic and technological change, and 2) approaches that states would have taken to comply with the 2015 CPP.[51] To help EPA better quantify the ranges of potential avoided compliance costs and forgone emission reductions, we suggest several different IPM runs. These runs, and the potential clarity that they can provide, are detailed below.

B. General Updates

Given the elapsed time since the 2015 IPM model runs used in the 2015 CPP RIA, EPA will need to make general updates to the existing conditions in the U.S. (and interconnected international) electricity markets, and fuel markets. These changes will apply to the Base Case and Policy Cases evaluated against this updated Base Case. Such changes will include updating the database of existing generators, planned (under construction) new generators, and announced retirements. EPA should also make updates if it determines that there are significant changes in

---

[50] CPP Repeal RIA, p.3

[51] 2015 CPP RIA, p. 79.

electricity demand projections, natural gas supply/demand fundamentals, and coal supply/demand fundamentals. Other areas warranting updates include new technology costs and characteristics and new/updated policies (*e.g.*, CSAPR Update Rule).

C. Economic and Technological Change Uncertainty

To address important economic and technological change uncertainties, EPA will need to model both Base Case and Policy Cases using different sets of assumptions on several key inputs. These inputs include natural gas supply (paired with non-electric sector natural gas demand), new technology costs, and electricity demand.

1. Natural Gas Supply

In past analyses, EPA has frequently only considered a single natural gas price outlook. This approach ignores the significant impact that a different outlook can have on the Base Case emissions and the costs to comply with the 2015 CPP. We suggest evaluating a range of natural gas prices (based on different outlooks on natural gas supply and non-electric sector natural gas demand). An outlook with lower natural gas prices would, *ceteris paribus*, lower Base Case CO_2 emissions in the power sector thereby requiring fewer emission reductions to meet the 2015 CPP. Further, to the extent that coal to natural gas switching is deemed to be a cost-effective compliance action, lower natural gas prices would lower the costs to comply with the 2015 CPP. Conversely, higher natural gas prices would have the opposite effect – likely increasing Base Case CO_2 emissions, increasing the required emission reductions, and increasing compliance costs. One potential source of lower and higher natural gas price outlooks is EIA's *AEO 2018*. *AEO 2018* includes side cases for "High oil and gas resource and technology" (low natural gas price) and "Low oil and gas resource and technology" (high natural gas price). We note that both of these side cases also have been evaluated with and without an implementation of the CPP.

2. New Technology Costs and Characteristics

Another important uncertainty relates to the costs and operating characteristics of new generating technologies within the electric sector. There has been considerable debate regarding the current and projected costs of newer generating technologies such as wind and solar photovoltaic, but there is also uncertainty around existing technologies such as natural gas combined cycle and coal. Other technologies such as nuclear, biomass, energy storage, and geothermal also have uncertainties associated with their costs and characteristics, but are unlikely to be added in sufficient quantities to significantly alter the power sector compliance costs by 2030. When considering cases with alternate technology costs and characteristics it is important to consider factors beyond the capital cost. For example, for wind and solar photovoltaic uncertainties also exist regarding the quantity and timing of their output; for fossil technologies there are uncertainties on their heat rates. We suggest that EPA evaluate optimistic and pessimistic technology cases. In an optimistic case, technology advances would likely lead to a more rapid turnover of the existing fleet of generators, thereby reducing wholesale electricity prices and emissions (the converse would likely be true for a pessimistic case).

3. Electricity Demand

Recent growth rates in annual on-grid electricity demand are lower than they have historically been. This has likely been due to lower economic growth, increased DSEE, and increases in distributed electricity generation, among other factors. The outlook for on-grid electricity demand may continue on the current path, or there could be increased electrification of other sectors (*e.g.*, transportation) that could spur higher rates of growth. We suggest a sensitivity case with higher rates of growth in annual on-grid electricity demand. Such a case would likely lead to higher CO_2 emissions and thereby require greater CO_2 emission reductions under the CPP. The power sector compliance costs to meet the CPP would also likely increase. A case with a lower growth rate for annual on-grid electricity demand is likely not necessary as such a policy case would already be simulated with reduction in electricity demand from DSEE (the demand-side EE is not part of the IPM run, but instead electricity demand is changed exogenously and costs for demand-side EE are added outside of the model run).[52]

D. Demand-Side Energy Efficiency Cost and Availability

Uncertainties concerning the cost and availability of DSEE add to the uncertainty of the costs of complying with the 2015 CPP. There have been many different approaches to estimating the costs of DSEE, and these reflect a fairly wide range of assumptions.[53] Sensitivities of the cost of achieving DSEE improvements can be evaluated outside of the IPM model runs (with some minor exceptions) because DSEE is not endogenously considered in the model.[54]

Analyses of sensitivities of the availability (or the quantity) of DSEE are appropriate for consideration within EPA's planned IPM runs. The assumed quantity is translated to reduced demand for electricity sales and reduced quantities of electricity generation. To date, EPA has only included such reductions in Policy Cases, but should also consider sensitivities that include additional DSEE in Base Cases. There is significant uncertainty about the quantities of DSEE that EPA assumed possible in its 2015 CPP analysis because these would reflect significant increases above historical levels and would likely go beyond the most common actions taken to date.

