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Regulatory Impact Analysis for the Review of the Clean Power Plan: Proposal

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Regulatory Impact Analysis for the Review of the Clean Power Plan: Proposal

U.S. Environmental Protection Agency
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1.1. Introduction

In this action, the U.S. Environmental Protection Agency (EPA) is proposing to repeal the Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units (EGUs), commonly referred to as the Clean Power Plan, found at 40 CFR part 60 subpart UUUU, as promulgated October 23, 2015. The Clean Power Plan (CPP) established emission guidelines for states to follow in developing plans to reduce greenhouse gas (GHG) emissions from existing fossil fuel-fired EGUs.

This proposed action is an economically significant regulatory action that was submitted to the Office of Management and Budget (OMB) for interagency review. Any changes made in response to interagency review have been documented in the docket. This regulatory impact analysis (RIA) presents an assessment of the avoided regulatory compliance costs and forgone benefits associated with this action and is consistent with Executive Order 12866. This RIA also includes a section that calculates the present value (PV) of the avoided regulatory compliance costs of the action for the purposes of Executive Order 13771, as well as calculations of the PV of the forgone benefits and net benefits for comparison purposes. This Executive Summary provides a brief overview of the RIA's analysis.

In addition to presenting results from the 2015 CPP RIA, this RIA uses two additional quantitative approaches to analyze the effects of the CPP in order to present information on the potential effects of the proposed repeal of the CPP. The first approach involves a modest reworking of the 2015 CPP RIA to increase transparency and illuminate the uncertainties associated with assessing benefits and costs of the CPP, as reflected in the 2015 analysis, as well as analyzing the potential effects of the CPP repeal. More specifically, this analysis increases transparency of the 2015 CPP analysis by presenting the energy efficiency cost savings as a benefit rather than a cost reduction and provides a bridge to future analyses that the agency is committed to performing. The current analysis also provides alternative approaches for examining the foregone benefits, including more clearly delineating the direct benefits from the co-benefits and exploring alternative ways to illustrate the impacts on the total net benefits of the uncertainty in health co-benefits at various $PM_{2.5}$ cutpoints. This approach shifts the focus to the domestic (rather than global) social cost of carbon, and employs both 3 percent and 7 percent discount rates. Finally, we consider that how changing market conditions and technologies may have affected future actions that may have been undertaken by states to comply with the CPP and how these changes may affect the potential benefits and costs of the CPP repeal.

The second approach uses U.S. Energy Information Administration's (EIA) 2017 Annual Energy Outlook (AEO) projections to presents a series of observations on recent power sector trends and produce alternative estimates of the forgone benefits and avoided compliance costs arising from the proposed repeal of the CPP. We also provide a review of recent studies of the CPP's projected costs and emission reductions performed by non-governmental organizations in order to provide a broader understanding of the uncertainties associated with the proposed repeal of the CPP.

The OMB circular *Regulatory Analysis* (Circular A-4) provides guidance on the preparation of regulatory analyses required under E.O. 12866. Circular A-4 requires a formal quantitative uncertainty analysis for rules with annual benefits or costs of $1 billion or more.[1] This proposed rulemaking potentially surpasses that threshold for both avoided compliance costs and forgone benefits. Throughout this RIA and the referenced 2015 CPP RIA, we considered a number of sources of uncertainty, both quantitatively and qualitatively, on benefits and costs. We summarize five key elements of our analysis of uncertainty here:

- Recent economic and technological changes to the electricity sector that may have affected the potential cost and benefits of complying with the 2015 CPP had it been implemented;
- Approaches that states would have taken to comply with the 2015 CPP had it been implemented, which will affect both the benefits and costs of this rule;
- Uncertainties associated with demand-side energy efficiency investments;
- Uncertainty in the health benefits estimation, including those associated with using a benefits-per-ton approach; and,
- Characterization of uncertainty in monetizing climate-related benefits.

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[1] Office of Management and Budget (OMB), 2003, *Circular A-4*, http://www.whitehouse.gov/omb/circulars_a004_a-4 and OMB, 2011. *Regulatory Impact Analysis: A Primer.* http://www.whitehouse.gov/sites/default/files/omb/*inforeg*/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf

Some of these elements are evaluated using probabilistic techniques. For other elements, where the underlying likelihoods of certain outcomes are unknown, we use scenario analysis to evaluate their potential effect on the benefits and costs of this rulemaking. Other types of uncertainties are acknowledged but remain unquantified, such as certain co-costs (e.g., the effects of higher electricity prices on market dynamics, wages, and labor supply) and the social costs associated with producing alternative fuels and technologies that are less carbon-intensive. As always, EPA solicits public comment on how best to treat analytically the underlying uncertainties. In addition, 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.

1.2. Avoided Compliance Costs using the 2015 RIA Results

Given that the CPP is not yet effective, and in the absence of an updated analysis of the rule's potential impacts if left in place, this analysis will assume that all of the costs of this rule as previously estimated upon original promulgation will be "cost savings" for this proposed action. For the purposes of estimating avoided regulatory compliance costs from the repeal of the CPP, the regulatory compliance costs estimated for the 2015 CPP RIA were adjusted to account for the cost of additional generation that would have been needed absent assumed demand reductions from energy efficiency programs (which was necessary in order to account for the value of savings from demand-side energy efficiency programs as a benefit of the rule).[2] Table 1-1 presents these adjusted regulatory compliance costs.

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[2] Section 3.3 of this RIA presents a methodology that approximates the reduced power system electricity production costs. This methodology calculates the compliance cost estimates without the cost savings associated with energy efficiency related measures, which are the compliance cost savings from the repeal of the CPP. This is consistent with this OMB guidance, which states that accounting for "savings, such as fuel savings associated with energy efficiency investments as benefits is a common accounting convention followed in the OMB Office of Information and Regulatory Affairs' reports to Congress on the benefits and costs of Federal regulations." This follows from the fact that consumers will ultimately realize benefits from demand-side energy efficiency investments as reductions in their electricity bills. In 2015 CPP analysis, cost savings associated with energy efficiency related measures reduced the gross or total compliance costs.

Table 1-1. Avoided Compliance Cost of 2015 CPP RIA for 2020, 2025, and 2030, Rate-Based and Mass-Based Illustrative Plan Approaches (billions 2011$)

Avoided Compliance Costs	Rate-Based			Mass-Based		
	2020	2025	2030	2020	2025	2030
With demand-side energy efficiency costs discounted at 3%	$3.7	$10.2	$27.2	$2.6	$13.0	$24.5
With demand-side energy efficiency costs discounted at 7%	$4.2	$14.1	$33.3	$3.1	$16.9	$30.6

Note: Avoided compliance costs equals the change in total power sector generating costs, plus the costs of demand-side energy efficiency programs (evaluated using a 3 percent and 7 percent discount rates), the costs of monitoring, reporting, and recordkeeping, plus an approximation of the cost of additional generation that would have been needed absent assumed demand reductions from energy efficiency programs (see Section 3.3 for further explanation).

It is important to emphasize that the 2015 RIA cost estimates and the current estimates for the purposes of this analysis build from the same regulatory cost assessment and that the differences in amounts reflect differing accounting conventions. Those accounting conventions differ in whether one views the power sector generating cost reductions from demand-side energy efficiency programs as a negative cost or as a benefit. In the 2015 RIA those cost reductions were included as a negative cost. In the current estimates they are instead included as a benefit. Also, the avoided compliance costs reported in Table 1-2 are not social costs. Please see Sections 3.2 and 3.3 of this RIA for a detailed discussion of the compliance cost estimates.

1.3. Forgone Emissions Reductions from the 2015 RIA

Table 1-2 shows the CO_2 emission reductions that EPA projected in the 2015 Final CPP RIA that would have been obtained under two illustrative plan approaches to comply with the CPP. These reductions are relative to projected emissions without the CPP in each year. The table also shows projected co-reductions of SO_2 and NO_X projected to have been obtained as a result of CO_2 mitigation strategies, had the CPP been implemented as modeled in the illustrative plan approaches.

Table 1-2. Forgone Climate and Air Pollutant Emission Reductions under the Proposed Repeal of the Clean Power Plan, Rate-Based and Mass-Based Illustrative Plan Approaches[1]

	CO_2 (million short tons)	SO_2 (thousand short tons)	Annual NO_X (thousand short tons)
Rate-based			
2020	69	14	50
2025	232	178	165
2030	415	318	282
Mass-based			
2020	82	54	60
2025	264	185	203
2030	413	280	278

Source: Integrated Planning Model, 2015. Emissions change may not sum due to rounding.
[1] Forgone CO_2 emission reductions are used to estimate the forgone climate benefits of repealing the CPP. SO_2, and NO_X reductions are relevant for estimating the forgone air quality health co-benefits of the repealing the CPP.

In 2030, when compared to the base case emissions, the EPA estimated that CO_2 emissions would have been reduced by 415 million short tons in 2030 under the rate-based approach, had the CPP been implemented. Meanwhile, EPA estimated that 413 million short tons of CO_2 emissions would have been reduced in 2030 under the mass-based approach. Under this proposed action to repeal the CPP, therefore, CO_2 emissions are projected to be 413-415 million short tons higher than they would have been had the CPP been implemented. Similarly, SO_2 emissions are projected to be 280-318 thousand short tons higher than they would have been and NO_X emissions 278-282 thousand short tons higher than under the final CPP.

1.4. Forgone Climate, Energy Efficiency, and Health Benefits using the 2015 RIA Results

We estimate the forgone climate benefits from this proposed rulemaking using a measure of the domestic social cost of carbon (SC-CO_2). The SC-CO_2 is a metric that estimates the monetary value of impacts associated with marginal changes in CO_2 emissions in a given year. The SC-CO_2 estimates used in this RIA focus on the direct impacts of climate change that are anticipated to occur within U.S. borders. As discussed in Sections 3.3 and 3.4, EPA used the projections from the power sector modeling that supported the 2015 CPP RIA to approximate the value of energy cost savings from the reduced demand attributable to the demand-side energy efficiency measures. Under this proposal to repeal the final CPP, these savings are counted as forgone benefits. In addition, under the repeal proposed in this action, the CPP would no longer reduce emissions of precursor pollutants (e.g., SO_2, NO_X, and directly emitted particles), which in turn would no longer lower ambient concentrations of $PM_{2.5}$ and ozone.[3]

These results are subject to important uncertainties related to data gaps, model capabilities and scientific uncertainty regarding the relationship between $PM_{2.5}$ exposure and the risk of premature death at low PM concentrations. It is important to note that, due to recent and anticipated improvements in air quality due to other federal and state pollution control efforts, an increasing fraction of the $PM_{2.5}$ exposures experienced in the U.S. are likely to occur at relatively low concentrations. In this analysis, the vast majority of such exposures are projected to occur at levels below the current annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$. In general, we are more confident in the magnitude of the risks we estimate from simulated $PM_{2.5}$ concentrations that coincide with the bulk of the observed PM concentrations in the epidemiological studies that are used to estimate the benefits. Likewise, we are less confident in the risk we estimate from simulated $PM_{2.5}$ concentrations that fall below the bulk of the observed data in these studies.[4]

To provide some insight into the potential implications of uncertainty in the estimated $PM_{2.5}$ mortality benefits at lower levels on the magnitude of the $PM_{2.5}$-attributable benefits, EPA typically conducts sensitivity analyses using alternative concentration cutpoints; this allows readers to observe the portion of population exposed to annual mean $PM_{2.5}$ levels at or above different concentrations. These analyses provide information useful to the public in understanding the uncertainty of benefits at lower ambient $PM_{2.5}$ levels. There are uncertainties inherent in identifying any particular point at which our confidence in reported associations becomes appreciably less, and the scientific evidence provides no clear dividing line. As air quality improves, we fully expect that fewer people would be exposed to high $PM_{2.5}$

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[3] We did not estimate the forgone co-benefits associated with the forgone reduction of direct exposure to SO_2 and NO_X. For this RIA, we did not estimate changes in forgone emissions of directly emitted particles. As a result, quantified $PM_{2.5}$ related forgone benefits are underestimated by a relatively small amount.

[4] The Clean Air Act directs the Agency to set NAAQS that, in the judgment of the Administrator, are "requisite" to protect the public health with an adequate margin of safety. In setting primary standards that are requisite, the EPA's task is to establish standards that are neither more nor less stringent than necessary, given the available scientific information. When setting the PM NAAQS, the Administrator acknowledged greater uncertainty in specifying the magnitude and significance of PM-related health risks at PM concentrations below the NAAQS. As noted in the Preamble to the 2012 PM NAAQS final rule, "EPA concludes that it is not appropriate to place as much confidence in the magnitude and significance of the associations over the lower percentiles of the distribution in each study as at and around the long-term mean concentration." 78 FR 3154, 1/15/2013.

concentrations (U.S. EPA, 2011a; Fann et al. 2017). Indeed, we project that by 2025 most of the U.S. will attain the 2012 $PM_{2.5}$ NAAQS due to existing federal measures and a large fraction of the U.S. population is projected to live in locations where annual mean $PM_{2.5}$ concentrations are below the Annual PM NAAQS and above the Lowest Measured Level (LML) of the Krewski et al. (2009) long-term mortality study (12 $\mu g/m^3$ and 5.8 $\mu g/m^3$, respectively).

The results presented in this document incorporate a range of assumptions regarding the risk of premature death at different $PM_{2.5}$ cutpoints. Section 3 describes in greater detail our approach for accounting for the uncertainty associated with the PM-related impacts estimated to occur at lower levels of ambient PM, particularly below the LML of the long-term epidemiological studies we used to quantify PM-attributable risk. This analysis does not include the type of detailed uncertainty assessment found in the 2012 $PM_{2.5}$ NAAQS RIA (U.S. EPA, 2012) because we lack the necessary air quality input and monitoring data to conduct a complete forgone benefits assessment. All benefit-per-ton approaches have inherent limitations, including that the estimates reflect the geographic distribution of the modeled sector emissions, which may not match the emission reductions anticipated by this proposed rule, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location.

Section 5.5 below discusses in greater detail the uncertainties associated with the benefits assessment, including uncertainties associated with: 1) quantifying PM effects at low concentrations; 2) quantifying risks attributable to individual $PM_{2.5}$ species; and 3) the importance of sequencing in evaluating policy impacts (i.e., other policies could achieve similar air quality co-benefits and may be adopted for other reasons).

To the extent feasible, the EPA intends to perform full-scale gridded photochemical air quality modeling to support the air quality benefits assessment informing subsequent regulatory analyses of CPP-related actions. Such model predictions would supply the data needed to: (1) quantify the $PM_{2.5}$ and ozone-related impacts of the policy case; (2) perform the full suite of sensitivity analyses summarized above, particularly the concentration cutpoint assessment. EPA further commits to characterizing the uncertainty associated with applying benefit-per-ton estimates by comparing EPA's approach with other reduced-form techniques found in the literature. All of these analyses will be available for peer review consistent with the requirements of OMB's Information Quality Bulletin for Peer Review within six months.

Table 1-3 provides the combined forgone domestic climate benefits, demand-side energy efficiency benefits, and health co-benefits estimated for 3 percent and 7 percent discount rates in the years 2020, 2025 and 2030, in 2011 dollars. In this table, the estimates for the health co-benefits are derived using $PM_{2.5}$ log-linear concentration-response functions that quantify risk associated with the full range of $PM_{2.5}$ exposures experienced by the population (EPA, 2009; EPA, 2010; NRC, 2002).[5] Table 1-4 presents a sensitivity analysis that illustrates the effect of removing $PM_{2.5}$ co-benefits that accrue to populations that live in areas at or below $PM_{2.5}$ concentrations that correspond to different cut points. We present two alternative models: a) forgone $PM_{2.5}$ co-benefits fall to zero in areas whose model-predicted air quality is at or below the annual average $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$ in the year 2025[6]; and b) forgone $PM_{2.5}$ co-benefits fall to zero the below LML in the epidemiological studies used to derive the concentration response function (8 and 5.8 $\mu g/m^3$). EPA has generally expressed a greater confidence in the effects observed around the mean $PM_{2.5}$ concentrations in the long-term epidemiological studies; this does not necessarily imply a concentration threshold below which there are no effects. As such, these analyses are designed to increase transparency rather than imply a specific lower bound on the size of the health co-benefits. While not presented here, the number of forgone premature deaths, including the forgone deaths from the two alternative models, can be found in Table 3-10 and Table 7-4; over 90% of the monetized health co-benefits are composed of the value of avoided premature deaths associated with reductions in $PM_{2.5}$ and ozone. We seek comment from the public on how best to use empirical data to quantitatively characterize the increasing uncertainty in $PM_{2.5}$ co-benefits that accrue to populations who live in areas with lower ambient concentrations.

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[5] This approach to calculating and reporting the risk of $PM_{2.5}$-attributable premature death is consistent with recent RIAs (U.S. EPA 2009b, 2010c, 2010d, 2011a, 2011b, 2011c, 2012, 2013, 2014, 2015a, 2016).

[6] We applied the air quality modeling predictions from air quality modeling developed to support the 2014 CPP proposal. This air quality modeling scenario projected annual mean $PM_{2.5}$ concentrations to the year 2025, prior to the implementation of the Mass- or Rate-Based CPP policy.

Table 1-3. Combined Estimates of Forgone Climate Benefits, Demand-Side Energy Efficiency Benefits and Health Co-Benefits (billions of 2011$)

Year	Discount Rate	Forgone Domestic Climate Benefits	Forgone Demand-Side Energy Efficiency Benefits	Total Forgone Targeted Pollutant Benefits	Forgone Health Co-benefits	Total Forgone Benefits
Rate-Based						
2020	3%	$0.4	$1.2	$1.6	$0.7 to $1.8	$2.3 to $3.4
	7%	$0.1	$1.2	$1.3	$0.6 to $1.7	$1.9 to $3.0
2025	3%	$1.4	$9.2	$10.6	$7.4 to $17.7	$18.0 to $28.4
	7%	$0.2	$9.2	$9.4	$6.7 to $16.2	$16.2 to $25.6
2030	3%	$2.7	$18.8	$21.5	$14.2 to $33.9	$35.8 to $55.5
	7%	$0.5	$18.8	$19.3	$12.9 to $30.9	$32.2 to $50.2
Mass-Based						
2020	3%	$0.4	$1.2	$1.6	$2.0 to $4.8	$3.6 to $6.4
	7%	$0.1	$1.2	$1.3	$1.8 to $4.4	$3.1 to $5.6
2025	3%	$1.6	$10.0	$11.6	$7.1 to $17.2	$18.7 to $28.8
	7%	$0.3	$10.0	$10.3	$6.5 to $15.7	$16.7 to $26.0
2030	3%	$2.7	$19.3	$22.0	$11.7 to $28.1	$33.8 to $50.1
	7%	$0.5	$19.3	$19.8	$10.6 to $25.7	$30.4 to $45.5

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The total forgone targeted pollutant benefit estimates in this summary table are the sum of the forgone domestic climate benefits and forgone demand-side energy efficiency benefits. Forgone co-benefits are based on regional benefit-per-ton estimates. Forgone ozone co-benefits occur in analysis year, so they are the same for all discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). These estimates do not include the health benefits from directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants (e.g. mercury), ecosystem effects, or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 1-4. Sensitivity Analysis Showing Potential Impact of Uncertainty at $PM_{2.5}$ Levels below the LML and NAAQS on Estimates of Health Co-Benefits (billions of 2011$)

		Forgone $PM_{2.5}$ Co-benefits Fall to Zero Below LML [a]		Forgone $PM_{2.5}$ Co-Benefits Fall to Zero Below NAAQS (12 µg/m3) [c]	
Year	Discount Rate	Forgone Health Co-Benefits [a]	Total Forgone Benefits [b]	Forgone Health Co-Benefits [c]	Total Forgone Benefits [b]
Rate-Based					
2020	3%	$0.7 to $1.2	$2.2 to $2.8	$0.1 to $0.6	$1.7 to $2.1
	7%	$0.6 to $1.1	$1.9 to $2.4	$0.1 to $0.6	$1.4 to $1.8
2025	3%	$6.9 to $10.1	$17.5 to $20.7	$0.8 to $2.7	$11.4 to $13.3
	7%	$6.3 to $9.3	$15.7 to $18.7	$0.7 to $2.6	$10.2 to $12.1
2030	3%	$13.2 to $19.1	$34.8 to $40.7	$1.4 to $4.9	$23.0 to $26.5
	7%	$12.0 to $17.6	$31.3 to $36.9	$1.3 to $4.8	$20.7 to $24.1
Mass-Based					
2020	3%	$1.9 to $2.8	$3.5 to $4.4	$0.2 to $0.8	$1.8 to $2.4
	7%	$1.7 to $2.6	$2.9 to $3.8	$0.2 to $0.8	$1.5 to $2.0
2025	3%	$6.6 to $10.0	$18.2 to $21.6	$0.8 to $3.0	$12.4 to $14.6
	7%	$6.0 to $9.2	$16.3 to $19.5	$0.8 to $2.9	$11.1 to $13.2
2030	3%	$10.9 to $16.1	$32.9 to $38.1	$1.3 to $4.5	$23.3 to $26.6
	7%	$9.9 to $14.8	$29.7 to $34.7	$1.2 to $4.4	$21.0 to $24.2

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Forgone health-related co-benefits are calculated using benefit-per-ton estimates corresponding to three regions of the U.S. Forgone ozone co-benefits occur in analysis year, so they are the same for all discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The monetized forgone health co-benefits do not include reduced health effects from reductions in directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

[a] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al. 2012; LML = 8 $\mu g/m^3$).

[b] Total forgone benefits is calculated by adding the total forgone targeted pollutant benefits and the forgone health co-benefits.

[c] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$.

1.5. Net Benefits of the Proposed Repeal of the CPP

In the decision-making process it is useful to consider the benefits due to reductions in the target pollutant relative to the costs, and whether alternative regulatory designs can achieve reductions in the targeted pollutants and/or the other affected pollutants more cost effectively. Therefore, in Table 1-5 we present a comparison of the forgone benefits from the targeted pollutant – CO_2 – (the costs of this proposed rule) with the avoided compliance cost (the benefits of this proposed rule).[7] Excluded from this comparison are the forgone benefits from the SO_2 and NO_X emission reductions that were also projected to accompany the CO_2 reductions. However, had those SO_2 and NO_X reductions been achieved through other means, then they would have been represented in the baseline for this proposed repeal (as well as for the 2015 Final CPP), which would have affected the estimated costs and benefits of controlling CO_2 emissions alone.

Regulating pollutants jointly can promote a more efficient outcome in pollution control management (Tietenberg, 1973). However, in practice regulations are promulgated sequentially and therefore, the benefit-cost analyses supporting those regulations are also performed sequentially. The potential for interaction between regulations suggests that their sequencing may affect the realized efficiency of their design and the estimated net benefits for each regulation. For the 2015 Final CPP rulemaking, the EPA did not consider alternative regulatory approaches to jointly control CO_2, SO_2, and NO_X emission from existing power plants.[8] This leaves open the possibility that an option which jointly regulates CO_2, SO_2, and NO_X emissions from power plants could have achieved these reductions more efficiently than through a single regulation targeting CO_2 emissions, conditional on statutory authority to promulgate such a regulation. To note, when considering whether a regulatory action is a potential welfare improvement (i.e., potential Pareto improvement) it is necessary to consider all impacts of the action.

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[7] The forgone benefits estimate also includes the benefits due to demand-side energy efficiency programs forecast as a result of the rule.

[8] The EPA did include in its analysis regulations affecting SO_2 and NO_X emissions that had been promulgated prior to the 2015 Final CPP analysis.

Table 1-5. Avoided Compliance Costs, Forgone Domestic Climate Benefits, Forgone Demand-Side Energy Efficiency Benefits, and Net Benefits of Repeal Associated with Targeted Pollutant (billions of 2011$)

Year	Discount Rate	Avoided Compliance Costs	Forgone Domestic Climate Benefits	Forgone Demand-Side Energy Efficiency Benefits	Net Benefits Associated with Targeted Pollutant
Rate-Based					
2020	3%	$3.7	$0.4	$1.2	$2.1
2020	7%	$4.2	$0.1	$1.2	$2.9
2025	3%	$10.2	$1.4	$9.2	($0.4)
2025	7%	$14.1	$0.2	$9.2	$4.7
2030	3%	$27.2	$2.7	$18.8	$5.7
2030	7%	$33.3	$0.5	$18.8	$14.0
Mass-Based					
2020	3%	$2.6	$0.4	$1.2	$1.0
2020	7%	$3.1	$0.1	$1.2	$1.8
2025	3%	$13.0	$1.6	$10.0	$1.4
2025	7%	$16.9	$0.3	$10.0	$6.6
2030	3%	$24.5	$2.7	$19.3	$2.5
2030	7%	$30.6	$0.5	$19.3	$10.8

Notes: Total forgone target pollutant benefits are the sum of forgone domestic climate benefits and forgone demand-side energy efficiency benefits. Estimates are rounded to one decimal point and may not sum due to independent rounding.

Tables 1-6 through 1-8 provide the estimates of the forgone climate benefits, demand-side energy efficiency benefits, health co-benefits, avoided compliance costs and forgone net benefits of the rate-based and mass-based illustrative plan approaches, respectively, from the proposed repeal of the CPP. There are additional important forgone benefits that the EPA could not monetize. Due to current data and modeling limitations, our estimates of the forgone benefits from reducing CO_2 emissions do not include important impacts like ocean acidification or potential tipping points in natural or managed ecosystems. Unquantified forgone benefits also include climate benefits from reducing emissions of non-CO_2 greenhouse gases and forgone co-benefits from reducing exposure to SO_2, NO_X, and hazardous air pollutants (e.g., mercury), as well as ecosystem effects and visibility impairment.