---

[52] This would be true for simulating a mass-based implementation of the CPP, but would not be true for a rate-based implementation. It might be necessary to do a Base Case with lower electricity demand growth, but we also recommend evaluating a Base Case with DSEE, which would serve this purpose.

[53] See for example, EPA (2015b), Section 4.3.2, and NERA (2014b), p. 12.

[54] DSEE costs could increase up to the level where customers would no longer find it cost effective. This level is roughly equal to double the customers' electricity rate given an assumption of a 50/50 split of the costs between customers and utilities.

To provide a full range of the impacts of the assumption on the feasible quantity of DSEE improvement, we recommend evaluating the Policy Cases without any DSEE (beyond what is currently embedded in the Base Case electricity demand forecast). Evaluating a case with no DSEE would also provide EPA with precise numbers on the increased sector costs from not undertaking DSEE measures that were assumed by EPA in its analyses for the 2015 CPP (and CPP Repeal) RIA. If EPA determines that adoption of DSEE measures at rates higher than those that were used in its 2015 CPP analysis are feasible, then EPA can also consider higher quantities as an upper bound range.

EPA's approach in the 2015 CPP RIA of continuing to add DSEE measures after 2030 and of presenting the resulting total costs in annualized form creates unnecessary challenges to developing an estimate of the present value of net benefits of this regulatory action because the costs and the benefits from DSEE activities extend beyond the modeling horizon used for all the other components of the BCA. It is not necessary to include these post-2030 investments in the analysis, and therefore, we recommend that EPA eliminate them. By not adding incremental DSEE after 2030, EPA could calculate a present value of both the full costs and the full benefits of the DSEE added between 2020 and 2030.[55] This recommendation is in addition to our recommendations above for considering sensitivities about the cost and availability of DSEE.

E. Use of a Computable General Equilibrium Model

In its evaluation of the CPP, EPA did not use a CGE model. The benefits of a CGE model include the ability to evaluate secondary market impacts because the entire economy is evaluated, as EPA noted in the CPP Repeal RIA at page 59. Thus, to the extent that there is fuel switching within the electricity sector to natural gas, this is likely to increase natural gas prices, which could impact the non-electricity sectors' consumption of natural gas. Higher electricity prices would likely lead to lower electricity demand and potentially higher costs of producing other goods and services. These types of impacts are not available from IPM. When EPA has previously evaluated economy-wide CO_2 reduction legislation it used CGE models, like the ADAGE model.[56]

We recommend evaluating at least one mass-based and one rate-based Policy Case using a CGE model to gain a better understanding of whether the compliance costs based on IPM are potentially understated or overstated. We also caution that when using a CGE model, the full costs of compliance will extend beyond the electricity sector and reflect potentially higher/lower costs in other sectors and potential lost/gained economic output due to changing prices of production and services.

[55] EPA assumes that more than 99% of DSEE added in 2030 would be expired by 2050, the last year included in EPA's IPM modeling.

[56] For example, EPA (2009) used the ADAGE model as part of its evaluation of H.R. 2454.

F. New Full-Scale Air Quality Modeling

The RIA states that EPA, "to the extent feasible," plans to perform full-scale photochemical air quality modeling. As discussed in Section III, we endorse the Agency's expressed intention to conduct refined co-benefits sensitivity estimates using photochemical modeling in future iterations of the CPP Repeal RIA. We also recommend that the photochemical modeling outputs (or, more specifically, the air quality grids that are BenMAP inputs) be made available to the public to develop comments on that additional work. The performance of updated full-scale photochemical air quality modeling would allow the EPA to move away from the BPT approach, and allow the Agency to develop estimates of the sensitivity of co-benefits to alternative assumptions about where the C-R relationship might end.

REFERENCES

Anthoff, D; Tol, RJ. 2010. "On International Equity Weights and National Decision Making on Climate Change," *Journal of Environmental Economics and Management* 60(1): 14-20.

Bloomberg, S. 2016. "EPA's Particulate Matter Co-Benefits: A Case of Ever-Declining Credibility," *Bloomberg BNA: Daily Environment Report* ISSN 1060-297. May. Available at: http://www.nera.com/content/dam/nera/publications/2016/Scott_Bloomberg_Co-benefits_BNA_Insights_Published.pdf.

Dudley, S; Belzer, R; Blomquist, G; Brennan, T; Carrigan, C; Cordes, J; Cox, LA; Fraas, A; Graham, J; Gray, G; Hammitt, J; Krutilla, K; Linquiti, P; Lutter, R; Mannix, B; Shapiro, S; Smith, A; Viscusi, WK; and Zerbe R. 2017. "Consumer's Guide to Regulatory Impact Analysis: Ten Tips for Being an Informed Policymaker," *Journal of Benefit-Cost Analysis* 8(2):187-204. Available at: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/FAF984595B822A70495621AEA7EF7DEB/S2194588817000112a.pdf/consumers_guide_to_regulatory_impact_analysis_ten_tips_for_being_an_informed_policymaker.pdf.

EIA. 2017. *Annual Energy Outlook 2017 with projections to 2050*. Available at: https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf.

EPA. 2009. *EPA Analysis of the American Clean Energy and Security Act of 2009 H.R. 2454 in the 111th Congress*. June. Available at: https://www.epa.gov/sites/production/files/2016-07/documents/hr2454_analysis.pdf.

EPA. 2012. *Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter*. EPA-452/R-12-003, December.

EPA. 2014. *Guidelines for Preparing Economic Analyses*. December 2010, with updates May 2014. Available at: https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses.

EPA. 2015a. *Regulatory Impact Analysis for the Clean Power Plan Final Rule*. EPA-452/R-15-003. Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC. August. ("2015 CPP RIA")

EPA. 2015b. *Demand-Side Energy Efficiency Technical Support Document.* August. Available at: https://www.epa.gov/sites/production/files/2015-11/documents/tsd-cpp-demand-side-ee.pdf.

EPA. 2015c. "Illustrative Demand-Side Energy Efficiency Plan Scenario at 3%." Spreadsheet available at: https://www.epa.gov/sites/production/files/2015-11/df-cpp-demand-side-ee-at3.xlsx.

EPA. 2015d. "Illustrative Demand-Side Energy Efficiency Plan Scenario at 7%." Spreadsheet available at: https://www.epa.gov/sites/production/files/2015-11/df-cpp-demand-side-ee-at7.xlsx.

EPA. 2015e. *Regulatory Impact Analysis of the Final Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone*. EPA-452/R-5-007. Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, NC. September.

EPA. 2015f. Parsed File: Base Case, 2025. Available at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2013-0602-36470.

EPA. 2015g. Parsed File: Mass-Based, 2025. Available at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2013-0602-36474.

EPA. 2015h. "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," *80 FR 64661*, October. Available at: https://www.federalregister.gov/documents/2015/10/23/2015-22842/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generatingEPA. 2017. *Regulatory Impact Analysis for the Review of the Clean Power Plan: Proposal,* Office of Air Quality Planning and Standards, Health and Environmental Impacts Division, Research Triangle Park, NC, October 2017. Available at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2017-0355-0110.

Farrow, S; Viscusi, WK. 2011. "Towards Principles and Standards for the Benefit-Cost Analysis of Safety," *Journal of Benefit-Cost Analysis* 2(3), Article 5.

78 *Federal Register* 3086, January 15, 2013.

Fraas, A; Lutter, R; Dudley, S; Gayer, T; Graham, J; Shogren, JF; Viscusi, WK. 2016. "Social Cost of Carbon: Domestic Duty," *Science* 351(6273): 569.

Gayer, T; Viscusi, K. 2016. "Determining the Proper Scope of Climate Change Policy Benefits in U.S. Regulatory Analyses: Domestic versus Global Approaches," *Review of Environmental Economics and Policy* 10(2): 245-63.

Gayer, T; Viscusi, K. 2017. "The Social Cost of Carbon: Maintaining the Integrity of Economic Analysis—A Response to Revesz *et al*. (2017)," *Review of Environmental Economics and Policy* 11(1): 174-5.

Interagency Working Group on Social Cost of Carbon, United States Government. 2010. *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. February. Available at: https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf.

Interagency Working Group on Social Cost of Carbon, United States Government. 2013a. *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. May.

Interagency Working Group on Social Cost of Carbon, United States Government. 2013b. *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. November. Available at: https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.

Interagency Working Group on Social Cost of Carbon, United States Government. 2015. *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*. July. Available at: https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf.

Kopp, RJ; Krupnick, AJ; Toman, M. 1997. *Cost-Benefit Analysis and Regulatory Reform: An Assessment of the Science and the Art*, Report to the Commission on Risk Assessment and Risk Management.

Mishan, EJ. 1977. "Economic Criteria for Intergenerational Comparisons," *Journal of Economics* 37(3-4):281-306.