Table 1-6. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits (billions of 2011$) [a]

	Rate-Based Approach		Mass-Based Approach	
	Discount Rate		Discount Rate	
	3%	7%	3%	7%
2020				
Cost: Forgone Benefits [b]	$2.3 to $3.4	$1.9 to $3.0	$3.6 to $6.4	$3.1 to $5.6
Benefit: Avoided Compliance Costs	$3.7	$4.2	$2.6	$3.1
Net Benefits	$0.3 to $1.4	$1.2 to $2.3	($3.8) to ($1.0)	($2.5) to $0.0
2025				
Cost: Forgone Benefits [b]	$18.0 to $28.4	$16.2 to $25.6	$18.7 to $28.8	$16.7 to $26.0
Benefit: Avoided Compliance Costs	$10.2	$14.1	$13.0	$16.9
Net Benefits	($18.1) to ($7.8)	($11.5) to ($2.0)	($15.8) to ($5.7)	($9.1) to $0.2
2030				
Cost: Forgone Benefits [b]	$35.8 to $55.5	$32.2 to $50.2	$33.8 to $50.1	$30.4 to $45.5
Benefit: Avoided Compliance Costs	$27.2	$33.3	$24.5	$30.6
Net Benefits	($28.3) to ($8.6)	($16.9) to $1.1	($25.7) to ($9.3)	($14.8) to $0.2
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)			
Forgone Non-Monetized Benefits	Non-monetized climate benefits; Health benefits from reductions in ambient NO_2 and SO_2 exposure; Health benefits from reductions in mercury deposition; Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury; Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)			

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. The forgone air quality health co-benefits reflect exposure to $PM_{2.5}$ and ozone associated with emission reductions of SO_2 and NO_X. The forgone co-benefits do not include the forgone benefits of reductions in directly emitted $PM_{2.5}$. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 98 percent of total monetized forgone co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. Estimates in the table are presented with air quality co-benefits calculated using two discount rates. The estimates of forgone co-benefits are annual estimates in each of the analytical years, reflecting discounting of mortality benefits over the cessation lag between changes in $PM_{2.5}$ concentrations and changes in risks of premature death (see Chapter 4 of the 2015 CPP RIA for more details), and discounting of morbidity benefits due to the multiple years of costs associated with some illnesses. The estimates are not the present value of the forgone benefits of the rule over the full compliance period.

Table 1-7. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, assuming that Forgone $PM_{2.5}$ Related Benefits Fall to Zero Below the Lowest Measured Level of Each Long-Term $PM_{2.5}$ Mortality Study (billions of 2011$) [a]

	Rate-Based Approach		Mass-Based Approach	
	Discount Rate		Discount Rate	
	3%	7%	3%	7%
2020				
Cost: Forgone Benefits [b]	$2.2 to $2.8	$1.9 to $2.4	$3.5 to $4.4	$2.9 to $3.8
Benefit: Avoided Compliance Costs	$3.7	$4.2	$2.6	$3.1
Net Benefits	$0.9 to $1.5	$1.8 to $2.3	($1.8) to ($0.9)	($0.7) to $0.2
2025				
Cost: Forgone Benefits [b]	$17.5 to $20.7	$15.7 to $18.7	$18.2 to $21.6	$16.3 to $19.5
Benefit: Avoided Compliance Costs	$10.2	$14.1	$13.0	$16.9
Net Benefits	($10.5) to ($7.3)	($4.6) to ($1.6)	($8.5) to ($5.2)	($2.5) to $0.7
2030				
Cost: Forgone Benefits [b]	$34.8 to $40.7	$31.3 to $36.9	$32.9 to $38.1	$29.7 to $34.7
Benefit: Avoided Compliance Costs	$27.2	$33.3	$24.5	$30.6
Net Benefits	($13.5) to ($7.6)	($3.6) to $2.0	($13.7) to ($8.4)	($4.0) to $0.9
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)			
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits from reductions in ambient NO_2 and SO_2 exposure Health benefits from reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)			

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. The forgone air quality health co-benefits reflect exposure to $PM_{2.5}$ and ozone associated with emission reductions of SO_2 and NO_X. The forgone co-benefits do not include the forgone benefits of reductions in directly emitted $PM_{2.5}$. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 98 percent of total monetized forgone co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. Estimates in the table are presented with air quality co-benefits calculated using two discount rates. The estimates of forgone co-benefits are annual estimates in

each of the analytical years, reflecting discounting of mortality benefits over the cessation lag between changes in $PM_{2.5}$ concentrations and changes in risks of premature death (see Chapter 4 of the 2015 CPP RIA for more details), and discounting of morbidity benefits due to the multiple years of costs associated with some illnesses. The estimates are not the present value of the forgone benefits of the rule over the full compliance period. The estimates above were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al 2012; LML = 8 $\mu g/m^3$).

Table 1-8. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, assuming that Forgone PM2.5 Related Benefits Fall to Zero Below the Annual $PM_{2.5}$ National Ambient Air Quality Standard (billions of 2011$) [a]

	Rate-Based Approach		Mass-Based Approach	
	Discount Rate		Discount Rate	
	3%	7%	3%	7%
2020				
Cost: Forgone Benefits [b]	$1.7 to $2.1	$1.4 to $1.8	$1.8 to $2.4	$1.5 to $2.0
Benefit: Avoided Compliance Costs	$3.7	$4.2	$2.6	$3.1
Net Benefits	$1.5 to $2.0	$2.4 to $2.8	$0.2 to $0.8	$1.1 to $1.7
2025				
Cost: Forgone Benefits [b]	$11.4 to $13.3	$10.2 to $12.1	$12.4 to $14.6	$11.1 to $13.2
Benefit: Avoided Compliance Costs	$10.2	$14.1	$13.0	$16.9
Net Benefits	($3.1) to ($1.1)	$2.1 to $4.0	($1.6) to $0.6	$3.7 to $5.9
2030				
Cost: Forgone Benefits [b]	$23.0 to $26.5	$20.7 to $24.1	$23.3 to $26.6	$21.0 to $24.2
Benefit: Avoided Compliance Costs	$27.2	$33.3	$24.5	$30.6
Net Benefits	$0.7 to $4.2	$9.2 to $12.7	($2.1) to $1.2	$6.4 to $9.6
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)			
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits from reductions in ambient NO_2 and SO_2 exposure Health benefits from reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)			

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. The forgone air quality health co-benefits reflect exposure to $PM_{2.5}$ and ozone associated with emission reductions of SO_2 and NO_X. The forgone co-benefits do not include the forgone benefits of reductions in directly emitted $PM_{2.5}$. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 98 percent of total monetized forgone co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. Estimates in the table are presented with air quality co-benefits calculated using two discount rates. The estimates of forgone co-benefits are annual estimates in

each of the analytical years, reflecting discounting of mortality benefits over the cessation lag between changes in $PM_{2.5}$ concentrations and changes in risks of premature death (see Chapter 4 of the 2015 CPP RIA for more details), and discounting of morbidity benefits due to the multiple years of costs associated with some illnesses. The estimates are not the present value of the forgone benefits of the rule over the full compliance period. Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 µg/m^3.

1.6. Alternative Emissions Reductions, Compliance Cost, and Benefit Estimates from 2017 Annual Energy Outlook

The starting point for assessing the cost savings and forgone benefits of proposed repeal of the CPP is the 2015 RIA that assessed the costs and benefits of promulgating and implementing the CPP. However, several notable changes have occurred that affect the electric power sector. These changes include changes in expected electricity demand, expected growth in electricity generation by renewable methods, retirement of older generating units, changes in the prices and availability of different fuels, and state and federal regulations. To better understand the potential implications of these changes on EPA's 2015 CPP-related regulatory analyses, Section 7 of this RIA draws upon a series of AEO projections to present a series of observations on recent power sector trends. This approach reflects the potential impact of updating the 2015 CPP analysis to reflect updated market conditions, underscoring the importance of updated modeling, which the EPA has committed to providing.

Generally, we observe that CO_2 emissions without the CPP are lower in each successive AEO, and along with other trends, this suggests that the projected cost of complying with the CPP would be lower than was estimated by EPA in 2015. Using the 2017 AEO, Section 7 also present the costs and emission reductions estimated by EIA's representation of a mass-based implementation of the CPP, applying additional analyses to quantify the forgone climate and air quality benefits. Two 2017 AEO cases were compared: the 2017 Reference Case, which includes a mass-based representation of the CPP, and a side case with the CPP removed. The following set of tables presents the forgone emissions reductions, avoided compliance costs, and forgone climate and air quality benefits in 2020, 2025, and 2030, as derived from 2017 AEO projections. Note that neither the avoided compliance costs nor forgone benefits presented are directly comparable to those based on the 2015 RIA results and presented in Sections 1.3 and 1.4 above because of differing accounting treatments of the reduction in power sector generating costs due to demand-side energy efficiency programs.

1.6.1. Avoided Compliance Costs using AEO2017

EPA obtained information from EIA to provide estimates of the change in electric power sector resource costs projected in the 2017 AEO to be associated with implementing the CPP. The total resource costs also include utility expenditures on demand-side energy efficiency. Because these utility expenditures on demand-side energy efficiency would likely influence consumer investment decisions, EPA also obtained information from EIA on residential and building shell and residential and commercial sector equipment investments consistent with the two 2017 AEO cases. These residential and commercial investment totals are net of utility rebates. Table 1-9 presents the results of this analysis of 2017 AEO information. The detailed calculations informing these estimates are described in detail in Section 7.4 of this RIA.

Table 1-9. Avoided Compliance Costs from Repealing CPP using the 2017 Annual Energy Outlook (billions 2011$)

	2020	2025	2030
Avoided Compliance Costs (billions 2011$)[1,2,3,4]	-$0.3	$14.5	$14.4

Note: Sums may not total due to independent rounding. Dollar years adjusted from 2016 to 2011 using GDP-IPD.
[1] Resource costs in this table represent annual expenses and capital payments, where the capital payments are calculated as an investment recovered as an annual payment.
[2] The AEO2017 reference case features a mass-based implementation of the CPP.
[3] Represents change in building shell (residential only) and equipment investments net of utility rebates. Negative values represent instances where rebate levels exceed incremental capital costs.
[4] These avoided compliance costs are not directly comparable to the avoided compliance costs presented in Section 1.3 above due to differing accounting treatments of the reduction in power sector generating costs due to demand-side energy efficiency programs.

Using the 2017 AEO, the estimated avoided annual compliance costs in 2020, 2025, and 2030 would be approximately -$0.3 billion, $14.5 billion, and $14.4 billion, respectively, in 2011 dollars. It is important to note, however, that because of data limitations, the EPA was unable to estimate the value of reduced electricity demand from demand-side energy efficiency programs, as was included in the EPA estimates as presented in Section 1.3 above.

1.6.2. Forgone Emissions Reductions using AEO2017

Table 1-10 shows forgone emission reductions from the proposed repeal of the CPP using the 2017 AEO reference case with CPP and the 2017 AEO side case without the CPP.

Table 1-10. Forgone Emissions Reductions from Repealing CPP 2020, 2025, and 2030 using the AEO2017

AEO2017	CO_2 (million short tons)	SO_2 (thousand short tons)	Annual NO_X (thousand short tons)
2020	17	-9	10
2025	210	191	150
2030	384	423	255

Source**:** 2017 Annual Energy Outlook. Emissions change may not sum due to rounding.
[1] The AEO2017 reference case features a mass-based implementation of the CPP.

In 2030, according to the 2017 AEO, CO_2 emissions would have been reduced by 384 million short tons, had the CPP been implemented. Under this proposed action to repeal the CPP, SO_2 emissions are projected to about 423 thousand short tons higher than they would have been, and NO_X emissions about 255 thousand short tons higher than they would have been under the CPP, according to the 2017 AEO.

1.6.3. Forgone Benefits using AEO2017

The EPA has evaluated the range of potential forgone impacts reflecting the preceding cost and benefit information based on AEO2017. Table 1-11 and 1-12 provide the total forgone benefits, comprised of forgone domestic climate benefits and health co-benefits estimated for 3 percent and 7 percent discount rates. All dollar estimates are in 2011 dollars. We calculate $PM_{2.5}$-related forgone benefits using a log-linear concentration-response function that quantifies risk from the full range of $PM_{2.5}$ exposures (EPA, 2009; EPA, 2010; NRC, 2002); this approach to calculating and reporting the risk of $PM_{2.5}$-attributable premature death is consistent with recent RIA's (EPA 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016).

Note that the forgone benefits presented in this section are not directly comparable to those presented in Section 1.4 above because they do not include an estimate of the forgone demand-side energy efficiency benefits.

Table 1-11. Combined Estimates of Forgone Climate Benefits and Health Co-benefits, based on the 2017 Annual Energy Outlook (billions of 2011$)

Year	Discount Rate	Forgone Domestic Climate Benefits	Forgone Health Co-benefits	Total Forgone Benefits
2020	3%	$0.1	($0.5) to ($0.3)	($0.5) to ($0.2)
	7%	$0.0	($0.5) to ($0.2)	($0.5) to ($0.2)
2025	3%	$1.3	$7.7 to $18.3	$9.0 to $19.6
	7%	$0.2	$7.0 to $16.7	$7.2 to $16.9
2030	3%	$2.5	$18.1 to $42.4	$20.6 to $44.9
	7%	$0.4	$16.4 to $38.5	$16.8 to $39.0

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 1-12. Sensitivity Analysis Showing Potential Impact of Uncertainty at $PM_{2.5}$ Levels below the LML and NAAQS on Estimates of Health Co-Benefits, based on the 2017 Annual Energy Outlook (billions of 2011$)

		Forgone $PM_{2.5}$ Co-Benefits Fall to Zero Below LML [a]		Forgone $PM_{2.5}$ Co-Benefits Fall to Zero Below NAAQS (12 $\mu g/m^3$) [c]	
Year	**Discount Rate**	**Forgone Health Co-Benefits [a]**	**Total Forgone Benefits [b]**	**Forgone Health Co-Benefits [c]**	**Total Forgone Benefits [b]**
2020	3%	($0.2) to ($0.2)	($0.2) to ($0.1)	$0.0 to $0.1	$0.1 to $0.2
	7%	($0.2) to ($0.2)	($0.2) to ($0.2)	$0.0 to $0.1	$0.0 to $0.1
2025	3%	$7.2 to $10.2	$8.4 to $11.5	$0.7 to $2.4	$2.0 to $3.6
	7%	$6.5 to $9.4	$6.7 to $9.6	$0.7 to $2.3	$0.9 to $2.5
2030	3%	$16.8 to $23.3	$19.3 to $25.8	$1.4 to $4.7	$4.0 to $7.3
	7%	$15.2 to $21.3	$15.6 to $21.7	$1.4 to $4.6	$1.8 to $5.0

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Forgone health-related co-benefits are calculated using benefit-per-ton estimates corresponding to three regions of the U.S. Forgone ozone co-benefits occur in analysis year, so they are the same for all discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The monetized forgone health co-benefits do not include reduced health effects from reductions in directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

[a] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al. 2012; LML = 8 $\mu g/m^3$).

[b] Total forgone benefits were calculated by adding the total forgone targeted pollutant benefits and the forgone health co-benefits.
[c] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 µg/m^3.

1.6.4. Net Benefit of Proposed Repeal of CPP using AEO2017

For the same rationale provided for Table 1-5 with respect to the decision-making process, EPA is providing the benefits due to reductions in the target pollutant relative to the costs in Table 1-13.

Table 1-13. Avoided Compliance Costs, Forgone Domestic Climate Benefits, and Net Benefits of Repeal Associated with Targeted Pollutant, based on the 2017 Annual Energy Outlook (billions of 2011$)

Year	Discount Rate	Avoided Compliance Costs	Forgone Domestic Climate Benefits	Net Benefits Associated with Targeted Pollutant
2020	3%	($0.3)	$0.1	($0.4)
2020	7%		$0.0	($0.3)
2025	3%	$14.5	$1.3	$13.2
2025	7%		$0.2	$14.3
2030	3%	$14.4	$2.5	$11.9
2030	7%		$0.4	$14.0

Notes: All estimates are rounded to one decimal point and may not sum due to independent rounding.

Table 1-14 through 1-16 provide the estimates of the forgone benefits, avoided compliance costs and forgone net benefits of the CPP in 2020, 2025, and 2030 reflecting the preceding cost and benefit information based on AEO2017. There are additional important forgone benefits that the EPA could not monetize. Due to current data and modeling limitations, our estimates of the forgone benefits from reducing CO_2 emissions do not include important impacts like ocean acidification or potential tipping points in natural or managed ecosystems. Unquantified forgone benefits also include climate benefits from changes in emissions of non-CO_2 greenhouse gases and forgone co-benefits from reducing exposure to SO_2, NO_X, and hazardous air pollutants (e.g., mercury), as well as reduced ecosystem effects and reduced visibility impairment. In addition, due to data limitations of AEO2017, our estimates of forgone benefits and avoided compliance costs are not directly comparable to those presented in sections 1.3 and 1.4 because of differing accounting treatments of the reduction in power sector generating costs due to demand-side energy efficiency.

Table 1-14. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, based on the 2017 Annual Energy Outlook (billions of 2011$) [a]

	Discount Rate	
	3%	7%
2020		
Cost: Forgone Benefits [b]	($0.5) to ($0.2)	($0.5) to ($0.2)
Benefit: Avoided Compliance Costs	($0.3)	($0.3)
Net Benefits	($0.2) to $0.1	($0.1) to $0.1
2025		
Cost: Forgone Benefits [b]	$9.0 to $19.6	$7.2 to $16.9
Benefit: Avoided Compliance Costs	$14.5	$14.5
Net Benefits	($5.0) to $5.5	($2.3) to $7.3
2030		
Cost: Forgone Benefits [b]	$20.6 to $44.9	$16.8 to $39.0
Benefit: Avoided Compliance Costs	$14.4	$14.4
Net Benefits	($30.6) to ($6.3)	($24.6) to ($2.5)
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)	
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits of reductions in ambient NO_2 and SO_2 exposure Health benefits of reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)	

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 1-15. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, based on the 2017 Annual Energy Outlook, assuming that Forgone PM2.5 Related Benefits Fall to Zero Below the Lowest Measured Level of Each Long-Term PM2.5 Mortality Study (billions of 2011$) [a]

	Discount Rate	
	3%	**7%**
2020		
Cost: Forgone Benefits [b]	(\$0.2) to (\$0.1)	(\$0.2) to (\$0.2)
Benefit: Avoided Compliance Costs	(\$0.3)	(\$0.3)
Net Benefits	(\$0.2) to (\$0.2)	(\$0.2) to (\$0.1)
2025		
Cost: Forgone Benefits [b]	\$8.4 to \$11.5	\$6.7 to \$9.6
Benefit: Avoided Compliance Costs	\$14.5	\$14.5
Net Benefits	\$3.1 to \$6.1	\$5.0 to \$7.8
2030		
Cost: Forgone Benefits [b]	\$19.3 to \$25.8	\$15.6 to \$21.7
Benefit: Avoided Compliance Costs	\$14.4	\$14.4
Net Benefits	(\$11.4) to (\$4.9)	(\$7.3) to (\$1.3)
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)	
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits of reductions in ambient NO_2 and SO_2 exposure Health benefits of reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)	

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. These estimates of forgone $PM_{2.5}$ co-benefits assume that the risk of PM-related premature death falls to zero at or below the lowest measured levels of the Krewski et al. (2009) and Lepeule et al. (2012) long-term epidemiological studies (5.8 µg/m^3 and 8 µg/m^3, respectively). Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 1-16. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, based on the 2017 Annual Energy Outlook, assuming that Forgone $PM_{2.5}$ Related Benefits Fall to Zero Below the Annual $PM_{2.5}$ National Ambient Air Quality Standard (billions of 2011$) [a]

	Discount Rate		
	3%		**7%**
2020			
Cost: Forgone Benefits [b]	$0.1 to $0.2		$0.0 to $0.1
Benefit: Avoided Compliance Costs		($0.3)	
Net Benefits	($0.5) to ($0.5)		($0.5) to ($0.4)
2025			
Cost: Forgone Benefits [b]	$2.0 to $3.6		$0.9 to $2.5
Benefit: Avoided Compliance Costs		$14.5	
Net Benefits	$10.9 to $12.6		$12.0 to $13.7
2030			
Cost: Forgone Benefits [b]	$4.0 to $7.3		$1.8 to $5.0
Benefit: Avoided Compliance Costs		$14.4	
Net Benefits	$7.1 to $10.4		$9.4 to $12.6
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)		
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits of reductions in ambient NO_2 and SO_2 exposure Health benefits of reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)		

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. These estimates of forgone $PM_{2.5}$ co-benefits assume that the risk of PM-related premature death falls to zero at or below the Annual PM NAAQS (12 µg/m_3). Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

1.7. Alternative Impacts Estimates from Recent Studies by Non-Governmental Institutions

In the 2015 Final CPP RIA the EPA did not analyze how the benefits, costs and impacts of different implementation scenarios vary with different assumptions about the future uncertain economic conditions. As discussed in Section 8.1, to gain insight into how differences in CPP implementation and future economic and technological conditions may affect the cost of the CPP, for this RIA EPA reviewed non-governmental studies of the CPP. We focused our review on studies that provide national estimates of the rule's cost and impacts and were conducted since May 2016 when the AEO2016 Early Release was published. The studies that meet these criteria have not necessarily been subjected to peer review, and certain specifics of the analysis are unclear due to limited documentation. These studies analyzed different methods of implementation of the CPP, including the mix of states adopting mass-based or rate-based programs and multiple ways to address leakage (as defined in the final CPP).

Table 1-17. Non-Peer Reviewed Analyses of Clean Power Plan Since May, 2016

	Publication Date	Range of National Cost of the CPP (Billion $)[a]	Format of Reported Cost	National CO_2 Reduction (Million Short Tons)
Bipartisan Policy Center	June 2016	$0 to $9[b]	Annualized cost from 2022 to 2032	Not reported with precision. See text for further details.
M.J. Bradley and Associates	June 2016	$-1.8 to $1.7; $-4.3 to $2.0; $-2.8 to $3.7 (2012$)	Annual cost for 2020, 2025 and 2030.	-3 to 119 in 2020; 15 to 231 in 2025; 57 to 330 in 2030
Duke Nicholas School (Ross et al.)	July 2016	$1.9 to $15.4	Present discounted value of total costs from 2020 to 2040	Not reported with precision. See text for further details.

[a] The dollar year for reported costs is not identified in the Bipartisan Policy Center and Duke Nicholas School studies.
[b] The reported costs are from EPA's read to the nearest $1 billion from graphs provided in this study.

Table 1-17 reports the range of cost of the CPP as reported in these studies and, when available, the forecast reduction in CO_2 emissions from the electricity sector. The accounting of costs in these studies is similar to the approach used in the 2015 Final CPP RIA, although they may be reported differently (e.g., a present discounted value over multiple years). The range of costs reflects the two scenarios analyzed with the highest and lowest cost from the study for those scenarios with reported cost data, while the range of CO_2 reductions reflects the range of scenarios with the greatest and least reduction in CO_2 emissions. Changes in the level of pollutants other than CO_2 are generally not reported in these studies. Within each study and across the studies, EPA observes that they forecast a range of costs and potential benefits of the CPP given various assumptions about the way CPP would be implemented and possible economic conditions, and that these ranges are quite large. Therefore, these studies suggest that, had EPA's future analysis incorporated varying economic conditions and implementation assumptions, it would likely have generated a meaningful range of potential avoided costs and forgone benefits of this proposed rule.

1.8. Conclusion

We present various and preliminary approaches to assess the CPP repeal proposal. The analysis underscores the profound uncertainties associated with possible outcomes of the CPP implementation analysis and, therefore, the preliminary repeal being offered at this time. EPA plans to conduct a more robust analysis before any final action is taken by the agency and provide an opportunity for the public to comment on the reanalysis. EPA also plans to carry forward the approach that underscores the uncertainty associated with any agency action of this magnitude, especially given the discretion afforded to the State governments.

2. Background

2.1. Purpose of RIA

In accordance with Executive Order 12866 and OMB Circular A-4, and the EPA's "Guidelines for Preparing Economic Analyses," the EPA prepared this RIA for this "significant regulatory action." This action is an economically significant regulatory action because it may have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or state, local, or tribal governments or communities.[9]

This RIA addresses the avoided regulatory compliance costs, forgone emission reduction benefits of the final emission guidelines that are the focus of this action. Additionally, this RIA includes information about potential impacts of the proposed rule on electricity markets, employment, and markets outside the electricity sector. The RIA also presents a discussion of uncertainties and limitations of the analysis.

2.2. Analysis Supporting the Clean Power Plan Review

The starting point for this analysis is the modeling results used for the 2015 RIA that was done for the original CPP rule. However, because those model runs reflect conditions in the electric power sector before 2015, including assumptions for demand-side energy efficiency, and the industry has gone through significant changes since that time, we have made a number of additions and planned additions to the body of analyses supporting this rulemaking.

1. We include results from the Energy Information Agency's Annual Energy Outlook 2017, which contains recent modeling results allowing us to develop an estimate of the of costs of the CPP (or cost savings from repeal of the CPP) as well as emission changes from these actions.

[9] The analysis in this proposal RIA constitutes the economic assessment required by CAA section 317. In the EPA's judgment, the assessment is as extensive as practicable taking into account the EPA's time, resources, and other duties and authorities.

2. We reviewed other studies assessing the impacts of the CPP to assess whether more recent studies beyond the EIA study could provide a more robust set of modeling results.
3. We make some technical changes to the analysis to capture uncertainty and make it more consistent with OMB Circular A-4.

We note that keeping track of all this additional information can be challenging for the reader. We have our original IPM model runs, the AEO2017 model runs, two sets of discount rates, rate-based and mass-based program designs, and a variety of other variables. To make things as straightforward as possible, EPA first presents the costs and benefits of the CPP (the cost savings and forgone benefits or repealing the CPP) derived from the original 2015 modeling runs. In that presentation, EPA discusses and sometimes quantitatively treats some of the key uncertainties inherent in this approach. After this full presentation of benefits and costs, EPA then applies similar methods to derive benefits and costs from EIA's AEO2017 cases with and without the CPP. The same technical approach to quantifying benefits is used in both cases so less detail is provided in the second analysis. However, because the AEO2017 analysis is more recent and reflects recent changes in electric utility sector conditions, EPA has incorporated these costs and emission changes as part of our main presentation of costs and benefits. This main presentation is summarized in the Executive Summary.

In evaluating the impacts of the proposed action, we discuss a number of uncertainties. For example, the analysis includes an evaluation of two illustrative plan approaches that states and affected EGUs may have taken under the CPP to accomplish state emission performance goals, a rate-based and a mass-based approach. The RIA also examines uncertainties in technical and economic changes to the electricity sector, estimates of regulatory compliance costs, the estimated benefits of demand-side energy efficiency investments, monetizing estimated climate benefits, and the estimated benefits of reducing other air pollutants.