NERA. 2011. *An Evaluation of the $PM_{2.5}$ Health Benefits Estimates in Regulatory Impact Analyses for Recent Air Regulations*, report prepared for Utility Air Regulatory Group. December. Available at: http://www.nera.com/content/dam/nera/publications/archive2/PUB_RIA_Critique_Final_Report_1211.pdf.

NERA. 2014a. *A Review of the Damage Functions Used in Estimating the Social Cost of Carbon*. Report prepared for American Petroleum Institute. February. Submitted to OMB SCC docket as Attachment 2 of comments of American Chemical Council and others, Docket # OMB-2013-0007-0100.

NERA. 2014b. *Potential Energy Impacts of the EPA Proposed Clean Power Plan*, included in comment submitted by Paul Bailey, Senior Vice President Federal Affairs and Policy, American Coalition for Clean Coal Electricity at https://www.regulations.gov/document?D=EPA-HQ-OAR-2013-0602-25764. Full NERA Report available at: http://www.nera.com/content/dam/nera/publications/2014/NERA_ACCCE_CPP_Final_10.17.2014.pdf.

NERA. 2015. *Analysis of Projected Health Co-Benefits in EPA's Proposed Clean Power Plan Report in Response to Virginia Senate Joint Resolution No. 273 (2015 Session)*. Report prepared for The Virginia Center for Coal and Energy Research of Virginia Polytechnic Institute and State

University, submitted to Virginia Department of Environmental Quality. Available at: https://rga.lis.virginia.gov/Published/2015/SD15/PDF.

Nordhaus, WD. 2007. "A Review of the Stern Review of the Economics of Climate Change," *Journal of Economic Literature* 45:686-702.

Nordhaus, WD. 2017. "Revisiting the Social Cost of Carbon," *Proceedings of the National Academy of Sciences of the United States* 114 (7): 1518-1523.

OMB. 2003. "Circular A-4. Regulatory Analysis." September. Available at: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf.

OMB. 2017. "Guidance Implementing Executive Order 13771, Titled 'Reducing Regulation and Controlling Regulatory Costs.'" April. Available at: https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/M-17-21-OMB.pdf.

Rawls, JB. 1971. *A Theory of Justice*. Cambridge, Massachusetts: Harvard University Press.

Revesz, RL; Schwartz, JA; Howard, PH; Arrow, K; Livermore, MA; Oppenheimer, M; Sterner T. 2017. "The Social Cost of Carbon: A Global Imperative," *Review of Environmental Economics and Policy* 11(1):172–173.

Smith, A. 2014. *Uncertainties in Estimating a Social Cost of Carbon Using Climate Change Integrated Assessment Models*, report prepared for Utility Air Regulatory Group and others, February. Submitted as comment to FR Doc # 2014-01605 (OMB Notice: Technical Support Documents: Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order No. 12866), February 26. Available at: https://www.regulations.gov/document?D=OMB-2013-0007-0091.

Smith, A. 2015. Expert report of Anne E. Smith on Social Cost of Carbon, submitted to Minnesota Public Utilities Commission Docket No. E-999/CI-14-643 as exhibit to written direct testimony of Anne E. Smith, June 1. Available at: https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=showPoup&documentId={6216F87C-7D9A-45B5-A159-DE5A583D8B06}&documentTitle=20156-111052-02.

Smith, A. 2016. "Inconsistencies in Risk Analyses for Ambient Air Pollutant Regulation," *Risk Anal.* 2016 Sep;36(9):1737-44.

Smith, A; Glasgow, G. 2015. *Technical Comments on the Proposed Rule to Revise the Ozone National Ambient Air Quality Standards (79 Fed. Reg. 75234)*, report prepared for Utility Air Regulatory Group, March. Submitted to 2015 Ozone NAAQS Review Docket EPA-HQ-OAR-2008-0699. Available at:

http://www.nera.com/content/dam/nera/publications/2015/Technical_Comments_Ozone_Standards_0315.pdf.

U.S. Supreme Court. 2014. Oral arguments in *Michigan v. EPA*, pages 61-62, transcript available at: https://www.supremecourt.gov/oral_arguments/argument_transcripts/2014/14-46_1b5p.pdf.

White House. 1993. Executive Order 12866, "Regulatory Planning and Review." September. Available at: https://www.archives.gov/files/federal-register/executive-orders/pdf/12866.pdf.

White House. 2017a. Executive Order 13771, "Reducing Regulation and Controlling Regulatory Costs." January. Available at: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-reducing-regulation-controlling-regulatory-costs/.