Finally, it is also important to consider that:

1. Costs that occur to entities and consumers beyond the directly regulated sector are only qualitatively described. Research has shown that higher electricity prices resulting from the CPP may exacerbate pre-existing market distortions in the economy, thereby increasing the dead weight loss associated with those

distortions. For example, price increases as a result of the rule may effectively lower the real wage, and as a result exacerbate existing distortions associated with taxes on labor.

2. The reductions in criteria air pollutants occur as a byproduct of the electric power sector shifting to less carbon-intensive methods of producing electricity. However, to the extent there are negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing) there would be social costs associated with increasing their use, which are not quantitatively represented in our analysis.

3. Regulating pollutants jointly can promote a more efficient outcome in pollution control management (Tietenberg, 1973). However, in practice regulations are promulgated sequentially and therefore, the benefit-cost analyses supporting those regulations are also performed sequentially. The potential for interaction between regulations suggests that their sequencing may affect the realized efficiency of their design and the estimated net benefits for each regulation. For this rulemaking, the EPA did not analyze whether there are more efficient options for joint regulations that target the individual pollutants other than CO_2 that may be affected by this rule.

2.3. Base Case and Year of Analysis from 2015 RIA

The base case for this 2015 RIA-based component of this RIA, which used the Integrated Planning Model (IPM), included state rules that had been finalized and/or approved by a state's legislature or environmental agencies, as well as final federal rules. The IPM Base Case v.5.15 included the Cross-State Air Pollution Rule (CSAPR), the Mercury and Air Toxics (MATS), the final Carbon Pollution Standards for New Power Plants (CPS), the Cooling Water Intakes (316(b)) Rule, the Combustion Residuals from Electric Utilities (CCR), and other state and Federal regulations to the extent that they contain measures, permits, or other air-related limitations or requirements. Additional legally binding and enforceable commitments for greenhouse gas (GHG) reductions considered in the base case are discussed in the documentation for IPM.[10] The 2015 RIA did not include the CSAPR Update Rule, which was finalized in September 2016.

While 2020 precedes the beginning of the interim compliance period (2022), the rule enabled states and affected EGUs to perform voluntary activities that would have facilitated compliance with interim and final goals of the CPP. These pre-compliance period activities might have included investments in renewable energy or demand-side energy efficiency projects, for example, that would have produced emissions reductions in the later compliance period. As a result, the EPA believed there would likely have been benefits and costs in 2020 under the CPP, so 2020 served as the first year of analysis for the illustrative analysis for the 2015 RIA, and is therefore the beginning of the analysis period for this RIA. The 2015 CPP RIA presented benefit and cost estimates in 2025, which represented a central period of the interim compliance time-frame as states and tribes would have been on glide paths toward fully meeting the final CO_2 emission performance goals. Lastly, the RIA presented costs and benefits for 2030, when the emission performance goals were to be fully achieved.

Please see Section 3.3 and 3.4 of the 2015 CPP Regulatory Impact Analysis (RIA) [11] for more discussion of the power sector modeling framework and reference case used in this analysis. Section 5.1 of this RIA also presents a discussion of how important economic and technical factors affecting the electricity sector may have changed and how new information regarding the costs and efficiency of various compliance options may be available since the analysis was conducted for the 2015 CPP RIA.

2.4. Approaches Examined in RIA

The 2015 CPP RIA analyzed two illustrative plan approaches each at the state level: the "rate-based" illustrative plan approach and the "mass-based" illustrative plan approach. The two plan types in these illustrative analyses represent two types of plans that would have been available to the states. Please see Section 3.6 of the 2015 CPP RIA for more description of the

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[10] Detailed documentation for IPM v.5.15 is available at: http://www.epa.gov/powersectormodeling.

[11] U.S. Environmental Protection Agency (U.S. EPA). 2015a. *Regulatory Impact Analysis for the Clean Power Plan Final Rule.* EPA-452/R-15-003. Office of Air Quality Planning and Standards, Health and Environmental Impacts Division, Research Triangle Park, NC.

design of these illustrative plan approaches. The power sector modeling conducted to evaluate these illustrative plan approaches encompassed states and areas of Indian country within the contiguous U.S. As stated in the preamble to this proposal, this action does not have tribal implications as specified in Executive Order 13175. It will not have substantial direct effects on tribal governments, on the relationship between the federal government and Indian tribes, or on the distribution of power and responsibilities between the federal government and Indian tribes, as specified in Executive Order 13175.

The two illustrative plan approaches were designed to reflect, to the extent possible, the scope and nature of the CPP guidelines. However, there was considerable uncertainty with regard to the regulatory form and precise measures that states would have adopted to meet the requirements, since there were considerable flexibilities afforded to the states in developing the state plans. As a result of these flexibilities, the estimates of regulatory costs, climate benefits, and health co-benefits that would have arisen from these alternative strategies to comply with the CPP would likely have been different than those presented here, had the CPP been implemented.

3. Summary of Regulatory Impacts

3.1. Avoided Regulatory Compliance Costs in 2015 CPP RIA

This section of the RIA first presents the regulatory cost estimates produced for the CPP in 2015. This is our starting point for calculating the reduction of compliance costs of this action. Given that the rule is not yet effective, and in the absence of updated analysis of the rule's potential impacts if left in place, this analysis will assume that all of the costs of this rule as previously estimated upon original promulgation will be "cost savings" for this proposed action.

The avoided compliance costs are composed of the previously estimated change in electric power system costs between the base case and the illustrative rate-based and mass-based approaches, including the cost of demand-side energy efficiency measures and costs associated with monitoring, reporting, and recordkeeping requirements (MR&R) that are expected not to be incurred as a result of repealing the CPP.[12] In practice, the extent of compliance costs actually avoided would depend on economic conditions which change over time.[13] In the rate-based approach, demand-side energy efficiency activities were modeled as being used by EGUs as a low-cost method of demonstrating compliance with their rate-based emissions standards. In the mass-based approach, demand-side energy efficiency activities were assumed to be adopted by states to lower demand, which in turn reduces the cost of achieving the mass limitations. The level of reduction in demand for electricity as a result of demand-side energy efficiency measures was determined outside of IPM and is assumed to be the same in the two illustrative plan approaches.[14]

The annual compliance cost is the previously projected cost of complying with the rule in the year analyzed and reflects the net difference in the sum of the annualized cost of capital investment in new generating sources and heat rate improvements at coal-fired steam facilities, the change in the ongoing costs of operating pollution controls, shifts between or amongst

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[12] See Chapter 3 of the 2015 CPP RIA (U.S. EPA 2015a) for a detailed discussion of the compliance cost estimates.

[13] As noted in Section 1.1, EPA plans to do updated modeling using the Integrated Planning Model, 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

[14] For more detailed information on demand-side energy efficiency, see U.S. EPA. 2015b. Technical Support Document (TSD) the Final Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Demand-Side Energy Efficiency.

various fuels, demand-side energy efficiency measures, and other actions associated with compliance. Related to the decrease in electricity demand, as noted in Tables 3-3 through 3-5, the electric power sector total production cost was projected to decrease. The 2015 RIA projected a 2030 decrease in capital, fixed, variable, and fuel expenditures. In other words, the analysis projected that some capital projects that were modeled to occur in the 2030 baseline would not occur in that year due to the decrease in electricity demand. Note that the estimated electricity demand reduction associated with demand-side energy efficiency measures from the 2015 CPP RIA, 8% reduction in 2030, differs from the Annual Energy Outlook projection of 3.8% in 2030, as noted in Chapter 7 of this RIA.

However, some adjustments to the 2015 RIA estimates were necessary to make the accounting convention of the 2015 CPP RIA consistent with the accounting conventions used by OMB and other federal agencies as noted by the OMB Guidance for Implementing E.O. 13771. In the 2015 RIA, the value of reduced electricity demand from demand-side energy efficiency programs was treated as a cost credit (or negative cost). The OMB guidance instructs EPA to treat these energy cost savings accruing to electricity consumers as a benefit of the rule – not a cost-savings.[15] In the electricity sector, consumers are the primary beneficiaries of the energy cost savings attributable to the energy efficiency programs. While the cost pass-through may not be perfect due to market structures and legal requirements, electricity generators will experience both reductions in costs and revenues. For purposes of calculating net benefits of the rule, the treatment makes no difference. EPA performed supplementary analysis to estimate potential power sector production cost reductions from demand-side energy efficiency investments that the 2015 RIA assumed would be made to help achieve CPP emissions goals. This analysis is described below, as well as the adjusted forgone benefit estimates that result from this analysis.

In the 2015 CPP RIA, EPA estimated the estimated annual compliance costs for 2020, 2025, and 2030, net of the value of savings from demand-side energy efficiency investments. Tables 3-1 through 3-3 below present these annual compliance costs, presented for both the rate-

[15] For the purposes of this document, "energy cost savings" is the value of the reduced costs of producing electricity that is attributable to the demand-side energy efficiency programs. The term "energy savings" is also commonly used to describe the amount of energy saved as a result of demand-side energy efficiency measures, usually expressed in terms of megawatt-hours, but in this document it will refer to the financial value of those savings unless otherwise noted.

based approach and mass-based approach under two discount rate assumptions for demand-side energy efficiency costs. EPA estimated that the annual compliance costs in 2030 for the rate-based approach, net of the value of savings from demand-side energy efficiency investments, would be approximately $8.4 billion under a three percent discount rate assumption for demand-side energy efficiency costs, and $14.5 under a seven percent discount rate assumption (2011$) (see Table 3-3). The annual compliance costs in 2030 for the mass-based approach, net of the value of savings from demand-side energy efficiency investments, would be approximately $5.1 billion under a three percent discount rate assumption for demand-side energy efficiency costs, and $11.3 under a seven percent discount rate assumption (2011$) (see Table 3-3). These compliance costs, reported in Table 3-1 through 3-3 below, are the starting point for EPA's estimates of the cost savings associated with this proposed repeal of the CPP.

Table 3-1. Net Avoided Compliance Cost from 2015 CPP RIA for 2020 (billions 2011$)

	Rate-Based Approach	Mass-Based Approach
Total power sector generating costs: base case [1]	$166.5	$166.5
Total power sector generating costs: CPP case [1]	$166.8	$165.7
Change in total power sector generating costs [2]	*$0.3*	*-$0.8*
Demand-side energy efficiency costs, discounted at 3% [3]	$2.1	$2.1
Demand-side energy efficiency costs, discounted at 7% [3]	$2.6	$2.6
Monitoring, reporting, and recordkeeping costs [4]	$0.07	$0.07
Total avoided compliance cost net of savings from demand-side energy efficiency, with demand-side energy efficiency discounted at 3%	**$2.5**	**$1.4**
Total avoided compliance cost net of savings from demand-side energy efficiency, with demand-side energy efficiency discounted at 7%	**$3.0**	**$1.9**

[1] Table 3-9, 2015 CPP RIA (U.S. EPA 2015a)
[2] The change in total power sector generating costs includes an approximation of the cost of additional generation that would have been needed absent assumed demand reductions from energy efficiency programs (see Section 3.3 for further explanation).
[3] Table 3-3, 2015 CPP RIA (U.S. EPA 2015a)
[4] Table 3-4, 2015 CPP RIA (U.S. EPA 2015a)

Table 3-2. Net Avoided Compliance Cost from 2015 CPP RIA for 2025 (billions 2011$)

	Rate-Based Approach	Mass-Based Approach
Total power sector generating costs: base case [1]	$178.3	$178.3
Total power sector generating costs: CPP case [1]	$162.6	$164.6
Change in total power sector generating costs [2]	*-$15.7*	*-$13.7*
Demand-side energy efficiency costs, discounted at 3% [3]	$16.7	$16.7
Demand-side energy efficiency costs, discounted at 7% [3]	$20.6	$20.6
Monitoring, reporting, and recordkeeping costs [4]	$0.01	$0.01
Total avoided compliance cost net of savings from demand-side energy efficiency, with demand-side energy efficiency discounted at 3%	**$1.0**	**$3.0**
Total avoided compliance cost net of savings from demand-side energy efficiency, with demand-side energy efficiency discounted at 7%	**$4.9**	**$6.9**

[1] Table 3-9, 2015 CPP RIA (U.S. EPA 2015a)
[2] The change in total power sector generating costs includes an approximation of the cost of additional generation that would have been needed absent assumed demand reductions from energy efficiency programs (see Section 3.3 for further explanation).
[3] Table 3-3, 2015 CPP RIA (U.S. EPA 2015a)
[4] Table 3-4, 2015 CPP RIA (U.S. EPA 2015a)

Table 3-3. Net Avoided Compliance Cost from 2015 CPP RIA for 2030 (billions 2011$)

	Rate-Based Approach	Mass-Based Approach
Total power sector generating costs: base case [1]	$201.3	$201.3
Total power sector generating costs: CPP case [1]	$183.3	$180.1
Change in total power sector generating costs [2]	*-$18.0*	*-$21.2*
Demand-side energy efficiency costs, discounted at 3% [3]	$26.3	$26.3
Demand-side energy efficiency costs, discounted at 7% [3]	$32.5	$32.5
Monitoring, reporting, and recordkeeping costs [4]	$0.01	$0.01
Total avoided compliance cost net of savings from demand-side energy efficiency, with demand-side energy efficiency discounted at 3%	**$8.4**	**$5.1**
Total avoided compliance cost net of savings from demand-side energy efficiency, with demand-side energy efficiency discounted at 7%	**$14.5**	**$11.3**

[1] Table 3-9, 2015 CPP RIA (U.S. EPA 2015a)
[2] The change in total power sector generating costs includes an approximation of the cost of additional generation that would have been needed absent assumed demand reductions from energy efficiency programs (see Section 3.3 for further explanation).
[3] Table 3-3, 2015 CPP RIA (U.S. EPA 2015a)
[4] Table 3-4, 2015 CPP RIA (U.S. EPA 2015a)

These estimates also reflect an annualized decrease in expenditures required to supply enough electricity to meet demand in 2030, consistent with implementation of demand-side energy efficiency measures.[16]

3.2. Forgone Emissions Reductions

Tables 3-4 and 3-5 show the emission reductions that EPA estimated would have been obtained under the illustrative plan approaches to comply with the CPP.

Table 3-4. Final 2015 CPP Climate and Air Pollutant Emission Reductions for the Rate-Based Illustrative Plan Approach[1]

	CO_2 (million short tons)	SO_2 (thousand short tons)	Annual NO_X (thousand short tons)
2020 Rate-Based Approach			
Base Case	2,155	1,311	1,333
Final Guidelines	2,085	1,297	1,282
Emissions Change	-69	-14	-50
2025 Rate-Based Approach			
Base Case	2,165	1,275	1,302
Final Guidelines	1,933	1,097	1,138
Emissions Change	-232	-178	-165
2030 Rate-Based Approach			
Base Case	2,227	1,314	1,293
Final Guidelines	1,812	996	1,011
Emission Change	-415	-318	-282

Source: Integrated Planning Model, 2015. Emissions change may not sum due to rounding.
[1] Forgone CO_2 emission reductions are used to estimate the forgone climate benefits of repealing the CPP. SO_2, and NO_X reductions are relevant for estimating the forgone air quality health co-benefits of the repealing the CPP.

[16] See discussion in Section 3.9.2 of the RIA for the Final CPP for more discussion of the projected compliance cost estimates.

Table 3-5. Final 2015 CPP Climate and Air Pollutant Emission Reductions for the Mass-Based Illustrative Plan Appproach[1]

	CO_2 (million short tons)	SO_2 (thousand short tons)	Annual NO_X (thousand short tons)
2020 Mass-Based Approach			
Base Case	2,155	1,311	1,333
Final Guidelines	2,073	1,257	1,272
Emissions Change	-82	-54	-60
2025 Mass-Based Approach			
Base Case	2,165	1,275	1,302
Final Guidelines	1,901	1,090	1,100
Emissions Change	-264	-185	-203
2030 Mass-Based Approach			
Base Case	2,227	1,314	1,293
Final Guidelines	1,814	1,034	1,015
Emission Change	-413	-280	-278

Source: Integrated Planning Model, 2015. Emissions change may not sum due to rounding.
[1] Forgone CO_2 emission reductions are used to estimate the forgone climate benefits of repealing the CPP. SO_2, and NO_X reductions are relevant for estimating the forgone air quality health co-benefits of the repealing the CPP.

In 2030, when compared to the base case emissions, the EPA estimated that CO_2 emissions would have been reduced by 415 million short tons in 2030 under the rate-based approach, had the CPP been implemented. Meanwhile, EPA estimated that 413 million short tons of CO_2 emissions would have been reduced in 2030 under the mass-based approach. Tables 3-4 and 3-5 also shows emission reductions for criteria air pollutants. Under this proposed action to repeal the CPP, therefore, CO_2 emissions are projected to be 413-415 million short tons higher than they would have been had the CPP been implemented. Similarly, SO_2 emissions are projected to be 280-318 thousand short tons higher than they would have been and NO_X emissions 278-282 thousand short tons higher than under the final CPP.

3.3. Demand-Side Energy Efficiency-related Adjustments to Avoided Regulatory Compliance Costs

The total annual compliance cost estimates presented in the 2015 CPP RIA reflected the net cost of simultaneous implementation of many available compliance options, including demand-side energy efficiency measures. The impacts of the demand-side energy efficiency measures on the power sector were modeled in combination with the other CPP compliance measures, and thus the 2015 CPP RIA did not present reduced power sector generating costs associated with demand-side energy efficiency measures independently from the estimate of total annual net compliance costs presented above.[17] These avoided power system costs include both variable costs (e.g., fuel and variable O&M) as well as fixed costs (e.g., new power plants and retrofits of existing power plants, and fixed O&M). The original RIA implicitly treated the energy cost savings projected to accrue to the power sector as a "negative cost" rather than a benefit of the CPP. However, the value of reduced generation costs accrues in part to consumers over time as a reduction in their electricity bills. For the electric utilities, the reduced generation costs would be offset by reduced revenue.[18] In terms of calculating a net benefit estimate, it does not matter if these energy cost savings are treated on the cost side – or the benefit side – of the ledger. OMB issued guidance on how to calculate the costs (and cost savings) for purposes of E.O. 13771 compliance. This RIA presents a methodology that provides a rough approximation of the reduced costs associated with demand-side energy efficiency measures. This methodology enables EPA to calculate the avoided compliance cost estimates (net of energy efficiency-related cost reductions) for the 2015 CPP to be consistent with OMB guidance. Additionally, OMB's Guidance implementing Executive Order 13771 states that accounting for "savings, such as fuel savings associated with energy efficiency investments, as benefits is a common accounting convention followed in the OMB Office of Information and Regulatory Affairs' reports to Congress on the benefits and costs of Federal regulations."[19]

For example, EPA assumed that by 2030 demand-side energy efficiency measures would reduce nationwide electricity demand by 327,092 GWh, which is about 7.83 percent of total

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[17] To independently present the incremental effect of representing demand-side energy efficiency programs on the costs, benefits, and impacts of the CPP, one could model compliance with the CPP with and without demand-side energy efficiency measures and compare the results. The 2015 CPP RIA did not do that.

[18] The ultimate economic incidence of energy efficiency programs on electricity consumers and producers depends in part on how the energy efficiency measures affect retail and wholesale electricity prices, as well as the economic incidence of energy efficiency participant and program costs given how they are funded. (Participant and program costs are the expenditures for energy efficiency outlayed by consumers and program administrators respectively). For example, the 2015 CPP RIA assumed that program costs would be funded through retail electricity prices affecting consumers, although they could be funded in a different way.

[19] U.S. Office of Management and Budget. 2017. "Guidance Implementing Executive Order 13771, Titled 'Reducing Regulation and Controlling Regulatory Costs'" [Memorandum]. Available at: < https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/M-17-21-OMB.pdf> Accessed April 28, 2017.

electricity demand forecast for that year.[20] The projected annual average wholesale price represents the annual average energy price in each region (the marginal cost of meeting demand in each time segment, averaged annually) plus any capacity prices associated with maintaining a reserve margin. In other words, this projection represents the average annual price of power on a firm basis that generators would earn. In order to approximate the reduction in production costs attributable to the reduction in demand due to demand-side energy efficiency programs, we use the annual average wholesale price in each region, as projected in the 2015 RIA under each illustrative scenario.

Figure 3-1 shows a representative electricity supply curve given the requirements of the 2015 CPP. The wholesale price is expected to rise with additional production; as electricity production increases, the cost of producing each additional unit increases as well. The representative electricity supply curve is upward-sloping for this reason. Also shown are two representative (fixed) demand curves for electricity; one with demand-side energy efficiency programs and one without. The wholesale electricity price that was estimated given compliance with the requirements of the 2015 CPP is identified from the intersection of the demand curve with energy efficiency programs in place and the supply curve with the CPP. The reduction in the cost of electricity production associated with reduced demand in a single year can be roughly approximated by multiplying the wholesale price by the change in the demand for electricity, the shaded rectangle in Figure 1. A better representation of the reduction in production costs associated with demand-side energy efficiency would be the entire area underneath the representative electricity supply curve. Conditional on other assumptions regarding the cost and effectiveness of demand-side energy efficiency programs in the 2015 CPP RIA, we note that our estimate of the reduced cost of electricity production is likely an underestimate as it does not account for the area represented by the triangle ABC in Figure 3-1 and, thus, this method for estimating the benefits of energy efficiency programs represents a lower-bound approximation.

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[20] From Table 3-2 in the 2015 CPP RIA. For further details on the nature of the scenario analysis that informed these values, see U.S. EPA. 2015b. Technical Support Document (TSD) the Final Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Demand-Side Energy Efficiency.

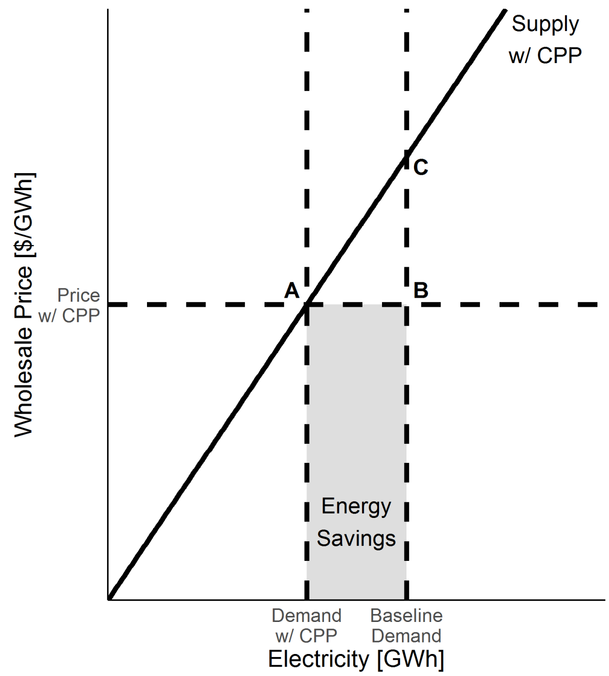

Figure 3-1. Private Value of Demand-Side Energy Efficiency

Projections from the modeling that supported the 2015 RIA are used to approximate the energy cost savings from the reduced demand attributable to the demand-side energy efficiency measures.[21] EPA used the Integrated Planning Model (IPM) to analyze the potential impacts of the 2015 CPP. This analysis included estimates of the average annual wholesale price for each of 64 IPM regions.[22] In order to calculate a lower-bound approximation of the benefit of reduced demand for electricity due to demand-side energy efficiency measures, the wholesale price for each model region from each illustrative scenario is multiplied by the reduced production from energy efficiency for that region, then summed across regions (see Appendix Tables A-1 through A-3).[23]

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[21] This analysis used the model projections that supported the final CPP RIA. The full suite of model outputs are available in the docket ("IPM Run Files: Illustrative Compliance Scenarios").

[22] The model regions representing the U.S. power market are largely consistent with the North American Electric Reliability Corporation assessment regions and with the organizational structures of the Regional Transmission Organizations and Independent System Operators, which handle dispatch on most of the U.S. grid.

[23] The calculation accounts for energy savings due to avoided line losses, and thus the reduction in electricity produced at the generator is greater than the reduction in the amount of electricity consumed. EPA assumes that line loss accounts for 7 percent of electricity production.

Table 3-6 shows how the regulatory compliance costs in the 2015 CPP RIA were adjusted to reflect the lower-bound approximation of the value of savings from demand-side energy efficiency programs for the purposes of estimating avoided regulatory compliance costs from the repeal of the CPP. It is important to emphasize that the 2015 RIA cost estimates and the current estimates for the purposes of this analysis build from the same regulatory cost assessment and that the differences in amounts reflect differing accounting conventions.[24]

Table 3-6. Avoided Compliance Cost of CPP (billions 2011$)

	Rate-Based Approach			**Mass-Based Approach**		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Total avoided compliance cost net of savings from demand-side energy efficiency programs, with demand-side energy efficiency costs discounted at 3%	$2.5	$1.0	$8.4	$1.4	$3.0	$5.1
Total avoided compliance cost net of savings from demand-side energy efficiency programs, with demand-side energy efficiency costs discounted at 7%	$3.0	$4.9	$14.5	$1.9	$6.9	$11.3
Approximate additional generation costs that would have occurred absent demand reductions from demand-side energy efficiency programs (to be applied to both 3% and 7%)	$1.2	$9.2	$18.8	$1.2	$10.0	$19.3
Avoided compliance costs, with demand-side energy efficiency costs discounted at 3%	**$3.7**	**$10.2**	**$27.2**	**$2.6**	**$13.0**	**$24.5**
Avoided compliance costs, with demand-side energy efficiency costs discounted at 7%	**$4.2**	**$14.1**	**$33.3**	**$3.1**	**$16.9**	**$30.6**

Notes: Estimates are rounded to one decimal point and may not sum due to independent rounding. The approximate additional generation costs that would have occurred absent reductions from demand-side energy efficiency programs equals the equals the approximate benefit, i.e. the value, of savings from demand-side energy efficiency programs.

The compliance costs reported in Table 3-6 are not social costs. These compliance cost estimates, which are counted here as cost savings of this action, are compared to estimates of social benefits to derive net benefits of the proposed repeal of the CPP, which are presented later in this section.

[24] The 2015 RIA used a convention that accounted for the production cost reductions from demand-side energy efficiency programs as a negative cost, whereas the current estimate treats that reduction in production costs as a benefit.

3.4. Forgone Monetized Climate Benefits, Demand-Side Energy Efficiency Benefits, and Health Co-benefits

The forgone climate benefits estimates have been calculated using a measure of the domestic social cost of CO_2 (SC-CO_2). Additionally, this analysis takes into account the forgone social benefits of changes in emissions of non-CO_2 pollutants from the electricity sector as well as the forgone benefits of demand-side energy efficiency measures. The range of combined benefits reflects different concentration-response functions for the air quality health co-benefits, but it does not capture the full range of uncertainty inherent in the health co-benefits estimates. Furthermore, we were unable to quantify or monetize all of the climate benefits and health and environmental co-benefits associated with the final CPP, including reductions in directly emitted $PM_{2.5}$, reduced exposure to SO_2, NO_X, and hazardous air pollutants (e.g., mercury), as well as ecosystem effects and visibility improvement. The omission of these endpoints from the monetized results should not imply that the impacts are small or unimportant. Table B-1 in Appendix B provides the list of the forgone quantified and unquantified health and environmental benefits in this analysis.

3.4.1. Estimating Forgone Domestic Climate Benefits

We estimate the forgone climate benefits from this proposed rulemaking using a measure of the domestic social cost of carbon (SC-CO_2). The SC-CO_2 is a metric that estimates the monetary value of impacts associated with marginal changes in CO_2 emissions in a given year. It includes a wide range of anticipated climate impacts, such as net changes in agricultural productivity and human health, property damage from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. It is typically used to assess the avoided damages as a result of regulatory actions (i.e., benefits of rulemakings that lead to an incremental reduction in cumulative global CO_2 emissions). The SC-CO_2 estimates used in this RIA focus on the direct impacts of climate change that are anticipated to occur within U.S. borders.

The SC-CO_2 estimates presented in this RIA are interim values developed under E.O. 13783 for use in regulatory analyses until an improved estimate of the impacts of climate change to the U.S. can be developed based on the best available science and economics. E.O. 13783 directed agencies to ensure that estimates of the social cost of greenhouse gases used in regulatory analyses "are based on the best available science and economics" and are consistent with the guidance contained in OMB Circular A-4, "including with respect to the consideration of domestic versus international impacts and the consideration of appropriate discount rates" (E.O. 13783, Section 5(c)). In addition, E.O. 13783 withdrew the technical support documents (TSDs) describing the global social cost of greenhouse gas estimates developed under the prior Administration as no longer representative of government policy. The withdrawn TSDs were developed by an interagency working group (IWG) that included the EPA and other executive branch entities and were used in the 2015 CPP RIA.

Regarding the two analytical considerations highlighted in E.O. 13783 – how best to consider domestic versus international impacts and appropriate discount rates – current guidance in OMB Circular A-4 is as follows. Circular A-4 states that analysis of economically significant proposed and final regulations "should focus on benefits and costs that accrue to citizens and residents of the United States." We follow this guidance by adopting a domestic perspective in our central analysis. Regarding discount rates, Circular A-4 states that regulatory analyses "should provide estimates of net benefits using both 3 percent and 7 percent." The 7 percent rate is intended to represent the average before-tax rate of return to private capital in the U.S. economy. The 3 percent rate is intended to reflect the rate at which society discounts future consumption, which is particularly relevant if a regulation is expected to affect private consumption directly. EPA follows this guidance below by presenting estimates based on both 3 and 7 percent discount rates in the main analysis. See Appendix C for a discussion the modeling steps involved in estimating the domestic SC-CO_2 estimates based on these discount rates.

The SC-CO_2 estimates developed under E.O. 13783 presented below will be used in regulatory analysis until improved domestic estimates can be developed, which would take into consideration the recent recommendations from the National Academies of Sciences, Engineering, and Medicine[25] for a comprehensive update to the current methodology to ensure that the SC-CO_2 estimates reflect the best available science.

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[25] See National Academies of Sciences, Engineering, and Medicine, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*, Washington, D.C., January 2017. http://www.nap.edu/catalog/24651/valuing-climate-changes-updating-estimation-of-the-social-cost-of

Table 3-7 presents the average domestic SC-CO_2 estimate across all the model runs for each discount rate for the years 2015 to 2050. As with the global SC-CO_2 estimates, the domestic SC-CO_2 increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change, and because GDP is growing over time and many damage categories are modeled as proportional to gross GDP. For emissions occurring in the year 2030, the two domestic SC-CO_2 estimates are $1 and $7 per metric ton of CO_2 emissions (2011$), using a 7 and 3 percent discount rate, respectively. Table 3-8 presents the forgone domestic climate benefits in 2020, 2025, and 2030 based on these domestic SC-CO_2 estimates.

Table 3-7. Interim Domestic Social Cost of CO_2, 2015-2050 (in 2011$ per metric ton)*

Year	Discount Rate and Statistic: 3% Average	Discount Rate and Statistic: 7% Average
2015	$5	$1
2020	6	1
2025	7	1
2030	7	1
2035	8	1
2040	9	2
2045	9	2
2050	10	2

* These SC-CO_2 values are stated in $/metric ton CO_2 and rounded the nearest dollar. These values may be converted to $/short ton using the conversion factor 0.90718474 metric tons in a short ton for application to the short ton CO_2 emission impacts provided in this rulemaking. Such a conversion does not change the underlying methodology nor does it change the meaning of the SC-CO_2 estimates. For both metric and short tons denominated SC-CO_2 estimates, the estimates vary depending on the year of CO_2 emissions and are defined in real terms, i.e., adjusted for inflation using the GDP implicit price deflator.

Table 3-8. Estimated Forgone Domestic Climate Benefits in 2020, 2025, 2030 (billions of 2011$)*

	2020		2025		2030	
Discount rate and statistic	Rate-Based Approach	Mass-Based Approach	Rate-Based Approach	Mass-Based Approach	Rate-Based Approach	Mass-Based Approach
Forgone CO_2 reductions (million short tons)	69	82	232	264	415	413
3% (average)	$0.38	$0.45	$1.40	$1.60	$2.74	$2.72
7% (average)	$0.06	$0.07	$0.23	$0.26	$0.48	$0.47

* The SC-CO_2 values are dollar-year and emissions-year specific. SC-CO_2 values represent only a partial accounting of domestic climate impacts.

The limitations and uncertainties associated with the SC-CO_2 analysis, which were discussed at length in the 2015 CPP RIA, likewise apply to the domestic SC-CO_2 estimates presented in this RIA. Some uncertainties are captured within the analysis, as discussed in detail in Appendix C, while other areas of uncertainty have not yet been quantified in a way that can be modeled. For example, limitations include the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, the incomplete way in which inter-regional and inter-sectoral linkages are modeled, uncertainty in the extrapolation of damages to high temperatures, and inadequate representation of the relationship between the discount rate and uncertainty in economic growth over long time horizons. The science incorporated into these models understandably lags behind the most recent research, and the limited amount of research linking climate impacts to economic damages makes the modeling exercise even more difficult. These individual limitations and uncertainties do not all work in the same direction in terms of their influence on the SC-CO_2 estimates. In accordance with guidance in OMB Circular A-4 on the treatment of uncertainty, Appendix C provides a detailed discussion of the ways in which the modeling underlying the development of the SC-CO_2 estimates used in this RIA addressed quantified sources of uncertainty, and presents a sensitivity analysis to show consideration of the uncertainty surrounding discount rates over long time horizons.

Recognizing the limitations and uncertainties associated with estimating the social cost of carbon, the research community has continued to explore opportunities to improve SC-CO_2 estimates. Notably, the National Academies of Sciences, Engineering, and Medicine conducted a multi-discipline, multi-year assessment to examine potential approaches, along with their relative merits and challenges, for a comprehensive update to the current methodology. The task was to ensure that the SC-CO_2 estimates that are used in Federal analyses reflect the best available science, focusing on issues related to the choice of models and damage functions, climate science modeling assumptions, socioeconomic and emissions scenarios, presentation of uncertainty, and discounting. In January 2017, the Academies released their final report, Assessing Approaches to Updating the Social Cost of Carbon, and recommended specific criteria for future updates to the SC-CO_2 estimates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process (National Academies 2017).

The Academies' report also discussed the challenges in developing domestic SC-CO_2 estimates, noting that current IAMs do not model all relevant regional interactions – i.e., how climate change impacts in other regions of the world could affect the United States, through pathways such as global migration, economic destabilization, and political destabilization. The Academies concluded that it "is important to consider what constitutes a domestic impact in the case of a global pollutant that could have international implications that impact the United States. More thoroughly estimating a domestic SC-CO_2 would therefore need to consider the potential implications of climate impacts on, and actions by, other countries, which also have impacts on the United States." (National Academies 2017, pg. 12-13).

In addition to requiring reporting of impacts at a domestic level, Circular A-4 states that when an agency "evaluate[s] a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately" (page 15). This guidance is relevant to the valuation of damages from CO_2 and other GHGs, given that GHGs contribute to damages around the world independent of the country in which they are emitted. Therefore, in accordance with this guidance in OMB Circular A-4, Appendix C presents the forgone global climate benefits from this proposed rulemaking using global SC-CO_2 estimates based on both 3 and 7 percent discount rates. Note the EPA did not quantitatively project the full impact of the CPP on international trade and the location of production, so it is not possible to present analogous estimates of international cost savings resulting from the proposed action. However, to the extent that the IPM analysis endogenously models international electricity and natural gas trade, and to the extent that affected firms have some foreign ownership, some of the cost savings accruing to entities outside U.S. borders is captured in the avoided compliance costs presented in this RIA. See Section 3.5.2.1 for more discussion of challenges involved in estimating the ultimate distribution of avoided compliance costs.

3.4.2. Estimating Forgone Demand-Side Energy Efficiency Benefits

As discussed in Section 3.3, EPA used the projections from the power sector modeling that supported the 2015 CPP RIA to approximate the value of energy cost savings from the reduced demand attributable to the demand-side energy efficiency measures. In this analysis, the wholesale price for each model region from each illustrative scenario was multiplied by the reduced production from demand-side energy efficiency for that region, then summed across regions to obtain an approximation of the value of savings from demand-side energy efficiency programs (see Appendix Tables A-1 through A-3).[26] Table 3-9 presents the results of this approximation of the value of savings from demand-side energy efficiency programs.[27] Under this proposal to repeal the final CPP, these savings are counted as forgone benefits. See Sections 5.3 and 7.7 for discussions uncertainties related to demand-side energy efficiency assumptions.

Table 3-9. Forgone Demand-Side Energy Efficiency Benefits (billions 2011$)

Year	Rate-Based Approach	Mass-Based Approach
2020	$1.2	$1.2
2025	$9.2	$10.0
2030	$18.8	$19.3

3.4.3. Estimating Forgone Health Co-Benefits

For this RIA we quantify the "co-benefits" of reduced criteria air pollutants that occur as the electric power industry responds to State plans to implement the CPP. For the purpose of this analysis, "co-benefits" are the represented by the number and economic value of avoided ozone and $PM_{2.5}$-related premature deaths and illnesses; these are expected to occur as the actions that plants take to reduce emissions of CO_2 also affect emissions of pollutants that are precursors to $PM_{2.5}$ and ozone, including SO_2 and NO_X.[28]

Under the repeal proposed in this action, the CPP would no longer reduce emissions of precursor pollutants (e.g., SO_2, NO_X, and directly emitted particles), which in turn would no longer lower ambient concentrations of $PM_{2.5}$ and ozone. This analysis quantifies the monetized forgone co-benefits associated with the continued exposure to these two pollutants in 2020, 2025, and 2030.[29] In the 2015 CPP RIA the air quality health co-benefits were only estimated for

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[26] Including accounting for avoided line losses.

[27] As we noted in the previous section, it is important to emphasize that the 2015 RIA costs estimates and the current estimates for the purposes of this analysis build from the same regulatory cost assessment and that the differences in amounts reflect differing accounting conventions. Those accounting conventions differ in whether one views the production cost reductions from demand-side energy efficiency programs as a negative cost or as a benefit.

[28] Considering these ancillary benefits is consistent with guidance from the Office of Management and Budget (https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf) and the EPA Economic Guidelines (https://www.epa.gov/environmental-economics/guidelines-preparing-economic-analyses).

[29] We did not estimate the forgone co-benefits associated with the forgone reduction of directly emitted $PM_{2.5}$ or direct exposure to SO_2 and NO_X. Where we have quantified these pollutants in previous RIA's addressing the EGU sector, the impacts have been modest. As a result, quantified forgone benefits are likely to be underestimated by a relatively small amount.

the contiguous U.S. Thus, the same approach can be used as the basis for estimating the forgone co-benefits of this proposed repeal. The estimates of forgone monetized $PM_{2.5}$ co-benefits include forgone avoided premature deaths (derived from effect coefficients in two cohort studies [Krewski et al. 2009 and Lepeule et al. 2012] for adults and one for infants [Woodruff et al. 1997]), as well as forgone avoided morbidity effects for ten non-fatal endpoints ranging in severity from lower respiratory symptoms to heart attacks[30] (U.S. EPA, 2012). The estimates of forgone monetized ozone co-benefits include forgone avoided premature deaths (derived from the range of effect coefficients represented by two short-term epidemiology studies [Bell et al. (2004) and Levy et al. (2005)]), as well as forgone avoided morbidity effects for five non-fatal endpoints ranging in severity from school absence days to hospital admissions. A list of these forgone health co-benefits are in Table B-1 in Appendix B.

We use a "benefit-per-ton" approach to estimate the forgone $PM_{2.5}$ and ozone co-benefits in this RIA. Benefit per-ton values are derived by calculating the human health benefits of a modeled air quality scenario and then dividing this value by the change in pollutant precursor emissions. When calculating the incidence and economic value of these air pollution-related effects, we apply concentration-response relationships and economic data from the peer reviewed scientific literature. In this analysis, we use a benefit-per-ton value to express the forgone human health benefits associated with not reducing emissions that are precursors to the formation of $PM_{2.5}$ and ozone.

We calculated the $PM_{2.5}$ and ozone benefit per ton values by using air quality modeling simulations of the base case and the proposed CPP (Option 1 State) scenario for 2025. As in the co-benefits analysis conducted for the 2015 CPP RIA, we estimated forgone benefit-per-ton estimates in each region by aggregating the forgone benefits estimates in the BenMAP-CE[31] program to the region (i.e., East, West, and California), then divided by the corresponding

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[30] See Chapter 4 and Appendix 4A of the Clean Power Plan Final Rule for details on this assessment of health co-benefits.

[31] BenMAP is an open-source computer program developed by the EPA that calculates the number and economic value of air pollution-related deaths and illnesses. The software incorporates a database that includes many of the concentration-response relationships, population files, and health and economic data needed to quantify these impacts. Information on BenMAP is found at: https://www.epa.gov/benmap/benmap-community-edition, and the source code is available at: https://github.com/BenMAPCE/BenMAP-CE

forgone emission reductions. This approach is described in detail in Appendix 4A of the 2015 CPP RIA.

To calculate the forgone co-benefits for this proposed rule, we applied the regional benefit-per-ton estimates generated from the 2025 air quality modeling for the EGU sector to the corresponding forgone emission reductions, population and health information. All benefit-per-ton estimates reflect the geographic distribution of the modeled emissions, which do not match the forgone emission reductions in this rulemaking, and thus they may not reflect the local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. Thus, these benefit per-ton values may over- or under-state the value of the forgone $PM_{2.5}$ and ozone-related benefits; the direction of this bias is unknown. To the extent feasible, the EPA commits to performing full-scale photochemical air quality modeling to support the air quality benefits assessment informing subsequent regulatory analyses of CPP-related actions. Such model predictions would supply the data needed to: (1) quantify the $PM_{2.5}$ and ozone-related impacts of the policy case; (2) perform the full suite of sensitivity analyses summarized above, particularly the concentration cutpoint assessment. EPA further commits to characterizing the uncertainty associated with applying benefit per ton estimates by evaluating the reliability of such estimates and comparing EPA's approach with other commonly employed techniques in the peer-reviewed literature. This report would be available for peer review within six months.

The estimated number of forgone long-term $PM_{2.5}$-related premature deaths implied by the benefit-per-ton estimates are based on risk coefficients from two long-term cohort studies (Krewski et al. 2009 and Lepeule et al. 2012). The Integrated Science Assessment for Particulate Matter (2009) PM ISA, which informed the setting of the 2012 PM NAAQS, reviewed available studies that examined the potential for a population-level threshold to exist in the concentration-response relationship. Based on such studies, the ISA concluded that the evidence supports the use of a "no-threshold" model and that "little evidence was observed to suggest that a threshold exists" (PM ISA, pp. 2-25 to 2-26). Consistent with the evidence, in setting the PM standards, the Agency noted that NAAQS are not meant to eliminate all risk and acknowledged that risk remains at levels below the 2012 standards.[32] Consistent with this approach, Tables 3-10 and 3-11 report the forgone $PM_{2.5}$ and ozone-related benefits (in terms of both health impacts and monetized values) for the two illustrative plan scenarios and for the years 2020, 2025 and 2030, where the $PM_{2.5}$-related forgone benefits are calculated using a log-linear concentration-response function that quantifies risk from the full range of $PM_{2.5}$ exposures (EPA, 2009; EPA, 2010; NRC, 2002).[33]

However, when setting the 2012 PM NAAQS, the Administrator also acknowledged greater uncertainty in specifying the magnitude and significance of PM-related health risks at PM concentrations below the NAAQS. As noted in the preamble to the 2012 PM NAAQS final rule, "EPA concludes that it is not appropriate to place as much confidence in the magnitude and significance of the associations over the lower percentiles of the distribution in each study as at and around the long-term mean concentration." (78 FR 3154, 15 January 2013). In general, we are more confident in the magnitude of the risks we estimate from simulated $PM_{2.5}$ concentrations that coincide with the bulk of the observed PM concentrations in the epidemiological studies that are used to estimate the benefits. Likewise, we are less confident in the risk we estimate from simulated $PM_{2.5}$ concentrations that fall below the bulk of the observed data in these studies.[34] Furthermore, when a study is viewed by itself there is necessarily uncertainty regarding the concentration-response relationship below the Lowest Measured Level for that study due the lack of observations from which the shape and magnitude of the relationship can be estimated.

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[32] The Federal Reference Notice for the 2012 PM NAAQS notes that "[i]n reaching her final decision on the appropriate annual standard level to set, the Administrator is mindful that the CAA does not require that primary standards be set at a zero-risk level, but rather at a level that reduces risk sufficiently so as to protect public health, including the health of at-risk populations, with an adequate margin of safety. On balance, the Administrator concludes that an annual standard level of 12 mg/m3 would be requisite to protect the public health with an adequate margin of safety from effects associated with long- and short-term $PM_{2.5}$ exposures, while still recognizing that uncertainties remain in the scientific information."

[33] This approach to calculating and reporting the risk of $PM_{2.5}$-attributable premature death is consistent with recent RIA's (U.S. EPA 2009b, 2010c, 2010d, 2011a, 2011b, 2011c, 2012, 2013, 2014, 2015a, 2016).

[34] The Federal Register Notice for the 2012 PM NAAQS indicates that "[i]n considering this additional population-level information, the Administrator recognizes that, in general, the confidence in the magnitude and significance of an association identified in a study is strongest at and around the long-term mean concentration for the air quality distribution, as this represents the part of the distribution in which the data in any given study are generally most concentrated. She also recognizes that the degree of confidence decreases as one moves towards the lower part of the distribution"

To provide some insight into the level of uncertainty in the estimated $PM_{2.5}$ mortality benefits at lower levels, we conducted a sensitivity analysis that illustrates the forgone $PM_{2.5}$ benefits in a model where benefits that accrue to those living in areas with ambient concentrations below the Lowest Measured Level (LML) of the two epidemiological studies used to quantify $PM_{2.5}$-related risk[35] and that $PM_{2.5}$ benefits fall to zero at levels below the Annual $PM_{2.5}$ NAAQS fall to zero (Tables 3-10 and 3-11).[36] These analyses provide information useful to the public in understanding the distribution of benefits at lower ambient levels of $PM_{2.5}$. It is important to note that there are uncertainties inherent in identifying any particular point at which our confidence in reported associations becomes appreciably less, and the scientific evidence provides no clear dividing line (NAS, 2002; U.S. EPA, 2009; Schwartz, 2008). EPA solicits comment from the public regarding this approach to estimating and reporting PM-related forgone benefits in this way.

Because we utilized a benefits-per-ton approach to estimating benefits, there is significant uncertainty about exactly how many of the benefits from final CPP actually fall below these alternative cutpoints. In order to determine the distribution of concentrations at which benefits are occurring, EPA must rely on air quality modeling. Because we lacked air quality modeling for the final CPP, EPA evaluated the air quality modeling from the CPP proposal that was used to derive the benefits-per-ton estimates; we calculated the percent of benefits in those earlier modeling runs that occurred below the alternative cutpoints and assumed that this percentage would apply to the final CPP policy case.

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[35] This is approach is a variant of one EPA previously employed, where it reported the distribution of $PM_{2.5}$-related benefits occurring above and below the Lowest Measured Levels of the two long-term epidemiological studies used to quantify risk in a number of previous RIA’s (see: EPA, U.S. 2010, 2011b, 2012). Here, we are assuming benefits fall to zero below the LML.

[36] We calculated these adjusted BPT values using the formula below:

$$Scaled\ PM_{2.5}BPT_{si} = BPT_{si} \times \%\ Premature\ Deaths\ above\ LML_i$$

Where *s* is the benefit per ton of each $PM_{2.5}$ species (nitrate or sulfate) and *i* is the long-term epidemiological study used to quantify $PM_{2.5}$-related premature deaths. We applied a similar function to calculate a scaled benefit per ton value reflecting the benefits above the NAAQS by substituting *% Premature Deaths above the NAAQS* for *Premature Deaths above LML*. Both the *LML* and *NAAQS* terms were defined by using information specified in Table 5-2 below.

Table 3-10. Estimated Forgone $PM_{2.5}$ and Ozone-Related Avoided Premature Mortality Estimates (premature deaths arrayed by concentration cutpoint)

Emissions Projections	Forgone Co-benefits (Full range of ambient $PM_{2.5}$ concentrations)	Forgone Co-benefits (PM Benefits Fall to Zero Below LML)	Forgone Co-Benefits ($PM_{2.5}$ Benefits Fall to Zero Below NAAQS
Rate-Based			
2020	75 to 200	70 to 130	14 to 57
2025	780 to 1,900	730 to 1,100	73 to 270
2030	1,500 to 3,600	1,400 to 2,000	130 to 460
Mass-Based			
2020	220 to 520	200 to 300	21 to 79
2025	750 to 1,800	700 to 1,000	78 to 290
2030	1,200 to 2,900	1,100 to 1,700	120 to 420

Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. The first model estimates the number of premature deaths for the full range of $PM_{2.5}$ levels to which the population is exposed using a no-threshold log-linear model. The second model estimates the number of premature deaths where risk falls to zero below the LML. The lowest measured levels of the Krewski et al. (2009) and Lepeule et al. (2012) long-term epidemiological studies (5.8 µg/m3 and 8 µg/m3, respectively). The third model estimates the number of premature deaths where risk falls to zero below the Annual PM NAAQS (12 µg/m3). The forgone health co-benefits reflect the sum of the forgone PM2.5 and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)).

Table 3-11. Estimated Forgone $PM_{2.5}$ and Ozone-Related Health Co-benefits (billions of 2011$, arrayed by concentration cutpoint)

Emissions Projections	Discount Rate	Forgone Co-Benefits (Full range of ambient $PM_{2.5}$ concentrations)	Forgone Co-Benefits ($PM_{2.5}$ Benefits Fall to Zero Below LML)	Forgone Co-Benefits ($PM_{2.5}$ Benefits Fall to Zero Below NAAQS)
Rate-Based				
2020	3%	$0.7 to $1.8	$0.7 to $1.2	$0.1 to $0.6
	7%	$0.6 to $1.7	$0.6 to $1.1	$0.1 to $0.6
2025	3%	$7.4 to $17.7	$6.9 to $10.1	$0.8 to $2.7
	7%	$6.7 to $16.2	$6.3 to $9.3	$0.7 to $2.6
2030	3%	$14.2 to $33.9	$13.2 to $19.1	$1.4 to $4.9
	7%	$12.9 to $30.9	$12.0 to $17.6	$1.3 to $4.8
Mass-Based				
2020	3%	$2.0 to $4.8	$1.9 to $2.8	$0.2 to $0.8
	7%	$1.8 to $4.4	$1.7 to $2.6	$0.2 to $0.8
2025	3%	$7.1 to $17.2	$6.6 to $10.0	$0.8 to $3.0
	7%	$6.5 to $15.7	$6.0 to $9.2	$0.8 to $2.9
2030	3%	$11.7 to $28.1	$10.9 to $16.1	$1.3 to $4.5
	7%	$10.6 to $25.7	$9.9 to $14.8	$1.2 to $4.4

Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. The first model estimates the number of premature deaths for the full range of $PM_{2.5}$ levels to which the population is exposed using a no-threshold log-linear model. The second model estimates the number of premature deaths where risk falls to zero below the LML. The lowest measured levels of the Krewski et al. (2009) and Lepeule et al. (2012) long-term epidemiological studies (5.8 µg/m3 and 8 µg/m3, respectively). The third model estimates the number of premature deaths where risk falls to zero below the Annual PM NAAQS (12 µg/m3). The forgone health co-benefits reflect the sum of the forgone PM2.5 and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

In evaluating these estimates in Tables 3-10 and 3-11, it is important to note certain key assumptions underlying the estimates for $PM_{2.5}$-related premature mortality, which accounts for 98 percent of the forgone monetized $PM_{2.5}$ health co-benefits:

1. We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because $PM_{2.5}$ varies considerably in composition across sources, but the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. The PM ISA concluded that "many constituents of $PM_{2.5}$ can be linked with multiple health effects, and the evidence is not yet sufficient to allow differentiation of those constituents or sources that are more closely related to specific outcomes" (U.S. EPA, 2009).