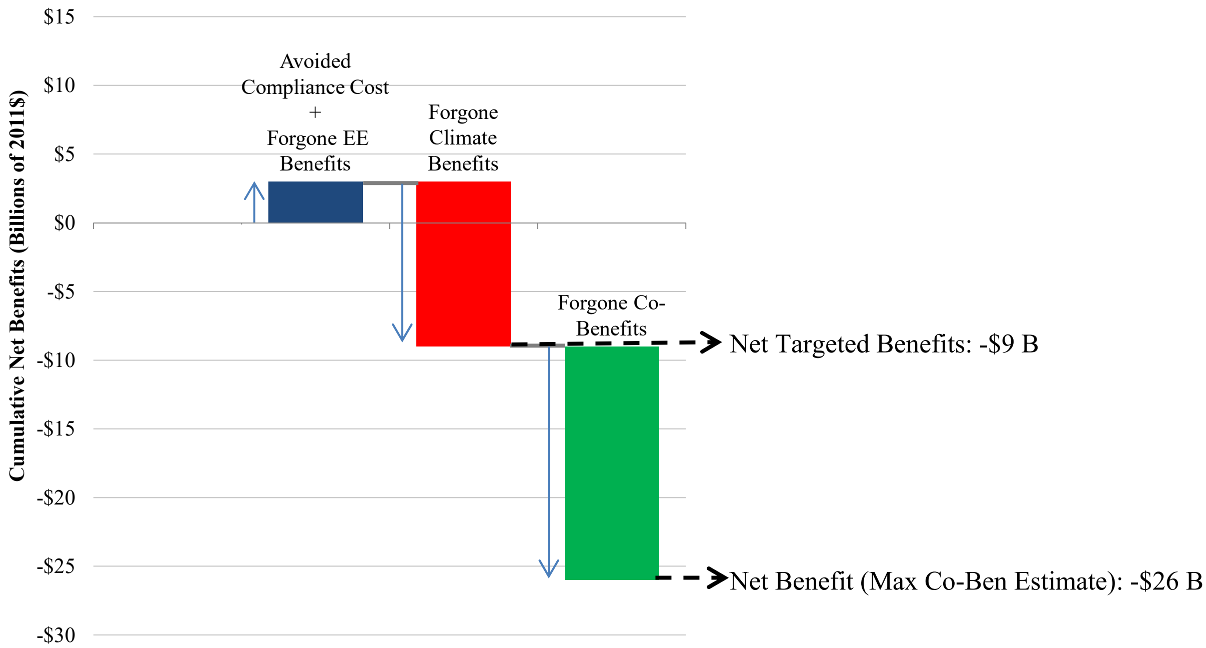
White House. 2017b. Executive Order 13783, "Promoting Energy Independence and Economic Growth." March. Available at: https://www.whitehouse.gov/presidential-actions/presidential-executive-order-promoting-energy-independence-economic-growth/.

Whittington, D; MacRae, D. 1986. "The Issue of Standing in Cost-Benefit Analysis," *Journal of Policy Analysis and Management*, 5(4): 665-682.

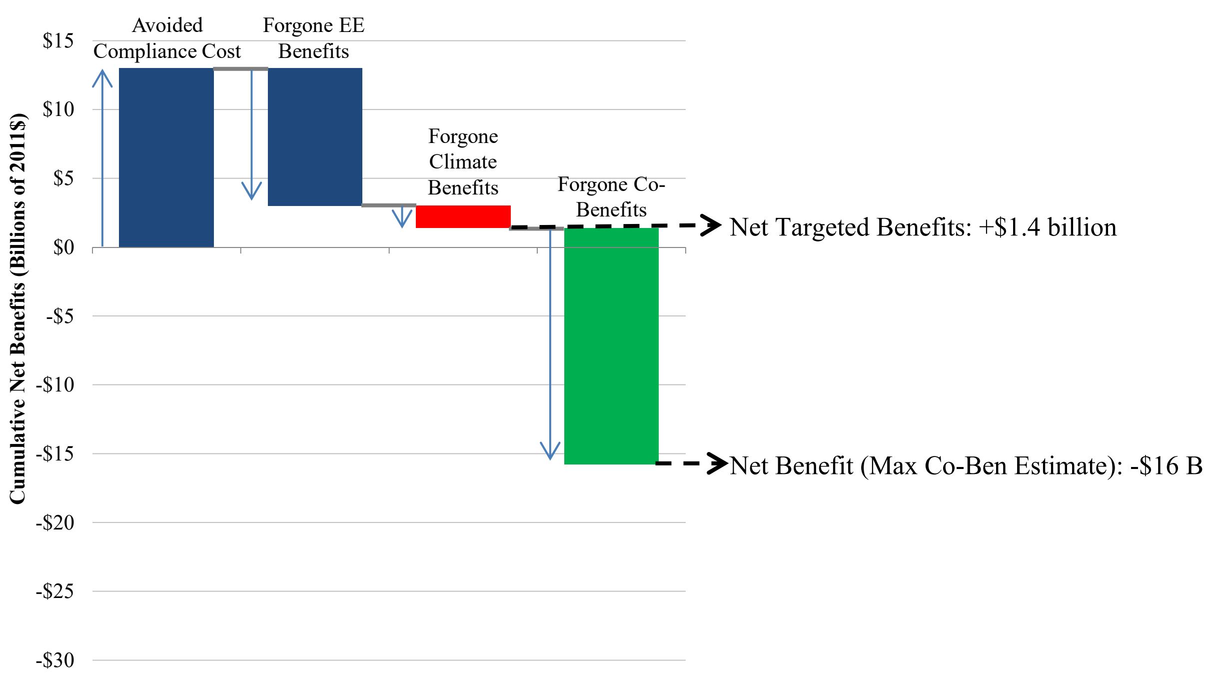
APPENDIX A.