2. Starting from the assumption that the health impact function for fine particles is log-linear without a threshold, we estimate benefits according to cutpoints. We explore the influence of such a cutpoint on the magnitude of the benefits in areas where model-predicted annual mean $PM_{2.5}$ concentrations in the year 2025 are at or below the LML or Annual PM NAAQS. This provides the reader with insight into the degree of uncertainty introduced by assumptions about risk attributable to $PM_{2.5}$ at different concentration cutpoints. It is important to note that, due continued improvements in air quality resulting from other federal and state pollution control efforts, an increasing fraction of the $PM_{2.5}$ exposures experienced in the U.S. are likely to occur at relatively low concentrations. In this analysis, the vast majority of such exposures are projected to occur at levels below the current annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$. While the PM ISA stated that the scientific evidence collectively is sufficient to conclude that the relationship between long-term $PM_{2.5}$

exposures and mortality is causal and that overall the studies support the use of a no-threshold log-linear model to estimate PM-related long-term mortality (U.S. EPA, 2009), this conclusion as applied in benefits analysis has a strong influence on the size of the $PM_{2.5}$ benefits estimates. However, for transparency, it is helpful to clarify how alternative assumptions can impact the benefits estimates. EPA has conducted such sensitivity analyses in the past. In addition to the LML-type analysis employed in this RIA, previous EPA analyses of PM-related mortality impacts accounted for the possibility of a threshold in the concentration-response relationship by employing effect coefficients from the 2006 PM Expert Elicitation, jointly developed by the EPA and the Office of Management and Budget. The $PM_{2.5}$ Expert Elicitation asked experts to describe the true relationship between $PM_{2.5}$ exposure and premature mortality (Roman, 2008; IEc., 2006). Of the 12 experts included in the elicitation, only one expert (Expert K) elected to specify a threshold, as the rest cited a lack of empirical and/or theoretical basis for a population threshold. Expert K specified a 50% chance of no threshold, a 40% chance that there would be a threshold at a concentration of less than 5 µg/m^3, and a 10% chance that there would be a threshold between 5 and 10 µg/m^3. No expert thought that there was any chance that there would be a threshold in excess of 10 µg/m^3.

3. We assume that there is a "cessation" lag between the change in PM exposures and the total realization of changes in mortality effects. Specifically, we assume that some of the incidences of premature mortality related to $PM_{2.5}$ exposures occur in a distributed fashion over the 20 years following exposure based on the advice of the SAB-HES (U.S. EPA-SAB, 2004), which affects the valuation of mortality co-benefits at different discount rates.

Every benefits analysis examining the potential effects of a change in environmental protection requirements is limited, to some extent, by data gaps, model capabilities (such as geographic coverage) and uncertainties in the underlying scientific and economic studies used to configure the benefit and cost models. Despite these uncertainties, we believe this analysis provides a reasonable indication of the expected forgone health co-benefits of the air quality emission reductions for this proposed rule under a set of reasonable assumptions. This analysis does not include the type of detailed uncertainty assessment found in the 2012 $PM_{2.5}$ NAAQS RIA (U.S. EPA, 2012) because we lack the necessary air quality input and monitoring data to conduct a complete forgone benefits uncertainty assessment. In addition, using a benefit-per-ton approach adds another important source of uncertainty to the forgone benefits estimates. Section 5.5 below discusses in greater detail the uncertainties associated with quantifying PM effects at low concentrations and quantifying risks attributable to individual $PM_{2.5}$ species.

3.4.4. Combined Forgone Benefits Estimates

The EPA has evaluated the range of potential forgone impacts by combining SC-CO_2 values with health co-benefits values at the 3 percent and 7 percent discount rates. Table 3-12 provides the combined forgone domestic climate benefits, demand-side energy efficiency benefits, and health co-benefits estimated for 3 percent and 7 percent discount rates. Table 3-13 provide similar information for the sensitivity analyses in which premature mortality co-benefits fall to zero under cutpoints. All dollar estimates are in 2011 dollars.

Table 3-12. Combined Estimates of Forgone Climate Benefits, Demand-Side Energy Efficiency Benefits and Health Co-Benefits (billions of 2011$)

Year	Discount Rate	Forgone Domestic Climate Benefits	Forgone Demand-Side Energy Efficiency Benefits	Total Forgone Targeted Pollutant Benefits	Forgone Health Co-benefits	Total Forgone Benefits
Rate-Based						
2020	3%	$0.4	$1.2	$1.6	$0.7 to $1.8	$2.3 to $3.4
	7%	$0.1	$1.2	$1.3	$0.6 to $1.7	$1.9 to $3.0
2025	3%	$1.4	$9.2	$10.6	$7.4 to $17.7	$18.0 to $28.4
	7%	$0.2	$9.2	$9.4	$6.7 to $16.2	$16.2 to $25.6
2030	3%	$2.7	$18.8	$21.5	$14.2 to $33.9	$35.8 to $55.5
	7%	$0.5	$18.8	$19.3	$12.9 to $30.9	$32.2 to $50.2
Mass-Based						
2020	3%	$0.4	$1.2	$1.6	$2.0 to $4.8	$3.6 to $6.4
	7%	$0.1	$1.2	$1.3	$1.8 to $4.4	$3.1 to $5.6
2025	3%	$1.6	$10.0	$11.6	$7.1 to $17.2	$18.7 to $28.8
	7%	$0.3	$10.0	$10.3	$6.5 to $15.7	$16.7 to $26.0
2030	3%	$2.7	$19.3	$22.0	$11.7 to $28.1	$33.8 to $50.1
	7%	$0.5	$19.3	$19.8	$10.6 to $25.7	$30.4 to $45.5

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The total forgone targeted pollutant benefit estimates in this summary table are the sum of the forgone domestic climate benefits and forgone demand-side energy efficiency benefits. Forgone co-benefits are based on regional benefit-per-ton estimates. Forgone ozone co-benefits occur in analysis year, so they are the same for all discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 3-13. Sensitivity Analysis Showing Potential Impact of Uncertainty at $PM_{2.5}$ Levels below the LML and NAAQS on Estimates of Health Co-Benefits (billions of 2011$)

		Forgone $PM_{2.5}$ Co-benefits Fall to Zero Below LML [a]		Forgone $PM_{2.5}$ Co-Benefits Fall to Zero Below NAAQS (12 µg/m3) [c]	
Year	**Discount Rate**	**Forgone Health Co-Benefits [a]**	**Total Forgone Benefits [b]**	**Forgone Health Co-Benefits [c]**	**Total Forgone Benefits [b]**
Rate-Based					
2020	3%	$0.7 to $1.2	$2.2 to $2.8	$0.1 to $0.6	$1.7 to $2.1
	7%	$0.6 to $1.1	$1.9 to $2.4	$0.1 to $0.6	$1.4 to $1.8
2025	3%	$6.9 to $10.1	$17.5 to $20.7	$0.8 to $2.7	$11.4 to $13.3
	7%	$6.3 to $9.3	$15.7 to $18.7	$0.7 to $2.6	$10.2 to $12.1
2030	3%	$13.2 to $19.1	$34.8 to $40.7	$1.4 to $4.9	$23.0 to $26.5
	7%	$12.0 to $17.6	$31.3 to $36.9	$1.3 to $4.8	$20.7 to $24.1
Mass-Based					
2020	3%	$1.9 to $2.8	$3.5 to $4.4	$0.2 to $0.8	$1.8 to $2.4
	7%	$1.7 to $2.6	$2.9 to $3.8	$0.2 to $0.8	$1.5 to $2.0
2025	3%	$6.6 to $10.0	$18.2 to $21.6	$0.8 to $3.0	$12.4 to $14.6
	7%	$6.0 to $9.2	$16.3 to $19.5	$0.8 to $2.9	$11.1 to $13.2
2030	3%	$10.9 to $16.1	$32.9 to $38.1	$1.3 to $4.5	$23.3 to $26.6
	7%	$9.9 to $14.8	$29.7 to $34.7	$1.2 to $4.4	$21.0 to $24.2

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Forgone health-related co-benefits are calculated using benefit-per-ton estimates corresponding to three regions of the U.S. Forgone ozone co-benefits occur in analysis year, so they are the same for all discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). . The monetized forgone health co-benefits do not include reduced health effects from reductions in directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

[a] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 µg/m^3; Lepeule et al. 2012; LML = 8 µg/m^3).

[b] Total forgone benefits is calculated by adding the total forgone targeted pollutant benefits and the forgone health co-benefits.

[c] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 µg/m^3

3.5. Economic Impacts

3.5.1. Market Impacts

The 2015 CPP may have had important energy market implications which are avoided by this proposed rule. Table 3-14 presents a variety of important national average energy market impacts which were forecast for the 2015 CPP under both the rate-based and mass-based approaches. The proposed action would reverse these potential impacts, and therefore the sign of these impacts are the opposite from what they were in the 2015 CPP RIA. The quantified market impacts in Table 3-14 are otherwise from 2015 CPP analysis without any adjustments. EPA plans to provide for public comment a new market impact assessment based on updated sectoral analysis before any action that relates to the CPP is finalized.

Table 3-14. Summary of Certain Energy Market Impacts of Proposed Rule (Percent Change from Case with CPP)

	Rate-Based Approach			Mass-Based Approach		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Retail electricity prices	-3%	0%	-1%	-3%	-2%	0%
Average electricity bills	-3%	4%	7%	-2%	3%	8%
Price of coal at minemouth	1%	6%	3%	1%	5%	3%
Coal production for power sector use	6%	16%	33%	8%	20%	32%
Price of natural gas delivered to power sector	-5%	8%	-2%	-4%	3%	2%
Price of Average Henry Hub price (spot)	-5%	8%	-3%	-4%	3%	2%
Natural gas use for electricity generation	-3%	1%	1%	-4%	0%	5%

The projected energy market and electricity retail rate impacts of the 2015 CPP are discussed more extensively in Chapter 3 of the 2015 CPP RIA, which also presents projections of power sector generation and capacity changes by technology and fuel type. The change in wholesale energy prices and the changes in power generation were forecasted using IPM and assuming reductions in demand from demand-side energy efficiency programs. The change in retail electricity prices reported in Table 3-14 is a national average across residential, commercial, and industrial consumers. The change in electricity retail prices and bills were forecasted using outputs of IPM, and assumed that the demand-side energy efficiency program costs would fully be recovered through electricity rates and, for the mass-based illustrative plan, that emission rights (e.g. allowances) would not be used to mitigate any electricity price increases. Conditional on these two important assumptions, the average regional electricity price was expected to increase up to 6.3 percent or fall as much as 10.1 percent in 2030. While average electricity prices were expected to rise slightly in both the rate-based and mass-based illustrative scenarios, national average electricity bills were forecast to fall due to reduced demand from demand-side energy efficiency programs. These conclusions depend, in part, on the projected level of decrease in electricity demand due to demand-side energy efficiency measures. If the electricity demand does not decrease as projected over time in the 2015 CPP RIA, then these conclusions may change. The extent to which they may change depends on how different the change in demand may be – the greater the difference in demand reduction, the more substantial the change in the conclusions.

Changes in supply or demand for electricity, natural gas, and coal can impact markets for goods and services produced by sectors that use these energy inputs in the production process or that supply those sectors. Changes in cost of production may result in changes in price and/or quantity produced by these sectors and these market changes may affect the profitability of firms and the economic welfare of their consumers. Similarly, demand for new generation or energy efficiency, for example, can result in changes in production and profitability for firms that supply those goods and services. The magnitude and direction of these potential effects outside the electricity sector and related fuel markets were not analyzed in the 2015 CPP RIA, and could not be fully analyzed without additional modeling tools beyond those that were used in the 2015 RIA.

One potential quantitative approach to evaluating secondary market impacts, which can be significant, is to use a computable general equilibrium (CGE) model. CGE models are able to provide aggregated representations of the entire economy in equilibrium in the baseline and under a regulatory or policy scenario. As such, CGE models may be able to capture interactions between economic sectors and provide information on changes outside of the directly-regulated sector attributable to a regulation. For example, CGE studies of air pollution regulations for the power sector have found that the social costs and benefits may be greater or lower than partial equilibrium estimates when these secondary market impacts are taken into account, and that the direction of these estimates may also depend on the form of the regulation (e.g. Goulder et al. 1999, Williams 2002, Goulder et al. 2016). The EPA has established a Science Advisory Board (SAB) panel on economy-wide modeling to consider the technical merits and challenges of using this analytical tool to evaluate costs, benefits, and economic impacts in regulatory development.[37] In addition, EPA is asking the panel to identify potential paths forward for improvements that could address the challenges posed when using economy-wide models to evaluate the effects of regulations. The panel's deliberations are ongoing. The EPA will use the recommendations and advice of this panel as an input into its process for improving benefit-cost and economic impact analyses used to inform agency decisions.

3.5.2. Distributional Impacts

The avoided compliance costs and forgone benefits presented earlier are not expected to be felt uniformly across the population, and may not accrue to the same individuals or communities. OMB recommends including a description of distributional effects, as part of a regulatory analysis, "so that decision makers can properly consider them along with the effects on economic efficiency [i.e., net benefits]. Executive Order 12866 authorizes this approach." (U.S. Office of Management and Budget 2003). Understanding the distribution of the avoided compliance costs and forgone benefits can aid in understanding community-level impacts associated with this action.[38] This section discusses the general expectations regarding how avoided compliance costs, forgone health co-benefits, and forgone demand-side energy efficiency savings might be distributed across the population, relying on a review of recent literature. For example, Fullerton (2011) discussed six potential distributional impacts related to environmental policy using a carbon permit system: impacts on consumers (e.g. higher energy prices); impacts on producers or factors (e.g., lower returns to capital); scarcity rents (e.g. value of emissions permits); benefits associated with pollution reduction; and transition costs (e.g., from changes in employment or capital mix). EPA did not conduct a quantitative assessment of these distributional impacts for the proposed repeal, but the qualitative discussion in this section provides a general overview of the types of impacts that could result from this action. We begin

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[37] Science Advisory Board, USEPA. *Economy-wide Modeling of the Benefits and Costs of Environmental Regulation.* https://yosemite.epa.gov/sab/sabproduct.nsf/0/07E67CF77B54734285257BB0004F87ED?OpenDocument

[38] Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* directs agencies to address impacts on minority and low-income populations, particularly those that may be considered disproportionate. EPA developed guidance, both in its *Guidelines for Preparing Economic Analyses* (U.S. EPA 2010) and *Technical Guidance for Assessing Environmental Justice in Regulatory Analyses* (U.S. EPA 2016) to provide recommendations for how to consider distributional impacts of rules on vulnerable populations.

each sub-section below with a general discussion of the incidence from the literature, followed by a brief discussion of the distributional consequences we might expect from this action.

3.5.2.1. Avoided Compliance Costs and Forgone Demand-Side Energy Efficiency Benefits

The compliance costs associated with an environmental action can impact households by raising the prices of goods and services; the extent of the price increase depends on if and how producers pass-through those costs to consumers. The literature evaluates the distributional effects of introducing a new regulation; as the literature relates to the proposed repeal these effects can be interpreted in reverse. Expenditures on energy are usually a larger share of low-income household income than that of other households, and this share falls as income increases. Therefore, policies that increase energy prices have been found to be regressive, placing a greater burden on lower income households (e.g., Burtraw et al., 2009; Hassett et al., 2009; Williams et al. 2015). However, compliance costs will not be solely passed on in the form of higher energy prices, but also through lower labor earnings and returns to capital in the sector. Changes in employment associated with lower labor earnings can have distributional consequences depending on a number of factors (Section 3.6 discusses employment effects further). Capital income tends to make up a greater proportion of overall income for high income households. As result, the costs passed through to households via lower returns to capital tend to be progressive, placing a greater share of the burden on higher income households in these instances (Rausch et al., 2011; Fullerton et al., 2011).

The ultimate distributional outcome will depend on how changes in electricity and other fuel and input prices and lower returns to labor and capital propagate through the economy and interact with existing government transfer programs. Some literature using an economy-wide framework finds that the overall distribution of compliance costs is progressive due to the changes in capital payments and the expectation that existing government transfer indexed to inflation will offset the burden to lower income households[39] (Fullerton et al., 2011; Blonz et al.,

[39] The incidence of government transfer payments (e.g., Social Security) is generally progressive because these payments represent a significant source of income for lower income deciles and only a small source for high income deciles. Government transfer programs are often, implicitly or explicitly, indexed to inflation. For example, Social Security payments and veterans' benefits are adjusted every year to account for changes in prices (i.e., inflation).

2012). However, others have found the distribution of compliance costs to be regressive due to a dominating effect of changes in energy prices to consumers (Fullerton 2011; Burtraw, et. al., 2009; Williams, et al., 2015). However, depending on the design of the policy, conclusions regarding the overall distributional impact can also depend on how the value of allowances are distributed or any revenue raised from a carbon policy is used (e.g., lowering other taxes) (Burtraw, et al., 2009). There may also be significant heterogeneity in the costs borne by individuals within income deciles (Rausch et al., 2011; Cronin et al., 2017). Different classifications of households, such as on the basis of lifetime income rather than contemporaneous annual income, may provide notably different results (Fullerton and Metcalf, 2002; Fullerton et al., 2011).

Furthermore, there may be important regional differences in the incidence of regulations. There are differences in the composition of goods consumed, regional production methods (e.g., the composition of the generation fleet), the stringency of a rule, as well as the location of affected labor and capital ownership (the latter of which may be foreign-owned) (e.g. Caron et. al 2017; Hassett et al. 2009). For example, as discussed in the 2015 CPP RIA, and noted above, the retail rate impacts differ notably across regions.

Understanding the full distributional impacts of compliance costs requires an economy-wide analysis (Rausch and Mowers, 2014). While such an analysis was not conducted for this proposal, we can attempt to understand the distributional impacts of a policy by examining its various components in their relevant partial equilibrium settings (Fullerton 2011). For example, using partial-equilibrium modeling, studies that have focused on the incidence of electricity sector regulations have generally found that consumers bear more of the compliance cost of a regulation than producers because demand for electricity is relatively inelastic and, in cost-of-service regions, increased production costs may be passed through electricity prices (e.g. Burtraw and Palmer 2008). Even in these studies, the details of the form of the regulation matters.

While the aforementioned components are important for understanding the ultimate distribution of avoided compliance costs in this context, it is not clear the degree to which the specific results may be transferred to the current context. For example, much of the previous literature has focused on the distributional impacts of first best policies, such as an economy-wide emissions fee or permit trading program.[40] Subsequent research focusing on second best policy designs such as economy-wide clean or renewable energy standards or power sector only permit trading programs have found the net distribution of costs to be relatively regressive even when accounting for the impacts on consumers and factors of production, as well as the indexing of transfer payments to inflation (Rausch and Mowers, 2014).

Examination of the distributional consequences of this action is complicated by the fact that demand-side energy efficiency was an allowable compliance option for the CPP. In the 2015 CPP RIA, EPA estimated that, although electricity prices increase, average electricity bills would ultimately decrease as a result of the savings from increased energy efficiency. As a result, the typical finding that compliance costs of electricity sector regulations are born more by electricity consumers may not be applicable, and thus consumers may not be better off with the proposed repeal. However, this conclusion critically depends on whether the level of energy efficiency assumed in the analysis would actually occur. In order to evaluate the distributional impacts of repealing this rule, further information would be required. For example, in the electricity bill analysis for CPP 2015, EPA assumed that the demand-side energy efficiency program costs would be recovered in electricity rates, but the EPA did not make assumptions about how local utilities could have distributed those costs across customer types. The CPP allowed for energy efficiency programs to be targeted at certain groups, like low-income households, which would have influenced the distributional outcomes of the policy.[41] Additionally, in the case of the mass-based scenario, the distributional impacts would also depend on how allowances would have been distributed. Ultimately, the distribution of avoided compliance costs and forgone energy efficiency benefits may also be regressive or progressive, depending on the factors indicated above as well as other implementation choices.

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[40] The directional results previously discussed are prior to any recycling of revenue from emissions fees or auctioned permits.

[41] Targeting may also affect the forgone cost of the regulation and not just their distributional consequences. For example, historically demand-side energy efficiency programs that are exclusively offered to qualifying low-income households have been more costly than other energy efficiency programs (see Hoffman, et al. 2017). Although, in this particular example, such programs may not have a significant effect on overall cost because they have historically not constituted a large portion of energy efficiency programs (Ibid.). Note that all customers (including low-income households) are typically able to participate in all other energy efficiency programs that are not exclusively limited to low-income households.

3.5.2.2. Distributional Aspects of the Forgone Health Co-Benefits

This section discusses the distribution, or environmental justice analysis, of forgone health co-benefits that result from the proposed repeal of the CPP. EPA guidance directs analysts to first consider the distribution of impacts in the baseline, prior to any regulator action (see U.S. EPA 2016). Often the baseline incidence of health outcomes is greater among low-income or minority populations due to a variety of factors, including a greater number of pollution sources located where low-income and minority populations live, work and play (Bullard, et al. 2007; United Church of Christ 1987); greater susceptibility to a given exposure due to physiology or other triggers (Akinbami 2012); and pre-existing conditions (Schwartz et al 2011). EPA (2016) then recommends analysts examine the distribution of health outcomes under the policy scenarios being considered. Finally, this can be followed by an examination of the change between the baseline and policy scenario, taking note of whether the action ameliorates or exacerbates any pre-existing disparities.

Because the manner in which the health benefits of a rulemaking are distributed is based on the correlation of housing and work locations to changes in atmospheric concentrations of pollutants, it is difficult to fully know the distributional impacts of a rule. Air dispersion models provide some information on changes in pollution, but it may be difficult to identify the characteristics of populations in those affected areas, as well as to perform local air dispersion modeling nationwide. Furthermore, the overall distribution of health benefits will depend on whether and how any households change their housing location choice in response to air quality changes (Sieg et al., 2004).

For the CPP final rule, the EPA examined the characteristics of populations living within three miles of EGUs and found a higher portion of low-income and minority communities located near power plants compared to national averages. However, air pollution from coal-fired units tends to be dispersed widely due to stack heights, atmospheric chemistry, and meteorological conditions. Pollution from utilities tends to affect regional air quality. Therefore, any changes in health outcomes associated with pollutants will vary according to these dispersion patterns. The correlation of those patterns with population characteristics will determine the distributional impact of any forgone health co-benefits associated with this action.

3.5.3. Impacts on Small Entities

Emission guidelines established under CAA section 111(d) do not impose any requirements on regulated entities and, thus, will not have a significant economic impact upon a substantial number of small entities. After emission guidelines are promulgated, states establish emission standards on existing sources, and it is those requirements that could potentially impact small entities. The proposed repeal of the CPP emissions guidelines will not impose any requirements on small entities. As a result, this action will not have a significant economic impact on a substantial number of small entities under the RFA.

Our analysis here is consistent with the analysis of the analogous situation arising when the EPA establishes NAAQS, which do not impose any requirements on regulated entities. As here, any impact of a NAAQS on small entities would only arise when states take subsequent action to maintain and/or achieve the NAAQS through their state implementation plans. See American Trucking Assoc. v. EPA, 175 F.3d 1029, 1043-45 (D.C. Cir. 1999) (NAAQS do not have significant impacts upon small entities because NAAQS themselves impose no regulations upon small entities).

3.6. Employment Impacts

Executive Order 13777 directs federal agencies to consider a variety of issues regarding the characteristics and impacts of regulations, including the effect of regulations on jobs (Executive Order 13777 (2017)). Employment impacts of environmental regulations are composed of a mix of potential declines and gains in different areas of the economy over time. Regulatory employment impacts can vary across occupations, regions, and industries; by labor demand and supply elasticities; and in response to other labor market conditions. Isolating such impacts is a challenge, as they are difficult to disentangle from employment impacts caused by a wide variety of ongoing concurrent economic changes.

Environmental regulation "typically affects the distribution of employment among industries rather than the general employment level" (Arrow *et. al.* 1996). Even if they are mitigated by long-run market adjustments to full employment, many regulatory actions have transitional effects in the short run (OMB 2015). These movements of workers in and out of jobs in response to environmental regulation are potentially important distributional impacts of interest to policy makers. Of particular concern are transitional job losses experienced by workers operating in declining industries, exhibiting low migration rates, or living in communities or regions where unemployment rates are high.

An environmental regulation affecting the power sector is expected to have a variety of transitional employment impacts, including reduced employment at retiring coal-fired facilities, as well as increased employment for the manufacture, installation, and operation of pollution control equipment and construction of new generation sources to replace retiring units (Schmalensee and Stavins (2011)). For the removal of such a regulation, as with the proposed CPP repeal, EPA expects increased employment at coal-fired facilities that would have otherwise retired, and decreased employment related to production and operation of pollution control equipment and reduced construction of new generation sources.[42]

In this section we discuss the anticipated employment impacts of repealing the CPP. To the extent possible, we describe the characteristics and labor market conditions of potentially affected workers, occupations, industries, and geographic areas.

The 2015 Clean Power Plan RIA, chapter 6, presented illustrative examples of employment impacts in the electricity, coal, and natural gas sectors using IPM estimates of the changes in generation and fuel use, as well as illustrative examples of employment impacts in demand-side energy efficiency sectors.

The employment analysis contained detailed categories of anticipated positive and negative employment effects within these sectors. First, for the electricity sector, tables 6-4 and 6-5 from the CPP RIA described the following detailed categories of employment:

- construction-related employment associated with heat rate improvements (boilermakers and general construction employment, engineering and management employment, equipment-related employment, and material-related employment);
- construction-related employment associated with new capacity (renewables construction employment and natural gas construction employment),

[42] The employment analysis in this RIA is part of EPA's ongoing effort to "conduct continuing evaluations of potential loss or shifts of employment which may result from the administration or enforcement of [the Act]" pursuant to CAA section 321(a).

- operation and maintenance (O&M) employment associated with renewable electricity generation;
- O&M employment associated with natural gas-fired generation;
- O&M employment associated with coal-fired generation; and
- employment declines due to retirements of oil, gas, or coal-fired generation capacity.

Second, for the coal and natural gas sectors, Tables 6-4 and 6-5 from the CPP RIA described categories of employment for coal extraction and natural gas extraction. Third, the categories of demand-side energy efficiency employment used in the 2015 CPP RIA came from the U.S. Bureau of Labor Statistics (BLS) green goods and services survey. BLS reports an energy efficiency employment category, which includes employment associated with products and services that improve energy efficiency, such as energy-efficient equipment, appliances, buildings, as well as products and services that improve the energy efficiency of buildings and the efficiency of energy storage and distribution, such as Smart Grid technologies. For the 2015 CPP RIA, EPA presented an aggregated "energy efficiency employment" category reflecting the jobs measured by BLS that EPA expected to be affected by the rule.[43]

This current RIA discusses the characteristics of the labor markets for the categories of employment presented in the 2015 CPP RIA. The U.S. Department of Energy, in cooperation with BLS, gathered and published detailed information on energy employment (U.S. DOE (2017a & 2017b)). [44] Detailed information on characteristics of workers, by job tasks, and areas of potential hiring difficulty, is available for the electricity sector and related sectors, and by geographic area (state). For workers in coal-fired utilities, there are notable differences in the characteristics of average groups of workers relative to national workforce averages. At coal-fired utilities, there are more men than women in the workforce (63 percent versus 53 percent), and they are, on average, younger (13 percent are 55 and over, versus 22 percent nationally)

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[43] Definition of BLS "energy efficiency" employment available here: https://www.bls.gov/ggs/ggsfaq.htm. In the CPP RIA analysis, EPA included only those categories potentially affected by the regulation, and removed unrelated categories such as transportation and vehicles (CPP RIA 2015, p. 6-28).

[44] Main website: https://energy.gov/downloads/2017-us-energy-and-employment-report, with links to the 2017 report (https://energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report_0.pdf) and associated state charts (https://energy.gov/sites/prod/files/2017/01/f34/2017%20US%20Energy%20and%20Jobs%20Report%20State%20Charts%202_0.pdf).

(U.S. DOE 2017a). Electric utilities and their workforce are distributed widely across the country. This lessens concerns that they are regionally concentrated in a high unemployment location. In the 2017 report, electric utilities (all types of generation, including coal-fired) report some hiring difficulties,[45] suggesting their demand for labor may somewhat outstrip the supply. Similarly, workers with construction firms building for the electric power sector may face tight labor markets. Construction firms working with the electric power sector reported in 2016 that they faced difficulties in hiring workers, with 82 percent reporting hiring was somewhat or very difficult (U.S. DOE 2017a).[46]

The demographic differences of employees in coal mining, relative to national workforce averages, are more notable than for electric utility workers. Men compose most of the coal mining workforce (76 percent versus national average 53 percent), and they are, on average, older, with 28 percent of the coal mining workforce age 55 and over, versus only 22 percent nationally (U.S. DOE 2017a). Coal mines are necessarily located on coal seams, and are not distributed evenly throughout the U.S. As such, coal workers are more tied to local labor markets and economies in terms of available employment opportunities. This raises a concern discussed further below.

The location of energy generation and fuel extraction activities is an important issue for considering distributional effects. Department of Energy (2017a) observes: “But within this overall story of [energy employment] growth is also an uneven trajectory where some states experience new jobs and others grapple with decline. States such as California and Texas, which have abundant solar, wind, and fossil fuel resources, have shown dramatic employment gains, despite some losses linked to low fossil fuel prices. Coal-dependent states, such as West Virginia and Wyoming, have seen declines in employment since 2015.” (U.S. DOE, 2017a). In addition to

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[45]The main reasons were: insufficient qualifications, certifications, education (61 percent), lack of experience, training, or technical skills (32 percent), and a small applicant pool (18 percent). The occupations reported as being the most difficult to hire for are: technician or technical support (29 percent), managers, directors, or supervisors (19 percent), and engineers (16 percent) (U.S. DOE 2017).

[46] The main reasons given for these difficulties were: insufficient qualifications, certifications, education (46 percent), lack of experience training or technical skills (41 percent), and a small pool of applicants (22 percent). The most difficult occupations to hire for, in the construction industry as part of electric power, are installation workers (29 percent), sales, marketing, or customer service representatives (29 percent), and managers, directors, or supervisors (27 percent) (U.S. DOE 2017).

the main report, Department of Energy has published similarly detailed information on energy employment, by state (DOE 2017a, 2017b).

Most energy efficiency employees, about 60 percent, work in construction firms installing or servicing energy efficiency goods and services, such as insulation (U.S. DOE 2017a). Manufacturing Energy Star certified products accounts for about 13 percent of the energy efficiency workforce. Notable differences in the demographics of the energy efficiency workforce include being predominantly male (76 percent), as compared to a national workforce average of 53 percent, and also younger – 17 percent are aged 55 and over, whereas 22 percent are in the national workforce, on average. Energy efficiency employers reported in 2016 at least some difficulty finding qualified job applicants, with over 80 percent reporting it was somewhat or very difficult (U.S. DOE 2017a).

The extent to which these workers just described will be significantly affected by the proposed repeal of the CPP, depends on such factors as the transferability of affected workers' skills with shifting labor demand in different sectors due to the repeal, the availability of local employment opportunities for affected workers in communities or industries with high unemployment, significant migration costs as barriers to job search in areas with historically low migration rates.

For example, if workers who would have been displaced by the original CPP lived in communities experiencing significant unemployment or possessed skill sets for which demand was falling (such as coal miners living in Appalachia), then there may have been negative employment effects with workers experiencing longer unemployment spells and persistent difficulties finding new employment. These negative outcomes may also have occurred if affected workers exhibited low migration rates, again for example, in rural areas such as Appalachia.[47] On the other hand, dislocated workers operating in tight labor markets may have experienced relatively brief periods of transitional unemployment. Some job seekers may have

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[47] Appalachia is an area with a history of poverty and few job opportunities. Morris (2016) summarizes data from the Bureau of Labor Statistics which show that as of February 2016, unemployment rates were above 10 percent in a third of the counties in West Virginia; and in 27 of 120 counties in Kentucky. The paper also cites the National Mining Association as reporting that coal miners typically do not have college educations and have a median age of 45. Their earnings are substantially higher than other US workers with no college education, thus upon losing coal mining jobs, locating new jobs with similar pay would likely prove to be difficult (Morris 2016).

found new employment opportunities due to the 2015 CPP regulation; for example, if their skill set qualified them for new environmental protection jobs or for working in renewable energy industries.

Speaking more generally, localized reductions in employment may adversely affect individuals and communities, just as localized increases may have positive effects (U.S. EPA 2015a p. 6-5). If potentially dislocated workers are vulnerable, for example as those in Appalachia likely are, besides experiencing persistent job loss as already mentioned, earnings can be permanently lowered, and the wider community may be negatively affected. Community-wide effects can include effects on the local tax base, the provision and quality of local public goods, and changes in demand for local goods and services. Neighborhood effects, when people influence neighbors' behaviors, may be possible. For example, social networks can influence job acquisition. Many job vacancies are filled by people who know an employee at the firm with the vacancy. This type of networking is weakened by high unemployment rates (Durlauf 2004).

The distributional effects of workforce disruptions may extend beyond impacts on employment. Sociological studies examine different effects than those that are typically examined in economic studies. Workers experiencing unemployment may also experience negative health impacts. The unemployed population is observed to be less healthy than those who are employed, and the differences in health across these groups can be significant (see, for example, Roelfs, et al. 2011) including different rates of substance abuse (Compton, et al. 2014). The literature describes difficulties in identifying the cause of poorer health for the unemployed population. Associations between unemployment and poorer health may be driven, in part, by the possibility that workers in poorer health may be more likely to become unemployed, and estimates of the magnitude of the association may be biased, in part, by factors not easily observed or addressed by researchers that contribute both to unemployment risk as well as poorer health (Jin 1995, Sullivan and von Wachtner 2009). Several recent papers have attempted to identify a causal relationship between unemployment and health. These papers examined the health effects of involuntary job loss by focusing on workers who have lost their jobs due to layoffs or other firm-level employment reductions. For example, Sullivan and von Wachtner (2009) found increased mortality rates among displaced workers in Pennsylvania; and in a study of displaced Austrian workers, Kuhn, et al. (2007) found that job loss negatively affected men's mental health.

4. Comparison of Benefits and Costs

In Table 4-1 we offer one perspective on the costs and benefits of this rule by presenting a comparison of the forgone benefits from the targeted pollutant – CO_2 – (the costs of this proposed rule) with the avoided compliance cost (the benefits of this proposed rule).[48] Excluded from this comparison are the forgone benefits from the SO_2 and NO_X emission reductions that were also projected to accompany the CO_2 reductions. However, had those SO_2 and NO_X reductions been achieved through other means, then they would have been represented in the baseline for this proposed repeal (as well as for the 2015 Final CPP), which would have affected the estimated costs and benefits of controlling CO_2 emissions alone.

Table 4-1. Avoided Compliance Costs, Forgone Domestic Climate Benefits, Forgone Demand-Side Energy Efficiency Benefits, and Net Benefits of Repeal Associated with Targeted Pollutant (billions of 2011$)

Year	Discount Rate	Avoided Compliance Costs	Forgone Domestic Climate Benefits	Forgone Demand-Side Energy Efficiency Benefits	Net Benefits Associated with Targeted Pollutant
Rate-Based					
2020	3%	$3.7	$0.4	$1.2	$2.1
2020	7%	$4.2	$0.1	$1.2	$2.9
2025	3%	$10.2	$1.4	$9.2	($0.4)
2025	7%	$14.1	$0.2	$9.2	$4.7
2030	3%	$27.2	$2.7	$18.8	$5.7
2030	7%	$33.3	$0.5	$18.8	$14.0
Mass-Based					
2020	3%	$2.6	$0.4	$1.2	$1.0
2020	7%	$3.1	$0.1	$1.2	$1.8
2025	3%	$13.0	$1.6	$10.0	$1.4
2025	7%	$16.9	$0.3	$10.0	$6.6
2030	3%	$24.5	$2.7	$19.3	$2.5
2030	7%	$30.6	$0.5	$19.3	$10.8

Note: Total forgone target pollutant benefits are the sum of forgone domestic climate benefits and forgone demand-side energy efficiency benefits. Estimates are rounded to one decimal point and may not sum due to independent rounding.

48 The forgone benefits estimate also includes the benefits due to demand side energy efficiency programs forecast a result of the rule.

When considering whether a regulatory action is a potential welfare improvement (i.e., potential Pareto improvement) it is necessary to consider all impacts of the action. Therefore, Tables 4-2 through 4-4 provide the estimates of the benefits, costs, and net benefits of the rate-based and mass-based approaches, respectively, from the proposed repeal of the CPP, using the estimates from the 2015 CPP RIA inclusive of the forgone benefits from the SO_2 and NO_X emission reductions that were also projected to accompany the CO_2 reductions. Note that in reporting the benefits, costs, and net benefits of this proposed action in the rows of Tables 4-2 through 4-4, we modify the relevant terminology to be more consistent with traditional net benefits analysis. In these rows, we refer to the avoided compliance costs discussed elsewhere in this RIA as the "benefits" of the rule and the forgone benefits of the rule discussed elsewhere in the RIA as the "costs" of the rule. Net benefits, then, equals the benefits minus the costs (or, in the terminology applied elsewhere in the RIA, the avoided compliance costs minus the foregone benefits).

There are additional important forgone benefits that the EPA could not monetize. Due to current data and modeling limitations, our estimates of the forgone benefits from reducing CO_2 emissions do not include important impacts like ocean acidification or potential tipping points in natural or managed ecosystems. Unquantified forgone benefits also include climate benefits from reducing emissions of non-CO_2 greenhouse gases and forgone co-benefits from reducing exposure to SO_2, NO_X, and hazardous air pollutants (e.g., mercury), as well as ecosystem effects and visibility impairment.

Table 4-2. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits (billions of 2011$) [a]

	Rate-Based Approach		Mass-Based Approach	
	Discount Rate		Discount Rate	
	3%	7%	3%	7%
2020				
Cost: Forgone Benefits [b]	$2.3 to $3.4	$1.9 to $3.0	$3.6 to $6.4	$3.1 to $5.6
Benefit: Avoided Compliance Costs	$3.7	$4.2	$2.6	$3.1
Net Benefits	$0.3 to $1.4	$1.2 to $2.3	($3.8) to ($1.0)	($2.5) to $0.0
2025				
Cost: Forgone Benefits [b]	$18.0 to $28.4	$16.2 to $25.6	$18.7 to $28.8	$16.7 to $26.0
Benefit: Avoided Compliance Costs	$10.2	$14.1	$13.0	$16.9
Net Benefits	($18.1) to ($7.8)	($11.5) to ($2.0)	($15.8) to ($5.7)	($9.1) to $0.2
2030				
Cost: Forgone Benefits [b]	$35.8 to $55.5	$32.2 to $50.2	$33.8 to $50.1	$30.4 to $45.5
Benefit: Avoided Compliance Costs	$27.2	$33.3	$24.5	$30.6
Net Benefits	($28.3) to ($8.6)	($16.9) to $1.1	($25.7) to ($9.3)	($14.8) to $0.2
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)			
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits from reductions in ambient NO_2 and SO_2 exposure Health benefits from reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)			

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.

[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. The forgone air quality health co-benefits reflect exposure to $PM_{2.5}$ and ozone associated with emission reductions of SO_2 and NO_X. The forgone co-benefits do not include the forgone benefits of reductions in directly emitted $PM_{2.5}$. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 98 percent of total monetized forgone co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. Estimates in the table are presented with air quality co-benefits calculated using two discount rates. The estimates of forgone co-benefits are annual estimates in each of the analytical years, reflecting discounting of mortality benefits over the cessation lag between changes in

$PM_{2.5}$ concentrations and changes in risks of premature death (see Chapter 4 of the 2015 CPP RIA for more details), and discounting of morbidity benefits due to the multiple years of costs associated with some illnesses. The estimates are not the present value of the forgone benefits of the rule over the full compliance period.

Table 4-3. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, assuming that Forgone $PM_{2.5}$ Related Benefits Fall to Zero Below the Lowest Measured Level of Each Long-Term $PM_{2.5}$ Mortality Study (billions of 2011$) [a]

	Rate-Based Approach		Mass-Based Approach	
	Discount Rate		Discount Rate	
	3%	7%	3%	7%
2020				
Cost: Forgone Benefits [b]	$2.2 to $2.8	$1.9 to $2.4	$3.5 to $4.4	$2.9 to $3.8
Benefit: Avoided Compliance Costs	$3.7	$4.2	$2.6	$3.1
Net Benefits	$0.9 to $1.5	$1.8 to $2.3	($1.8) to ($0.9)	($0.7) to $0.2
2025				
Cost: Forgone Benefits [b]	$17.5 to $20.7	$15.7 to $18.7	$18.2 to $21.6	$16.3 to $19.5
Benefit: Avoided Compliance Costs	$10.2	$14.1	$13.0	$16.9
Net Benefits	($10.5) to ($7.3)	($4.6) to ($1.6)	($8.5) to ($5.2)	($2.5) to $0.7
2030				
Cost: Forgone Benefits [b]	$34.8 to $40.7	$31.3 to $36.9	$32.9 to $38.1	$29.7 to $34.7
Benefit: Avoided Compliance Costs	$27.2	$33.3	$24.5	$30.6
Net Benefits	($13.5) to ($7.6)	($3.6) to $2.0	($13.7) to ($8.4)	($4.0) to $0.9
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)			
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits from reductions in ambient NO_2 and SO_2 exposure Health benefits from reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)			

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.

[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. The forgone air quality health co-benefits reflect exposure to $PM_{2.5}$ and ozone associated with emission reductions of SO_2 and NO_X. The forgone co-benefits do not include the forgone benefits of reductions in directly emitted $PM_{2.5}$. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 98 percent of total monetized forgone co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. Estimates in the table are presented with air quality co-benefits calculated using two discount rates. The estimates of forgone co-benefits are annual estimates in

each of the analytical years, reflecting discounting of mortality benefits over the cessation lag between changes in $PM_{2.5}$ concentrations and changes in risks of premature death (see Chapter 4 of the 2015 CPP RIA for more details), and discounting of morbidity benefits due to the multiple years of costs associated with some illnesses. The estimates are not the present value of the forgone benefits of the rule over the full compliance period. Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al 2012; LML = 8 $\mu g/m^3$).

Table 4-4. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, assuming that Forgone $PM_{2.5}$ Related Benefits Fall to Zero Below the $PM_{2.5}$ National Ambient Air Quality Standard (billions of 2011$) [a]

	Rate-Based Approach		Mass-Based Approach	
	Discount Rate		Discount Rate	
	3%	7%	3%	7%
2020				
Cost: Forgone Benefits [b]	$1.7 to $2.1	$1.4 to $1.8	$1.8 to $2.4	$1.5 to $2.0
Benefit: Avoided Compliance Costs	$3.7	$4.2	$2.6	$3.1
Net Benefits	$1.5 to $2.0	$2.4 to $2.8	$0.2 to $0.8	$1.1 to $1.7
2025				
Cost: Forgone Benefits [b]	$11.4 to $13.3	$10.2 to $12.1	$12.4 to $14.6	$11.1 to $13.2
Benefit: Avoided Compliance Costs	$10.2	$14.1	$13.0	$16.9
Net Benefits	($3.1) to ($1.1)	$2.1 to $4.0	($1.6) to $0.6	$3.7 to $5.9
2030				
Cost: Forgone Benefits [b]	$23.0 to $26.5	$20.7 to $24.1	$23.3 to $26.6	$21.0 to $24.2
Benefit: Avoided Compliance Costs	$27.2	$33.3	$24.5	$30.6
Net Benefits	$0.7 to $4.2	$9.2 to $12.7	($2.1) to $1.2	$6.4 to $9.6
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)			
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits from reductions in ambient NO_2 and SO_2 exposure Health benefits from reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)			

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.

[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. The forgone air quality health co-benefits reflect exposure to $PM_{2.5}$ and ozone associated with emission reductions of SO_2 and NO_X. The forgone co-benefits do not include the forgone benefits of reductions in directly emitted $PM_{2.5}$. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 98 percent of total monetized forgone co-benefits from $PM_{2.5}$ and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type. Estimates in the table are presented with air quality co-benefits calculated using two discount rates. The estimates of forgone co-benefits are annual estimates in

each of the analytical years, reflecting discounting of mortality benefits over the cessation lag between changes in $PM_{2.5}$ concentrations and changes in risks of premature death (see Chapter 4 of the 2015 CPP RIA for more details), and discounting of morbidity benefits due to the multiple years of costs associated with some illnesses. The estimates are not the present value of the forgone benefits of the rule over the full compliance period. Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$.

5. Limitations and Uncertainty

The Office of Management and Budget's circular *Regulatory Analysis* (Circular A-4) provides guidance on the preparation of regulatory analyses required under E.O. 12866, and requires a formal and quantitative uncertainty analysis for rules with annual benefits or costs of $1 billion or more.[49] This proposed rulemaking potentially surpasses that threshold for both avoided compliance costs and forgone benefits. Throughout this RIA and the referenced 2015 CPP RIA, we considered a number of sources of uncertainty, both quantitatively and qualitatively, on benefits and costs. We summarize five key elements of our analysis of uncertainty here:

- Recent economic and technological changes to the electricity sector that may have affected the potential cost and benefits of complying with the 2015 CPP had it been implemented;
- Approaches that states would have taken to comply with the 2015 CPP had it been implemented, which will affect both the costs and benefits of this rule;
- Uncertainties associated with demand-side energy efficiency investments;
- Uncertainty in the health benefits estimation, including using a benefits-per-ton approach; and
- Characterization of uncertainty in monetizing climate-related benefits.

Some of these elements are evaluated using probabilistic techniques. For other elements, where the underlying likelihoods of certain outcomes are unknown, we use scenario analysis to evaluate their potential effect on the benefits and costs of this rulemaking.

5.1. Insights from Interstate Ozone Transport-related Power Sector Modeling Performed in 2016

The compliance cost estimates presented in the 2015 CPP RIA were based upon information available when the analysis was conducted. Since that time, important economic and technical factors affecting the electricity sector may have changed and new information

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[49] Office of Management and Budget (OMB), 2003, *Circular A-4*, http://www.whitehouse.gov/omb/circulars_a004_a-4 and OMB, 2011. *Regulatory Impact Analysis: A Primer.* http://www.whitehouse.gov/sites/default/files/omb/*inforeg*/regpol/circular-a-4_regulatory-impact-analysis-a-primer.pdf

regarding the costs and efficiency of various compliance options (e.g., demand-side energy efficiency) may be available. Recent economic and technical changes to the electricity sector that may have affected the potential cost of complying with the CPP had it been implemented include:

- Changes to the inventory of existing electric generating units, reflecting new units and retirements;
- Changes in natural gas supply;
- Changes in coal supply;
- Extension of federal tax incentives for renewable energy, which affects the cost of renewable capacity;
- Updates to state rules and laws; and
- Changes to nuclear costs (fixed and variable operating costs).

In 2016, EPA conducted an updated power sector scenario using IPM and produced interstate ozone transport modeling data to share with states and other stakeholders for purposes of addressing the Clean Air Act's interstate transport requirements.[50] This new scenario included updates to key assumptions that reflect more recent information than was available when EPA finalized the CPP, specifically those issues noted above.[51]

This modeling did not evaluate the projected compliance costs associated with the CPP. However, the modeling did indicate that the CPP would have had a more modest impact at lower cost than projected at the time the CPP was finalized. This new modeling scenario reflected the same implementation of the illustrative mass-based scenario presented in the 2015 CPP RIA, including power sector production cost reductions in each model run-year that reflect demand-side energy efficiency measures that were assumed in the 2015 CPP RIA to occur in response to the CPP. A new scenario representing the rate-based illustrative scenario was not modeled.

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[50] U.S. EPA, "Notice of Availability of the Environmental Protection Agency's Preliminary Interstate Ozone Transport Modeling Data for the 2015 Ozone National Ambient Air Quality Standard (NAAQS)", Docket ID No. EPA-HQ-OAR-2016-0751.

[51] EPA Base Case v.5.16 for 2015 Ozone NAAQS Transport NODA Using IPM Incremental Documentation, available at https://www.epa.gov/airmarkets/incremental-documentation-epa-base-case-v516-2015-ozone-naaqs-transport-noda-using-ipm-0.

The effect of recent trends in the power sector on the expected compliance costs of the CPP can be observed through changes in the shadow prices for the CO_2 limitations that were applied to 47 states. These shadow prices are a model output that reflect the marginal abatement cost of meeting the state goals in the illustrative mass-based scenario. The marginal abatement cost is the cost of reducing emissions by one more ton from the covered sources in a state, given the assumed level of demand reductions from demand-side energy efficiency programs adopted in response to the CPP.[52] The marginal abatement costs provide a meaningful basis for demonstrating the relative stringency of the program and the cost of reducing the last ton of emissions to implement the CPP.

Focusing on the 2030 model year, the 2015 CPP RIA modeling showed the highest marginal abatement cost for any state was \$26/ton of CO_2, with the average marginal abatement cost of \$11/ton of CO_2 across all of the affected states. In contrast, the 2016 analysis found the highest marginal abatement cost had dropped to \$17/ton of CO_2 and that the average marginal abatement cost had dropped to \$4/ton of CO_2. Modeling supporting 2015 CPP RIA projected that the CO_2 constraints did not result in marginal abatement costs in seven states. Under identical levels of demand reduction attributable to the demand-side energy efficiency measures, that number increased to 18 states in the updated modeling. Note that since the updated modeling did not include a scenario without the CPP, an updated model-based estimate of the costs of the CPP is not available. However, the reduced marginal abatement cost results point to the costs of complying with the CPP would likely be less than was estimated in the final RIA.[53]

The updated power sector modeling provides useful information as to the effect of recent technical and economic changes on the efforts and costs that would have been required to comply with the CPP. However, this modeling does not reflect a complete reassessment of all

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[52] The marginal abatement costs do not necessarily reflect the cost of demand-side energy efficiency programs, which were exogenously incorporated into the CPP modeling. Some states have a modeled zero marginal abatement cost because the modeling indicated that they would not need to make any additional reductions beyond those achieved by the assumed demand-side energy efficiency programs. However, the marginal abatement costs inclusive of the cost of the demand-side energy efficiency programs may not be zero.

[53] The results are indicative of lower compliance costs over the lifetime of the rule, though in a forward-looking model the recent changes may cause the timing of certain investments to shift, possibly leading to higher compliance cost estimates in a given year even though the net present value of compliance costs **may have** gone down.

new information might affect the cost of complying with the CPP. As discussed in the 2015 CPP RIA, there is uncertainty regarding different aspects of the analysis including the regulatory form and precise measures that states will adopt to meet the requirements, the cost effectiveness of demand-side energy efficiency programs, future baseline demand, and other technical and economic factors. For example, the updated modeling previously discussed did not revisit the costs and effectiveness of demand-side energy efficiency programs, which is an active and evolving area of research. While the aforementioned updated power sector modeling does provide useful information as to the way in which some changes in the electric power sector would affect the costs of complying with the CPP, it was not for the purpose of, or intended to be, a full reanalysis incorporating all the new information that might affect estimates of the costs of complying with or repealing the CPP.

5.2. Regulatory Compliance Costs

Our best estimates of the avoided compliance costs of repealing the CPP are based on the cost analysis of the 2015 CPP RIA and are included in the cost modeling in this RIA for both the rate-based and mass-based approaches. Cost estimates for the final emission guidelines were based on rigorous power sector modeling using ICF's Integrated Planning Model. IPM assumes "perfect foresight" of market conditions over the time horizon modeled; to the extent that utilities and/or energy regulators misjudge future conditions affecting the economics of pollution control, costs may be understated.

One important element of the final CPP was the flexibility afforded to states in the development of requirements for their existing emitting sources. Each state had discretion on how to best achieve the standards of performance and/or state goals. As such, states had the ability to apply requirements to sources that achieved greater reductions than required during the interim period, and use those earlier reductions in the final period (i.e., banking of reductions). In the analysis and modeling for the 2015 RIA, such flexibilities were not explicitly modeled in the compliance scenarios. Doing so would have required additional assumptions about the specific opportunities states choose to adopt in their plans, including the form of the standard that states might apply, the manner in which it might have been applied, and the economic signal that such a mechanism might have provided to sources over time, such that sources would have had an incentive to make greater reductions earlier.

As previously stated, the analysis in the 2015 RIA is intended to be illustrative to inform the broad impacts of repealing the rule across the power sector, and not intended to evaluate the many specific approaches individual states might have chosen, or how sources might have achieved the emission reductions consistent with each state plan in response to particular policy signals or requirements. In estimating the avoided compliance cost of repealing the rule, not representing banking of earlier reductions into the final period captures this uncertainty, namely that there is inadequate and incomplete information regarding avoided state plans in the analytic approach.

5.3. Demand-side Energy Efficiency

The Agency used the best available information at the time of developing the 2015 CPP to establish a reasonable modeling framework for analyzing the impacts of demand-side energy efficiency, particularly as this analysis results in a substantial 8 percent reduction in 2030 electricity demand from projected business as usual sales. In doing so, the Agency leveraged the standard methods, available data, and research used by utilities and public utility commissions for evaluating the cost-effectiveness of demand-side energy efficiency investments. However, these types of analyses are being continually evaluated and refined, and there are certain uncertainties and limitations of the demand-side energy efficiency analysis that informs the avoided costs and forgone benefits of this proposed rule. In this section uncertainties that affect the energy efficiency analysis are discussed; these factors include measure lives, the ratio of program to participant costs, energy efficiency reflected in the base case demand forecast, recognition of pre-compliance energy efficiency investments, EIA Form 861 as a data source, and methods and sources for estimating energy efficiency costs. It is uncertain in which direction the levels of energy efficiency would change in an updated evaluation of these factors. In any updated analysis, EPA will further evaluate demand-side energy efficiency programs on the benefits and costs of the review of the CPP.