Figure 7. Cumulative 2025 Net Benefits of Repeal as Benefit/Cost Components Are Sequentially Added – Mass-Based (3% Discount Rate)

(A) 2015 CPP RIA (Data Stated in Terms of Repeal)

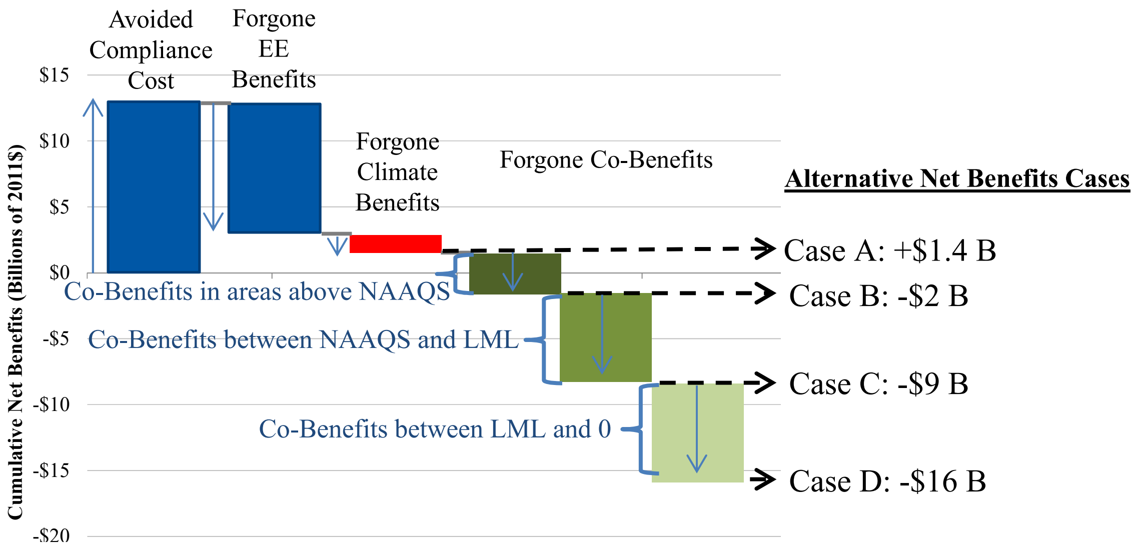


(B) CPP Repeal RIA



Sources and notes: (A) 2015 CPP RIA, Table ES-10; (B) CPP Repeal RIA, Tables 1-1, 1-3, 1-5, and 3-6.

Figure 8. Alternative Potential Estimates of Net Benefits of Repeal for CPP Repeal RIA's Co-Benefit Sensitivity Cases (Mass-Based Option, 2025 Compliance Year, 3% Discount Rate)



LEGEND

Case A: Includes targeted benefits (*i.e.*, excludes all forgone co-benefits)
Case B: Includes only high-confidence co-benefits estimates (*i.e.*, includes co-benefits only in areas above the NAAQS)
Case C: Also includes lower-confidence co-benefits (*i.e.,* in areas with concentrations attaining the NAAQS and as low as the LML)
Case D: Also includes co-benefits for which there is no observational evidence of a health effects relationship (*i.e.*, in areas with concentrations below the LML)

Table 8. Sensitivity of Net Benefits of CPP Repeal to Inclusion of Increasing Uncertain Forgone Co-Benefits (for Mass-Based Option)

		Discount rate case	
		3%	**7%**
2020	No co-benefits Cutpoint at NAAQS Cutpoint at LML No cutpoint	\$1.0 \$0.2 to \$0.8 (\$1.8) to (\$0.9) (\$3.8) to (\$1.0)	\$1.8 \$1.1 to \$1.7 (\$0.7) to \$0.2 (\$2.5) to \$0.0
2025	No co-benefits Cutpoint at NAAQS Cutpoint at LML No cutpoint	\$1.4 (\$1.6) to \$0.6 (\$8.5) to (\$5.2) (\$15.8) to (\$5.7)	\$6.6 \$3.7 to \$5.9 (\$2.5) to \$0.7 (\$9.1) to (\$0.2)
2030	No co-benefits Cutpoint at NAAQS Cutpoint at LML No cutpoint	\$2.5 (\$2.1) to \$1.2 (\$13.7) to (\$8.4) (\$25.7) to (\$9.3)	\$10.8 \$6.4 to \$9.6 (\$4.0) to \$0.9 (\$14.8) to \$0.2