Considerations discussed here that affect demand-side energy efficiency analyses are the chosen methodology (e.g., bottom-up engineering-based analysis versus top-down statistical analysis), cost and savings assumptions, assumed measure life, and data inputs. These and other analytical components are discussed in detail in the Demand-Side Energy Efficiency Technical Support Document (TSD). (U.S. EPA, 2015b)

A key component of the cost analysis is the assumed cost of saved energy. The cost values used in this analysis are based on a review of energy efficiency data and studies, and expert judgment. The estimated levelized cost of saved energy (LCSE) used in our analysis is approximately eight cents per kWh (2011 $) in 2030.[54] This LCSE value is the total levelized cost, including both program and participant costs.[55] A review of the literature, including studies that use a variety of methodologies and assumptions, found that calculated LCSE values vary significantly. For example, a recent review by ACEEE examined studies across 20 states between 2009 and 2012, and estimated LCSE for electricity energy efficiency program costs in the range of 1.3-5.6 cents/kWh, with a mean value of 2.8 cents/kWh (ACEEE, 2014). Using our assumption of a 1:1 ratio of program to participant costs, discussed further below, this can be approximated to a mean total LCSE of 5.6 cents/kWh. In 2015, an LBNL study analyzed the total cost of saved energy based on data from their Demand-side Management (DSM) Program Database and found a national average total LCSE of 4.6 cents/kWh of gross savings.[56] (LBNL, 2015b) As compared to these studies, our LCSE is higher.

Most available research, including many of the studies referenced above, uses bottom-up engineering-based analyses to calculate LCSE values. The engineering-based methods derive savings by comparing energy consumption data collected prior to the implementation of measures to consumption data post-implementation. The economic literature has also evaluated the LCSE of energy efficiency measures using top-down modeling with econometric techniques. This body of studies is smaller than the bottom-up, engineering-based analyses due to the substantial data requirements. However, this type of study offers the potential to account for

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[54] The analysis assumed changing costs based on the level of demand-side energy efficiency deployment. The estimated total LCSE in 2020 was approximated at 9 cents/kWh (2011 $).

[55] Levelized cost of saved energy (LCSE) is a common metric for comparing alternative electricity resource options within utility resource plans (U.S. EPA and U.S. DOE, 2007). Our analysis provides the LCSE of total costs, so that both program and participant costs are included as part of the analysis. Typically, when LCSE values are used for the purposes of, for example, utility investment decisions, only program administrator utility costs (also known as program costs or utility costs) are considered. Thus, estimates of LCSE from other studies generally refer to program costs only, and we provide an approximation of the related total costs to make those results comparable to our estimate LCSE. Also, discount rates, average measure lives, dollar years and other assumptions affecting the calculation of LCSE were not always consistent or reported in the studies discussed.

[56] At the time of this study, the database included spending, savings and other data for more than 6,000 program years from about 1,700 programs. Utilities and other EE program administrators in 34 states contributed to those data through their regulatory filings, statewide databases, and other sources.

some behavioral responses before and after adoption of energy efficiency measures based on observed preferences that are statistically estimated in an internally consistent framework. When applied to relatively similar EE measures, these studies may offer more predictive power than alternative methods that either assume no behavioral response or transfer estimates of behavioral response from other settings. These studies provided varied insight into considerations such as free ridership, spillover, energy efficiency program endogeneity, and the rebound effect. The different assumptions used in these analyses make direct comparison challenging, but overall these empirical analyses present a wider range of estimates of cost of saved energy. For example, a 2008 study examining utility DSM programs estimated the average utility cost of saved energy in the range of 5.1 to 14.6 cents per kWh (Auffhammer et al., 2008). Some other studies in the economic literature suggest estimated LCSE in a similar range as from the bottom-up analyses. Another study calculated an average cost of 3.4 cents per kWh saved from utility energy efficiency programs, based on the utility-reported savings in the EIA Form 861 (Gillingham et al., 2006). Again, compared to these studies, our cost assumptions are either relatively conservative or within the range of these estimates. Regardless of the methods applied, energy efficiency program studies are generally carried out by third-party evaluators and reviewed in regulatory proceedings by oversight entities such as state Public Utility Commissions (PUCs) and regional Independent System Operators (ISOs).[57]

Other studies have applied comparison group analysis, such as randomized control trials (RCTs) and quasi-experimental methods, to particular demand-side energy efficiency programs and have found varying results.[58] While some studies have shown comparable results to

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[57] For further details on the chosen analytical methods and alternatives, see U.S. EPA. 2015b. Technical Support Document (TSD) the Final Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units. Demand-Side Energy Efficiency.

[58] See for example: Meredith Fowlie, Michael Greenstone, Catherine Wolfram. “Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program”, NBER Working Paper No. 21331, Issued in July 2015. Allcott and Greenstone. 2017. “Measuring the Welfare Effects of Residential Energy Efficiency Programs.” NBER Working Paper No. 23386, Issued in May 2017. Zivin and Novan. 2016. Upgrading Efficiency and Behavior: Electricity Savings from Residential Weatherization Programs. The Energy Journal. Steven Nadel, “Critiques of Energy Efficiency Policies and Programs: Some Truth But Also Substantial Mistakes and Bias,” American Council for an Energy Efficient Economy, April 2016. Judson Boomhower and Lucas Davis. “Do Energy Efficiency Investments Deliver at the Right Time?”, NBER Working Paper No. 23097, Issued in January 2017. Weatherization Assistance Program (WAP) prepared by Oak Ridge National Laboratory (ORNL). August 2015. http://weatherization.ornl.gov/WAP_NationalEvaluation_WxWorks_v14_blue_8%205%2015.pdf Allcott,

engineering-based methods, some have suggested that achieved savings are lower than expected for certain demand-side energy efficiency programs. Given the limited number of these comparison group methods or any other program-specific analysis it is still unclear if they are generalizable to all energy efficiency programs. When interpreting these studies, it is useful to consider whether the program being analyzed included objectives other than targeting the least-cost demand-side energy efficiency investment, such as implementing new technologies or targeting measures in housing for mid- and low-income individuals. Overall, quantifying the energy savings and cost-effectiveness of energy efficiency programs continues to be an active area of research that produces a range of results consistent with the uncertainty ranges discussed above.

Participant costs, the component of the total cost of demand-side energy efficiency programs that is paid by the consumer for an energy efficiency investment, are a key component of total costs and are less consistently estimated and reported than program costs. This analysis follows the standard practice of using a ratio between program and participant costs. These costs will vary significantly from one program to the next within a utility's portfolio. To determine an appropriate ratio for the impacts assessment of the CPP proposed rule, EPA conducted research and analysis of industry data (annual EE program reports from administrators in 22 states) and found that on average program costs represented 53 percent of total measured costs (with direct participant costs representing the remaining 47 percent) (U.S. EPA, 2014). Based on this analysis, the EPA used a ratio of 1-to-1 for program to participant costs for the energy efficiency cost estimates contained in the CPP proposed rule, a ratio that aligns with LBNL analysis (LBNL 2015b). While based on the average result across 22 states, the assumption of a 1-to-1 ratio for program method is still an approximation that may not precisely reflect the participant costs for the portfolio of measures adopted.

It should also be noted that generally there are features of demand-side energy efficiency programs that may have benefits or costs to the participant that are not included in program

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H. and T. Rogers (2014). "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." American Economic Review 104(10): 3003-3037. Allcott, H. (2011). "Social Norms and Energy Conservation." Journal of Public Economics 95(9-10): 1082-1095. Ayres, I., S. Raseman, and A. Shih (2009). "Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage." Journal of Law, Economics, and Organization 29 (5): 992-1022.

costs, included social costs and benefits not accounted for in this analysis. One reason the expenditures associated with demand-side energy efficiency may differ from social costs is due to differences in the services provided by more energy efficient technologies and services adopted under the program relative to the baseline. For example, if under the program end-users adopted more energy efficient products which were associated with quality or service attributes deemed less desirable, then there would be an additional welfare loss that should be accounted for in social costs but is not necessarily captured in the measure of expenditures. However, there is an analogous possibility that in some cases the quality of services, outside of the energy savings, provided by the more energy efficient products and practices are deemed more desirable by some end-users. For example, weatherization of buildings to reduced electricity demand associated with cooling will likely have a significant impact on natural gas use associated with heating. In either case, these real welfare impacts are not fully captured by end-use energy efficiency expenditure estimates.

Another key input that informs the avoided costs and forgone benefits of this proposed rule is measure life.[59] Most comparable studies have used a single average measure life to represent a diverse portfolio of programs that range in measure lives from less than ten years (e.g., commercial lighting technologies and applications, residential behavioral feedback) to as long as twenty years or more (e.g., residential HVAC, residential building insulation). This analysis relied on a recent work by the Lawrence Berkeley National Laboratory (LBNL) on the distribution of energy efficiency program lifetimes (LBNL, 2015a).[60] The weighted average of EE measure lifetimes for the entire population in the LBNL analysis is 10.2 years, but this analysis assumed a four-tier distribution of energy efficiency program measure lifetimes, based

[59] Measure life is the duration of time a demand-side energy efficiency project or measure is anticipated to remain in place and operable with the potential to save electricity. For example, the purchase of a high-efficiency refrigerator may lead to savings for twelve years, before being replaced with a new model. The cumulative incremental savings in a given year represents the total impacts of all energy efficiency measures, those put in place in that year and all prior years, that still have remaining savings impacts in the given year. The cumulative savings account for the continuing impacts of energy efficiency measures that remain in place for the "measure life" before being replaced.

[60] The analysis was based on the LBNL DSM Program Database. At the time of this study, program savings lifetimes were available for about 1,600 program years across a database of nearly 6,000 program years of data (27% of the program years). More than 50 utilities and other energy efficiency program administrators in 25 states contributed to those data through their regulatory filings, statewide databases, and other sources.

on a cluster analysis – a statistical approach for grouping values based on their similarity.[61] While more refined than a single measure life assumption, this method is still a statistical approximation that may not precisely reflect the measure lives of the portfolio of measures adopted.

Regarding estimation of energy savings and their impact on demand, it is useful to keep in mind that the base case electricity demand in IPM v.5.15 (based upon AEO2015) may reflect the impacts of existing state demand-side energy efficiency policies, though it does not explicitly represent the most significant existing state policies (e.g., energy efficiency resource standards). To some degree, the implicit representation of state policies in the EPA's base case alters the avoided costs and impacts, and forgone benefits, of this proposed rule, but the direction and magnitude of these changes is not known with certainty. In addition, AEO2015 reflects finalized state and federal legislation and rulemakings that affect demand-side energy efficiency including federal and state appliance standards, and state adoption of federal energy building codes. This is a longstanding standard practice of EIA in developing the Annual Energy Outlook.

Also, the analysis of the "rate-based" illustrative plan approach does not fully reflect the demand-side energy-efficiency measures potentially eligible for recognition under the CPP final rule. The CPP final rule allowed for pre-compliance emission reduction measures implemented after 2012 to be recognized for emission rate credits (ERCs) for the emission reductions those measures provide during the interim and final performance periods (i.e., 2022-2030). However, this analysis limited recognition of demand-side energy efficiency measures implemented starting in 2020, limiting the pool of eligible measures.

It should also be acknowledged that the source of sales and savings data, The EIA Form 861 "Annual Electric Power Industry Report," while it remains the most comprehensive effort that collects data annually on energy efficiency costs and spending, is self-reported by utilities and other demand-side management program administrators and the definitions and data

[61] The method used for the cluster analysis is the k-means approach. The method starts with assignment of each data point to a cluster so as to minimize the distance of cluster members from the center of the cluster, which is designated randomly. In essence, the method seeks to minimize differences within each cluster and maximize differences among the clusters. In this case, the programs within each cluster would have similar lifetimes and program types.

categories may not be consistently applied across different program administrators, utilities, and states, and may vary by data year.[62] Additionally, the data used were from 2014, the most recent data available at the time of the analysis. This historic data informed projections of future growth rates of savings from demand-side energy efficiency measures implemented by utilities or other program administrators. While these projected growth rates were selected based upon an evaluation of saving growth rates historically achieved by a diverse group of states, investor-owned utilities and cooperative-owned utilities, those projections may not accurately reflect the future trajectory of particular state investments in demand-side energy efficiency measures and the associated savings, assuming states adopt unique portfolios of demand-side energy efficiency programs. Savings can be affected by a variety of regional characteristics including avoided power system costs, economic growth, sectoral mix, climate, and level of past EE efforts.

5.4. Social Cost of Carbon

For detailed discussion of uncertainties in the estimates of SC-CO_2, please see Appendix C.

5.5. $PM_{2.5}$ and Ozone Health Co-Benefits Assessment

5.5.1. Overview

In any complex analysis using estimated parameters and inputs from numerous models, there are likely to be many sources of uncertainty. This analysis is no exception. This analysis includes many data sources as inputs, including emission inventories, air quality data from models (with their associated parameters and inputs), population data, population estimates, health effect estimates from epidemiology studies, economic data for monetizing co-benefits, and assumptions regarding the future state of the world (i.e., regulations, technology, and human behavior). Each of these inputs may be uncertain and would affect the estimate of co-benefits. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified benefits. In addition, the use of the benefit-per-ton approach adds additional uncertainties beyond those for analyses based directly on air quality

[62] Over time, the data quality has improved significantly and there is increased standardization in data reporting and more detailed and up-to-date data categories are being reported.

modeling. Therefore, the estimates of co-benefits in each analysis year should be viewed as representative of the general magnitude of co-benefits of the illustrative plan approach, rather than the actual co-benefits anticipated from implementing the final emission guidelines.

This RIA does not include the type of detailed uncertainty assessment found in the PM NAAQS RIA (U.S. EPA, 2012a) or the Ozone NAAQS RIA (U.S. EPA, 2008b) because we lack the necessary air quality modeling input and/or monitoring data to run the benefits model. However, the results of the quantitative and qualitative uncertainty analyses presented in the PM NAAQS RIA and Ozone NAAQS RIA can provide some information regarding the uncertainty inherent in the estimated co-benefits results presented in this analysis. For example, sensitivity analyses conducted for the PM NAAQS RIA indicate that alternate cessation lag assumptions could change the estimated PM2.5-related mortality co-benefits discounted at 3 percent by between 10 percent and –27 percent and that alternative income growth adjustments could change the PM2.5-related mortality co-benefits by between 33 percent and −14 percent. Although we generally do not calculate confidence intervals for benefit-per-ton estimates and they can provide an incomplete picture about the overall uncertainty in the benefits estimates, the PM NAAQS RIA provides an indication of the random sampling error in the health impact and economic valuation functions using Monte Carlo methods. In general, the 95th percentile confidence interval for monetized PM2.5 benefits ranges from approximately -90 percent to +180 percent of the central estimates based on Krewski et al. (2009) and Lepeule et al. (2012). The 95th percentile confidence interval for the health impact function alone ranges from approximately ±30 percent for mortality incidence based on Krewski et al. (2009) and ±46 percent based on Lepeule et al. (2012).

Unlike RIAs for which the EPA conducts scenario-specific air quality modeling, we do not have information on the specific location of the air quality changes associated with the final emission guidelines. As such, it is not feasible to estimate the proportion of co-benefits occurring in different locations, such as designated nonattainment areas. Instead, we applied benefit-per-ton estimates, which reflect specific geographic patterns of emissions reductions and specific air quality and benefits modeling assumptions. For example, these estimates may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual co-benefits of controlling PM and ozone precursors. Use of these benefit-per-ton values to estimate co-benefits may lead to higher or lower benefit estimates than if co-benefits were calculated based on direct air quality modeling. Great care should be taken in applying these estimates to emission reductions occurring in any specific location, as these are all based on a broad emission reduction scenario and therefore represent average benefits-per-ton over the entire region. The benefit-per-ton for emission reductions in specific locations may be very different than the estimates presented here. To the extent that the geographic distribution of the emissions reductions achieved by implementing the final emission guidelines is different than the emissions in the air quality modeling of the proposal, the co-benefits may be underestimated or overestimated. To the extent feasible, the EPA intends to perform full-scale gridded photochemical air quality modeling to support the air quality benefits assessment informing subsequent regulatory analyses of CPP-related actions. Such model predictions would supply the model-predicted changes in air quality needed to: (1) quantify the $PM_{2.5}$ and ozone-related impacts of the policy case; (2) perform the full suite of sensitivity analyses summarized above, particularly the concentration cutpoint assessment. EPA further commits to characterizing the uncertainty associated with applying benefit-per-ton estimates by evaluating the reliability of such estimates and comparing EPA's approach with other reduced-form techniques in the peer-reviewed literature. All of these analyses will be available for peer review consistent with the requirements of OMB's Information Quality Bulletin for Peer Review within six months

A full description of the underlying data, studies, and assumptions is provided in the PM NAAQS RIA (U.S. EPA, 2012) (see in particular the table 5B "Comprehensive Characterization of Uncertainty in Benefits Analysis) and Ozone NAAQS RIA (U.S. EPA, 2008a). In general, EPA provides the PM-related results using concentration-response functions from two key epidemiology studies, as well as two epidemiology studies of ozone mortality risk. To further explore uncertainty in the premature mortality benefits, the 2015 CPP RIA also included an assessment of the distribution of population exposure in the modeling underlying the benefit-per-ton estimates. Below we describe the key sources of uncertainty in this analysis and our approach for addressing these uncertainties. These key sources of uncertainty include: (1) using benefit per-ton estimates to quantify the number and economic value of forgone air pollution-related deaths and illnesses; (2) the incidence of $PM_{2.5}$-related premature deaths occurring at low ambient concentrations; (3) the risk attributable to individual $PM_{2.5}$ species.

5.5.2 *Benefit-per-ton estimates*

When quantifying the benefits of modeled air quality changes, EPA provides information on the relative uncertainty in the benefits estimates based on the 95th percentile confidence interval for avoided PM-related and ozone-related premature deaths and the associated economic valuation estimated in the benefits analysis. Confidence intervals are unavailable for this rule because of the benefits-per-ton methodology.

In addition to the uncertainties in the underlying concentration-response and valuation functions, all benefit-per-ton approaches have inherent limitations, including that the estimates reflect the geographic distribution of the modeled sector emissions, which may not match the emission reductions anticipated by this proposed rule, and they may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors for any specific location. In addition, these estimates reflect the regional average benefit-per-ton for each ambient $PM_{2.5}$ precursor emitted from EGUs, in this rule, the forgone NOx emissions, which assumes a linear atmospheric response to emission reductions. The regional benefit-per-ton estimates, although less subject to these types of uncertainties than national estimates, still should be interpreted with caution.

Even though we assume that all fine particles have equivalent health effects as discussed in Section 3.4.3, the benefit-per-ton estimates vary between precursors depending on the location and magnitude of their impact on $PM_{2.5}$ levels, which drive population exposure. The 2015 CPP RIA further discusses the uncertainty using the benefits-per-ton in locations below the lowest measureable limits (LML) of $PM_{2.5}$ compared to RIAs that have air quality modeling of the proposed rule. As part of a project now underway, the Agency is systematically evaluating the uncertainty associated with its technique for generating and applying this reduced-form technique for quantifying benefits, with the goal of better understanding the suitability of this, and comparable, approaches to estimating the health impacts from the EGU sector.

5.5.3. *Estimating $PM_{2.5}$-related impacts at low ambient levels*

We estimated the number of forgone long-term $PM_{2.5}$-related premature deaths using risk coefficients from two long-term cohort studies (Krewski et al. 2009 and Lepeule et al. 2012). The Integrated Science Assessment for Particulate Matter (2009) PM ISA, which informed the setting of the 2012 PM NAAQS, reviewed available studies that examined the potential for a population-level threshold to exist in the concentration-response relationship. Based on such studies, the ISA concluded that the evidence supports the use of a "no-threshold" model and that "little evidence was observed to suggest that a threshold exists" (PM ISA, pp. 2-25 to 2-26). Consistent with the evidence, in setting the PM standards, the Agency noted that NAAQS are not meant to eliminate all risk and acknowledged that risk remains at levels below the 2012 standards.

The Clean Air Act directs the Agency to set NAAQS that, in the judgment of the Administrator, are "requisite" to protect the public health with an adequate margin of safety. In setting primary standards that are requisite, the EPA's task is to establish standards that are neither more nor less stringent than necessary, given the available scientific information.

When setting the PM NAAQS, the Administrator acknowledged greater uncertainty in specifying the magnitude and significance of PM-related health risks at PM concentrations below the NAAQS though the scientific evidence did not support the absence of risk. In general, we are more confident in the magnitude of the risks we estimate from simulated $PM_{2.5}$ concentrations that coincide with the bulk of the observed PM concentrations in the epidemiological studies that are used to estimate the benefits. Likewise, we are less confident in the risk we estimate from simulated $PM_{2.5}$ concentrations that fall below the bulk of the observed data in these studies. We start to have appreciably less confidence in the magnitude of the associations observed in the epidemiological studies at concentration below the lowest measured level of the long-term epidemiological studies. Most of the estimated forgone avoided premature deaths for this rulemaking occur at or above the lowest measured $PM_{2.5}$ concentration in the two studies that are used to estimate mortality benefits. There are uncertainties inherent in identifying any particular point at which our confidence in reported associations becomes appreciably less, and the scientific evidence provides no clear dividing line. In light of the conclusion above, and as a means of making more transparent the magnitude of the health co-benefits occurring above and below both the 2012 annual PM NAAQS and the Lowest Measured Levels of the two long-term epidemiological studies, we performed the sensitivity analysis below.

First, we identify the fraction of people exposed to $PM_{2.5}$ concentrations above and below an annual mean of 12 $\mu g/m^3$ using the CPP proposal baseline air quality modeling simulation (developed in 2015) noted above. The percent of baseline exposures above and below an annual mean of 12 µg/m^3 for the CPP proposal is then compared to baseline exposures in other recent analyses (Table 5-1 and Figure 5-1). This approach builds on the existing LML analysis presented in Section 4.3.6 of the RIA for the final CPP RIA (Table 4-28; Figures 4-3, 4-4). These comparisons illustrate the declining percentage of individuals exposed to concentrations at or above the LML of each long-term epidemiological study and annual PM NAAQS over time. As air quality improves, we fully expect that fewer people would be exposed to high $PM_{2.5}$ concentrations (U.S. EPA, 2011a; Fann et al. 2017); indeed, by 2025, most of the U.S. is projected to be in attainment with the 2012 $PM_{2.5}$ NAAQS due to existing federal measures.

Second, we consider what percent of benefits of recent rules are estimated to occur above and below these thresholds. Where modeled benefits estimates are available as part of recent analyses, we report the percentage of avoided $PM_{2.5}$-related premature deaths estimated to occur at or above the PM NAAQS or the LML of underlying epidemiological studies (Table 5-2 and Figure 5-2). The results indicate a declining share of the benefits accruing above the annual $PM_{2.5}$ NAAQS, reflecting the role of national-scale programs in reducing regional particle levels. This reinforces the point that the order in which policy actions are taken is extremely important in determining the size of the benefits estimates for each subsequent action. The size of the forgone co-benefits we estimate in this RIA are a function of the "regulatory path" by which facilities complied with the rule. Had other policies affected the level of pollutants emitted by these same sources prior to implementing the CPP, the forgone co-benefits (and forgone compliance costs) reported here would have been lower. EPA requests public comment on this approach for characterizing uncertainty associated with the estimated number of PM-related deaths occurring below the NAAQS and LML of each epidemiological study.