APPENDIX B. EXCERPTS FROM SMITH AND GLASGOW (2015)

Excerpt from Smith and Glasgow (2015), pages 13 through 15, attached to UARG Comments on 2015 Ozone Proposed Rule noting the overstatement when simple cutpoints are used rather than recalculating risk relative to alternative assumed ending point of the ozone C-R relationship.

Quantitative Sensitivity of Short-Term Mortality Risks to Potential Thresholds

The Proposed Rule notes that there is uncertainty in the shape of the concentration-response functions for short-term mortality and morbidity as well, but these epidemiological studies do not provide precise evidence to narrowly define an appropriate threshold assumption, as is possible for the long-term mortality study described above. Section II of these comments has explained in more detail the reason for the Proposed Rule to have noted this weakness in the epidemiological evidence. However, in attempting to characterize the sensitivity of the short-term mortality risks to potential alternative thresholds by summarizing information in the HREA, the Proposed Rule makes a conceptual error that greatly understates that sensitivity.

Table 3 of the Proposed Rule (copied as Figure 3 below) reports the fractions of the total estimated short-term mortality (the sum of estimated deaths in all 12 urban study areas) that is attributable to ozone above certain levels (20 ppb, 40 ppb, and 60 ppb). This table is based on data in the HREA, but has been derived specifically for the Proposed Rule, by aggregating data presented in the HREA in a different format. While the data in the table can be replicated from various tables in the HREA, the Proposed Rule incorrectly interprets those data. The Proposed Rule suggests that this table can be used to infer the sensitivity in the HREA's total short-term mortality estimates if the concentration-response function were not to continue to apply all the way to zero below each of the levels in the column headers. For example, in reference to use of its Table 3, the Proposed Rule states:

> *A focus on estimates of total risks would place greater weight on the possibility that concentration-response relationships are linear over the entire distribution of ambient O_3 concentrations, and thus on the potential for morbidity and mortality to be affected by changes in relatively low O_3 concentrations. A focus on risks associated with O_3 concentrations in the upper portions of the ambient distribution would place greater weight on the uncertainty associated with the shapes of concentration-response curves for O_3 concentrations in the lower portions of the distribution.*[32]

[32] 79 *Fed. Reg.* 75234, December 17, 2014, at 75276.

13

In other words, the Proposed Rule is interpreting the alternative estimates in Table 3 as if they were showing the implications of the possibility that the concentration-response relationship used is *not* "linear over the entire distribution" of ozone, which is what is meant by a threshold. This is an incorrect interpretation of what Table 3 reports; this table only reports how much of the total daily no-threshold risk estimate in the first column (which is the sum of risks calculated for each day in a season) remains if risks on some of those days (*i.e.*, days when ozone is lower than the ppb level identified in the other column headers) are excluded from the summation. For each of the other columns, the risks estimated for the days above its listed ppb level are exactly the same as in the original "total O_3" calculation. In other words, all of the numbers in each row of the Proposed Rule's Table 3 are based on a single risk model run, using the same concentration-response function. This is not how a threshold affects risk estimation. A threshold affects the "shape of the concentration-response" function, which changes the risk level for days at *every* ppb level, whether above or below the threshold.[33] Thus, estimating the sensitivity to alternative possible threshold levels requires re-estimating the total seasonal risk on every day of the season being assessed, and then summing them – not simply dropping some days from the summation based on a single (no-threshold) risk model run.

Table 1 provides the total short-term mortality risk estimates that the HREA would have reported if it had actually performed a sensitivity analysis to potential thresholds by re-running its risk model (called BenMAP) with thresholds specified at 20 ppb, 40 ppb, and 60 ppb. As can be seen by comparing the estimates in Table 1 to those in Figure 3, the short-term mortality risk estimates are much more sensitive to potential thresholds than the Proposed Rule currently recognizes. As Table 2 shows, the short-term mortality risk estimates would be reduced by essentially 100% if a threshold exists at 60 ppb. Even if a threshold were to exist at 40 ppb, the short-term mortality risk estimates at the current standard of 75 ppb would be 87% and 88% lower than the HREA has estimated (for 2007 and 2009 ozone, respectively). This is a very substantial degree of sensitivity associated with remaining uncertainties in the shape of the concentration-response functions, which echoes the sensitivity reported in the HREA for long-term respiratory mortality risk estimates.

[33] Days that fall below the threshold are assigned zero risk, as Table 3 is doing, while days above the threshold are assigned a risk that is based on the level of its concentration *relative* to the threshold. (This is what the BenMAP model that EPA has used for its HREA and RIA calculations does if its user chooses to specify a threshold.)

Figure 3. Copy of Table 3 from the Proposed Rule

TABLE 3—ESTIMATES OF O_3-ASSOCIATED DEATHS ATTRIBUTABLE TO THE FULL DISTRIBUTION OF 8-HOUR AREA-WIDE O_3 CONCENTRATIONS AND TO CONCENTRATIONS AT OR ABOVE 20, 40, OR 60 PPB O_3

[Deaths summed across urban case study areas][83]

Number of O_3-associated deaths summed across urban case study areas				
Standard level	Total O_3	20+ ppb	40+ ppb	60+ ppb
2007				
75 ppb	7,500	7,500	5,400	500
70 ppb	7,200	7,200	4,900	240
65 ppb	6,500	6,500	2,800	90
60 ppb[84]	6,400	6,400	2,300	10
2009				
75 ppb	7,000	7,000	4,700	270
70 ppb	6,900	6,900	4,300	80
65 ppb	6,400	6,400	2,600	40
60 ppb	6,300	6,300	2,100	10

Table 1. Proposed Rule's Table 3 Calculated with Correct Threshold Logic: Estimates of Total O_3-Associated Deaths Using Various Alternative Assumptions on Level of Potential Threshold in the Short-Term Mortality Association

Number of O_3-associated deaths summed across urban case study areas				
Standard level	Total O_3 - No Threshold	Total O_3 - Threshold at 20 ppb	Total O3 - Threshold at 40 ppb	Total O3 - Threshold at 60 ppb
2007				
75 ppb	7,500	4,100	1,000	0
70 ppb	7,200	3,800	700	0
65 ppb	6,500	3,100	400	0
60 ppb	6,400	2,900	300	0
2009				
75 ppb	7,000	3,700	830	0
70 ppb	6,900	3,500	640	0
65 ppb	6,400	3,000	350	0
60 ppb	6,300	2,900	230	0

Table 2. Percentage Reduction in Total Short-Term Mortality Relative to the Zero-Threshold Calculations Used in the HREA under Alternative Assumptions of Level of Potential Threshold

Number of O_3-associated deaths summed across urban case study areas				
Standard level	Total O_3 - No Threshold	Total O_3 - Threshold at 20 ppb	Total O3 - Threshold at 40 ppb	Total O3 - Threshold at 60 ppb
2007				
75 ppb	0%	45%	87%	100%
70 ppb	0%	47%	90%	100%
65 ppb	0%	52%	94%	100%
60 ppb	0%	55%	95%	100%
2009				
75 ppb	0%	47%	88%	100%
70 ppb	0%	49%	91%	100%
65 ppb	0%	53%	95%	100%
60 ppb	0%	54%	96%	100%

APPENDIX C. ESTIMATING AVOIDED COSTS FROM AEO 2017

The *AEO 2017* included reference cases with and without the CPP. The CPP Repeal RIA uses a comparison of these two cases to provide a more recent analysis of the avoided costs and forgone benefits associated with repeal of the CPP. The CPP analysis included in *AEO 2017* is a mass-based implementation, with regional caps (as opposed to state-based caps). Comparing the costs of the reference case without the CPP to that with the CPP provides the avoided compliance costs (Table 9). The CPP Repeal RIA does note that the avoided compliance costs based on *AEO 2017* are "not directly comparable" to the avoided compliance costs based on the 2015 CPP RIA.[57]

Table 9. Avoided Compliance Costs of CPP from *AEO 2017* (Billions of 2011$)

	2020	2025	2030
Total avoided compliance cost	-$0.3	$14.5	$14.4

Source and notes: CPP Repeal RIA, Table 1-9, p. 18. Negative values denote avoided credits.

Since the comment period on the CPP Repeal RIA was opened, the EIA has released *AEO 2018*. The reference and sensitivity cases modeled have been evaluated with and without an implementation of the CPP, but it is unclear if the EIA has produced tables to evaluate the avoided compliance costs of the CPP as was included in the CPP Repeal RIA since these are not standard tables that are created and publicly-released.

[57] CPP Repeal RIA, p. 18. EPA was not able to estimate the value of reduced electricity demand associated with DSEE, as was done for the avoided compliance costs based on the 2015 CPP RIA. Also, the DSEE costs from *AEO 2017* are expenditures ("first-year costs" in EPA's language describing DSEE costs).

NERA
ECONOMIC CONSULTING

NERA Economic Consulting
1255 23rd Street NW
Washington, DC 20037
Tel: +1 202 466 3510
Fax: +1 202 466 3605
www.nera.com