Table 5-1. Percentage of Individuals Living in Locations at or above the National Ambient Air Quality Standards for PM or the Lowest Measured Level of the Two Long-Term Epidemiological Studies used to Quantify PM-Related Premature Deaths for Recent Air Quality Modeling Simulations of the Electricity Generating Unit Sector

	LML[a]		NAAQS
Model	**5.8 µg/m^3**	**8.0 µg/m^3**	**12.0 µg/m^3**
CSAPR	95.80%	80.10%	16.40%
MATS	90.20%	53.90%	3.40%
Sector	93.70%	68.10%	5.50%
CPP Proposal	88.00%	46.40%	1.80%

[a]LML of the Krewski et al. (2009) study = 5.8 µg/m^3; LML of the Lepeule et al. (2012) study= 8.0 µg/m^3

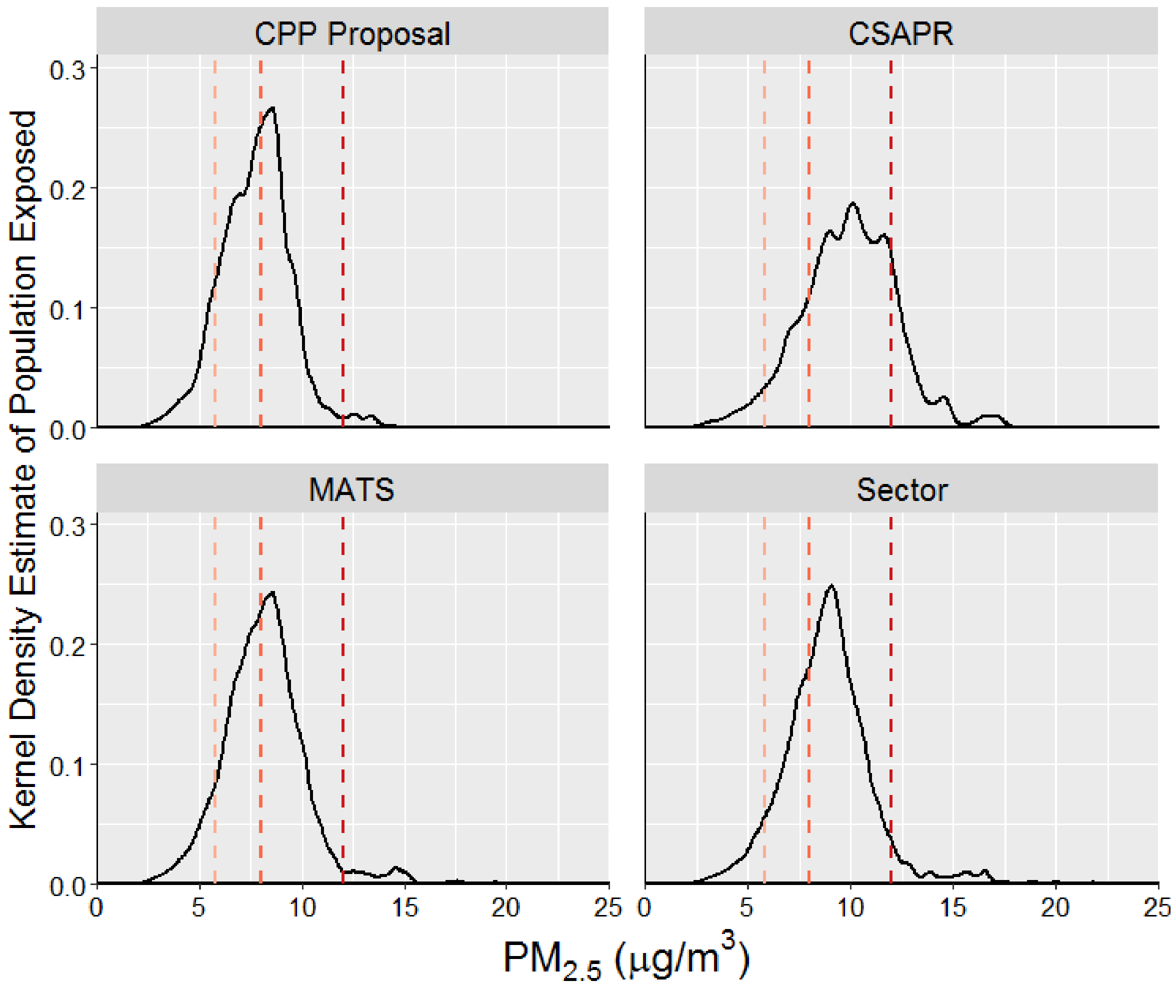

Figure 5-1. Density of population exposed at or below the Lowest Measured Level of the Krewski et al. (2009) or Lepeule et al (2012) epidemiological studies and the 2012 PM NAAQS

Table 5-2. Percentage of Avoided $PM_{2.5}$-Related Premature Deaths Occurring at or above the National Ambient Air Quality Standards for PM or the Lowest Measured Level of the Two Long-Term Epidemiological Studies used to Quantify PM-Related Premature Deaths for Recent Air Quality Modeling Simulations of the Electricity Generating Unit Sector

	LML[a]		NAAQS
Model	**5.8 µg/m³**	**8.0 µg/m³**	**12.0 µg/m³**
CSAPR	99.50%	92.70%	21.40%
MATS	95.70%	61.40%	0.40%
CPP Proposal	92.30%	51.20%	0.40%

[a]LML of the Krewski et al. (2009) study = 5.8 µg/m³; LML of the Lepeule et al. (2012) study= 8.0 µg/m³

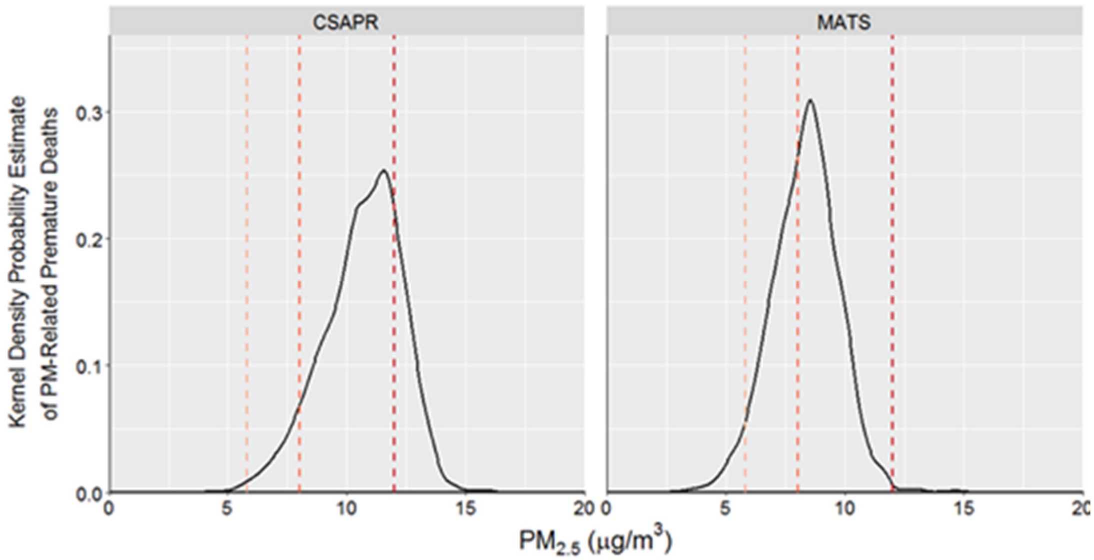

Figure 5-2. Density of Avoided PM-related premature deaths at or below the Lowest Measured Level of the Krewski et al. (2009) or Lepeule et al (2012) epidemiological studies and the 2012 PM NAAQS

Similar to what is discussed in Section 5.2 on uncertainties of avoided regulatory cost estimates, there may be other indirect co-benefit impacts not accounted for in this RIA. As discussed in Section 5.2. the implementation of the CPP as written was forecast to produce criteria pollutant emission co-reductions that may have helped some regions with attainment of the NAAQS. By repealing the CPP, these regions may need to obtain criteria pollutant emission reductions via other mechanisms. To the extent that states use other mechanisms in order to comply with the NAAQS, and still achieve the criteria pollution reductions that were anticipated under the CPP, the forgone benefits of the CPP may also be lower.

With respect to the criteria pollutant emissions reductions forecast under the CPP within areas already in attainment of the NAAQS, to the extent that criteria pollutant emission reductions in these areas under the CPP would have created room for new and expanding sources to increase emissions in these areas, the health co-benefits may have been overestimated in the 2015 CPP RIA. The extent to which the health co-benefits may have been overestimated in the 2015 CPP RIA for this reason depends also on a variety of federal and state decisions with respect to NAAQS implementation and compliance, including Prevention of Significant Deterioration (PSD) requirements. Furthermore, although the potential increase in the emissions from local sources may reduce health co-benefits under the CPP, the ability for those sources to expand because of the CPP may have had economic benefits.

5.5.4. PM-related impacts attributable to individual species

Variation in effect estimates reflecting differential toxicity of particle components and regional differences in $PM_{2.5}$ composition (mixtures) is a source of uncertainty in assessments of PM-related health impacts. PM composition and the size distribution of those particles vary within and between areas due to source characteristics. Any specific location could have higher or lower contributions of certain PM species and other pollutants than the national average, meaning potential regional differences in health impact of given control strategies. Depending on the toxicity of each PM species reduced in the control strategies, assuming equal toxicity could over or underestimate benefits.

Epidemiology studies examining regional differences in $PM_{2.5}$-related health effects have found differences in the magnitude of those effects, and composition remains one potential explanatory factor (PM ISA, section 2.3.2). In addition to differences in the contribution of any given species to the baseline concentrations, use of different control strategies would have a differing magnitude of the effect in different regions. Depending on the extent of the differences in toxicity and the exact mix if species controlled, different control strategies could have a differing magnitude of the effect in different regions. The PM ISA concluded many compounds can be linked with multiple health effects and the evidence is not yet sufficient to allow differentiation of effects estimates by particle type (pg. 2-17).

Although our assumption that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality is consistent with SAB advice (U.S. EPA-SAB, 2010, pg. 18), EPA is initiating a process for reconsidering the scientific evidence that has accrued since this advice was given. We also specifically seek public comments on how, in the interim, EPA should quantify the uncertainty associated with the current assumption.

We also use national risk coefficients with no local variations due to differential exposure. The PM ISA states that available evidence and the limited amount of city-specific speciated $PM_{2.5}$ data does not allow differentiation of PM effects in different locations (pg. 2–17). Using national risk coefficients is supported by SAB (U.S. EPA- SAB, 2010) and NAS

(NRC, 2002). Regional differences in hazard ratios from studies conducted in California shown in Table 5.A-8 of the PM NAAQS RIA (EPA, 2012). The hazard ratios from the California studies range from -83% to +1300% compared to the national estimate applied from Krewski et al. (2009).

6. Present Value Analysis of 2020-2033 for E.O. 13771, Reducing Regulation and Controlling Regulatory Costs

6.1. Introduction

This proposed action, when finalized, would be considered a deregulatory action under E.O. 13771, Reducing Regulation and Controlling Regulatory Costs, as the action has total costs less than zero. An E.O. 13771 deregulatory action qualifies as both: (1) one of the actions used to satisfy the provision to repeal or revise at least two existing regulations for each regulation issued, and (2) a cost savings for purposes of the total incremental cost allowance.

To inform E.O. 13771, the EPA calculated the present value of cost savings for the years 2020-2033 using both a three percent and seven percent end-of-period discount rate. These calculations were performed for both the rate-based and mass-based illustrative plan scenarios discussed in this RIA. The present value of avoided costs was estimated from the perspective of 2016.

A present value analysis was not performed and presented in the 2015 CPP RIA, which presented annual cost impacts forecast to occur in three representative years of analysis: 2020, 2025, and 2030. This section presents the methods and results from the 2015 CPP RIA used to calculate the present values, as well as related assumption and caveats that are important to consider when interpreting the results.

6.2. Methods

The CPP, which is proposed to be repealed by this action, established an 8-year interim compliance period that was to begin in 2022 with a glide path for meeting interim CO_2 emission performance rates separated into three steps: 2022-2024, 2025-2027, and 2028-2029. The final CO_2 emission performance rates were to be in effect in 2030. The 2015 CPP RIA presented results for the analysis years 2020, 2025, and 2030.

The calculation of a present value requires an annual stream of avoided costs for each year of the 2020-2033 timeframe. For the purpose of this proposed rule, that annual stream of avoided costs was estimated based on the projections presented in the 2015 CPP RIA. In the final CPP RIA, the EPA used IPM to estimate cost and emissions changes for the projection years

2020, 2025, and 2030. Estimates of costs and emission changes in other years are determined from the mapping of projection years to the calendar years they represent.[63] In the modeling that supported the RIA for final rule, the 2020 projection year represents the 2019-2022 calendar years, the 2025 projection year represents 2023-2027, and the 2030 projection year represents 2028-2033. The present value analyses begin in the year 2020 to be consistent with the first year of analysis presented in the 2015 CPP RIA. The concluding year of the analysis period for the present value calculations is 2033, the latest year that is mapped to 2030. Similarly, the value of demand-side energy efficiency savings for each year in the analysis period was estimated based on the modeling presented in the 2015 CPP RIA and using the methodology discussed in Section 3.3 of this RIA. The projection years represent certain calendar years. (The annual compliance costs were also adjusted using the method described in Section 3.3 to account for the value of savings from demand-side energy efficiency measures.) In order to estimate the avoided costs of this proposed repeal, the approximate cost of additional generation that would have been needed absent assumed demand reductions from energy efficiency programs is added to the compliance cost.[64] In conclusion, the annual stream from 2020-2033 of avoided compliance costs includes: avoided compliance costs, avoided MR&R costs[65], and the cost of demand-side energy efficiency programs.

Using a three percent and a seven percent discount rate, the EPA calculated the present value of both avoided compliance costs in 2016.[66] The annual estimates of avoided were adjusted

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[63] For more information regarding the mapping of projection years to calendar years, see Chapter 7 of the Documentation for Base Case v.5.15 Using the Integrated Planning Model.

[64] The approximate additional generation costs that would have occured absent reductions from demand-side energy efficiency programs equals the equals the approximate benefit, i.e. the value, of savings from demand-side energy efficiency programs of the CPP. The value of savings from demand-side energy efficiency is treated as a forgone benefit of this proposed rule.

[65] In the 2015 CPP RIA, MR&R costs were estimes for the years 2020, 2025, and 2030. For this proposal RIA, like other avoided compliance costs we assumed the MR&R costs in projection years were the same in associated calendar years.

[66] For consistency, when calculating the present value of avoided compliance costs under the assumption of a seven percent discount rate, we assume a discount rate of seven percent in annualizing the cost of demand-side energy efficiency measures. In the 2015 CPP RIA, the total annualized compliance costs included demand-side energy efficiency costs calculated using a three percent discount rate. For a more detailed discussion of the demand-side energy efficiency cost analysis, refer to the Demand-Side Energy Efficiency TSD, published in conjunction with the promulgation of the CPP. Also, see Table 3-3 in the 2015 CPP RIA for more detail.

to represent present values in 2016. Whereas the analysis presented elsewhere in this RIA is generally presented in terms of 2011 dollars, the EPA adjusted all present value estimates to be in terms 2016 dollars, per E.O. 13771 implementation guidance. To do this, the EPA applied the GDP deflator provided in the implementation guidance.[67]

EPA calculated the avoided costs over the 2020- 2033 timeframe for the two illustrative plan approaches evaluated in the 2015 CPP RIA. The two illustrative plan approaches are the "rate-based" illustrative plan approach and the "mass-based" illustrative plan approach. Detailed, annual results for avoided compliance costs are presented in Appendix D.

6.2. Results

Table 6-1 presents the present values of the avoided compliance costs from the proposed repeal of the CPP under rate-based and mass-based illustrative plan scenarios, calculated using 3 and 7 percent discount rates over the 2020-2033 timeframe.

6.2.1. Present Values

Under the rate-based approach, the present value of the stream of avoided compliance costs over the 2020-2033 timeframe is $167.4 billion when discounted at 3 percent and $132.8 billion when discounted at 7 percent (Table 6-1). Under the mass-based approach, the present value of the stream of avoided compliance costs over the 2020-2033 timeframe is $164.6 billion when discounted at 3 percent and $131.9 billion when discounted at 7 percent. These avoided compliance cost estimates represent the regulatory cost savings related to the regulatory allowance under to E.O. 13771.

6.2.2. Equivalent Annual Values

Table 6-1 presents the equivalent annualized value, which is a calculation that yields an even-flow of figures that would yield an equivalent present value. Under the rate-based approach, the equivalent annual value of avoided compliance costs over the 2020-2033 timeframe is $14.8 billion when discounted at 3 percent and $15.2 billion when discounted at 7

[67] For GDP-IPD figures used in this analysis, see https://www.bea.gov/iTable/print.cfm?fid=ED8379E3B870D35D721D155A07EDCC602C8B75B9F62BF3144F0AD5C40B910F675527EA67256537B0B861F837692ADA4863A36A58B7AA75B2536A5A8352E74CE6. Accessed 5/30/17.

percent. Under the mass-based approach, the present value of the stream of avoided compliance costs over the 2020-2033 timeframe is $14.6 billion when discounted at 3 percent and $15.1 million when discounted at 7 percent.

Table 6-1. Present Value of Avoided Compliance Costs from the Proposed Repeal of the CPP, 3 and 7 Percent Discount Rates, 2020-2033 (billion 2016$) [a]

	Rate-Based [b]		Mass-Based [b]	
	3%	**7%**	**3%**	**7%**
2020	3.5	3.4	2.5	2.6
2021	3.4	3.2	2.4	2.4
2022	3.3	3.0	2.4	2.2
2023	9.0	9.5	11.4	11.4
2024	8.7	8.9	11.1	10.6
2025	8.5	8.3	10.8	9.9
2026	8.2	7.8	10.5	9.3
2027	8.0	7.2	10.2	8.7
2028	20.6	16.0	18.5	14.7
2029	20.0	14.9	18.0	13.7
2030	19.4	13.9	17.5	12.8
2031	18.8	13.0	16.9	12.0
2032	18.3	12.2	16.5	11.2
2033	17.7	11.4	16.0	10.5
Present Value	**167.4**	**132.8**	**164.6**	**131.9**
Equivalent Annualized Value	**14.8**	**15.2**	**14.6**	**15.1**

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] Avoided compliance costs include avoided compliance costs, avoided MR&R costs, and the costs of demand-side energy efficiency programs.

6.3. Caveats Related to Present Value Analysis of Avoided Compliance of the Proposed Repeal of the CPP

RIA Section 5 (that precedes this section) discusses a number of limitations and uncertainties associated with the impacts estimates discussed in this RIA, including discussions of recent economic and technical changes to the electricity sector that may have affected the potential cost of complying with the 2015 CPP had it been implemented, uncertainties in the approaches that states would have taken to comply with the 2015 CPP had it been implemented, and uncertainties associated with demand-side energy efficiency. Before concluding this section, it is important to note that by assuming avoided compliance cost impacts are equal in the calendar years associated with the power sector modeling run years, important information about the compliance glide path anticipated under the CPP may be omitted. For purposes of modeling the illustrative CPP compliance plan scenarios, the CPP goals for the year 2025 are applied in the IPM modeling run year for that same year, which represents the interim period. In 2030, the final rule 2030 goals are the modeled goals for the 2030 IPM analysis year and all subsequent IPM analysis years. The analysis and projections for the year 2025 reflect the impacts across the power system of complying with the interim goals, and the analysis and projections for 2030 reflect the impacts of complying with the final goals. In addition to the 2025 and 2030 projections, modeling results and projections are also shown for 2020. There is no regulatory requirement reflected in the 2020 run-year in IPM, consistent with the CPP as finalized.

7. Additional Observations of Potential Clean Power Plan Impacts based upon the U.S. Energy Information Administration's 2015 through 2017 Annual Energy Outlooks

7.1. Introduction

The starting point for assessing the cost savings and forgone benefits of proposed repeal of the Clean Power Plan (CPP) is the 2015 RIA that assessed the costs and benefits of promulgating and implementing the CPP. However, as discussed in Section 5.1, several notable changes have occurred that affect the electric power sector. These changes include changes in expected electricity demand, expected growth in electricity generation by renewable methods, retirement of older generating units, changes in the prices and availability of different fuels, and state and federal regulations.

This section begins with an examination of how expected market conditions have changed since 2015. We examine how those changes may affect the 2015 EPA analysis by drawing upon insights about how changes in the electric power sector have influenced the Annual Energy Outlook (AEO) projections from the Energy Information Administration (EIA). EIA's 2017 Annual Energy Outlook presents an updated assessment of the CPP, and, given the recent vintage of this analysis, it provides insight into the potential impact of repealing the CPP under more current conditions in the electric power sector.

The following section also draws upon the EIA's 2015, 2016, and 2017 Annual Energy Outlooks to provide a quantitative discussion of the sensitivity of CPP compliance cost to demand-side energy efficiency levels (EE) levels (based on EIA's analysis of the Clean Power Plan of May 2015 and the No EE and High EE sensitivity cases[68]) and to provide a discussion of the impacts of changes in the power sector and their effect on CPP compliance (based on AEO2016 and AEO2017 with and without CPP cases).

7.2. Observations on AEO Trends from 2015 to 2017

This section presents a series of observations on AEO trends across three sections:

[68] See "Analysis of the Impacts of the Clean Power Plan," U.S. Energy Information Administration, May 2015. Available at: https://www.eia.gov/analysis/requests/powerplants/cleanplan/. This analysis used AEO2015 Reference case to represent the scenario without the CPP and presented policy cases with CPP, with CPP without energy efficiency (No EE) and with CPP with high energy efficiency (High EE).

- Trends in AEO Projections without CPP,
- Trends in Projected Impacts of CPP (AEO2016 vs. AEO2017), and
- Implications for Updating EPA's RIA Projections

We also present the costs and emission reductions estimated by EIA for implementation of the CPP, applying additional analyses to quantify the forgone climate benefits and health co-benefits.

7.2.1. Trends in AEO Projections without CPP

Projections of electric power demand have decreased since 2015. EIA's AEO projection of electricity demand over the 2020 to 2030 horizon have generally decreased over time. For example, the AEO2017 demand forecast for 2030 is about 1.5 percent lower than the AEO2015 demand forecast for that year (Figure 7-1).

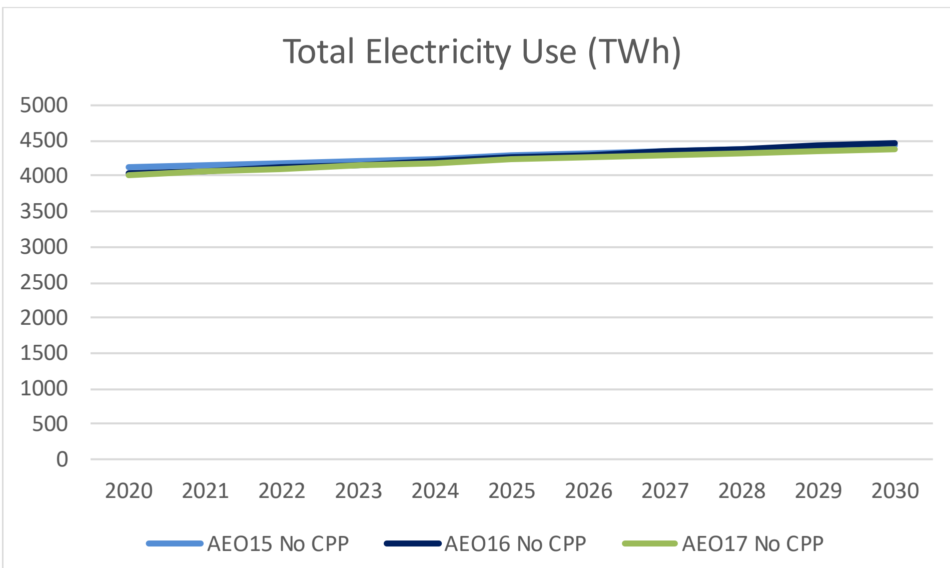

Figure 7-1. Total Electricity Use in Annual Energy Outlook Projections without the CPP (TWh)

Projections of new renewable capacity have increased since 2015. EIA's AEO projection of cumulative unplanned new renewable capacity builds in the electric power sector (e.g., not end use on-site or distributed generation) is substantially higher in the 2017 projection than in the 2015 projection. For example, EIA's projection of cumulative unplanned new renewable energy capacity for 2030 has increased from about 13 GW in the AEO2015 Reference Case (No CPP) to about 66 GW in the AEO2017 No CPP Case, a nearly 400 percent increase (Figure 7-2). (Unplanned generation is the new capacity endogenously identified by the model as cost-effective to construct to satisfy demand.) Similarly, EIA's projection of total renewable energy capacity for 2030 has increased from 198 GW in the AEO2015 Reference Case (No CPP) to 273 GW in the AEO2017 No CPP Case, approximately a 38 percent increase (Figure 7-3). Most of this capacity consists of new onshore wind and solar photovoltaics (PV), and the increase in projected new builds of these generation technologies reflects the fact that the private cost of building these technologies has decreased over the past few years both because of PTC/ITC tax credit extensions and because of decreases in the cost of new capacity.

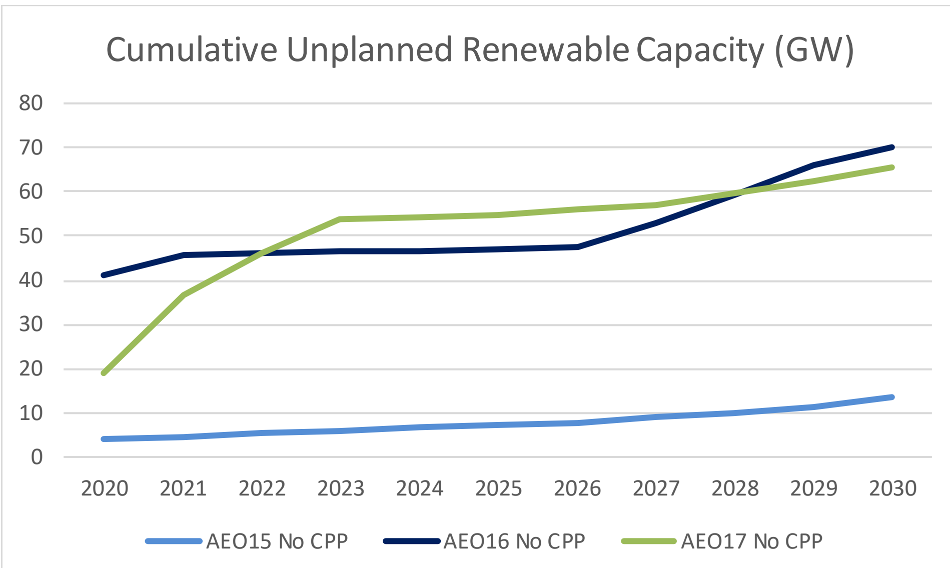

Figure 7-2. Cumulative Electric Power Sector Unplanned Renewable Capacity Additions in Annual Energy Outlook Projections without the CPP (GW)

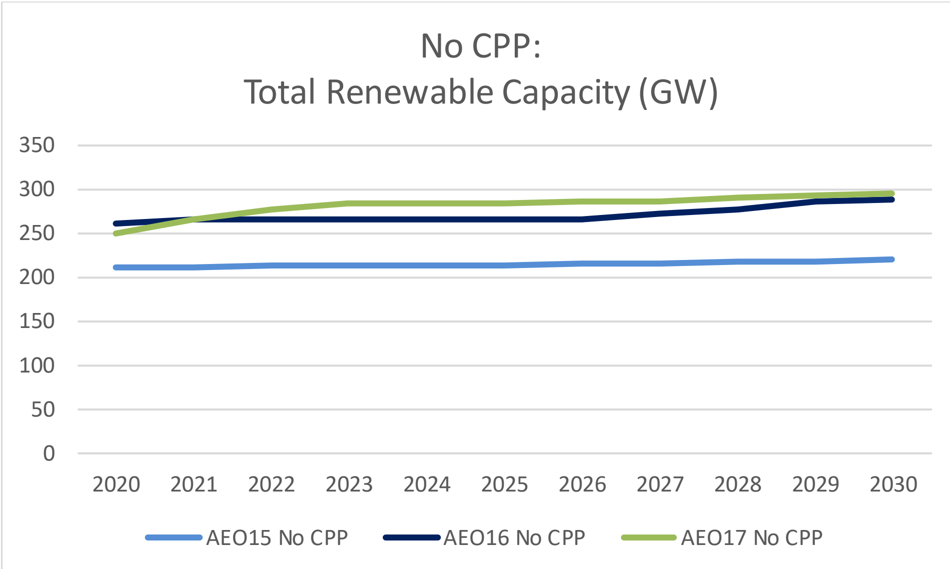

Figure 7-3. Total Electric Power Sector Renewable Capacity in Annual Energy Outlook Projections without the CPP (GW)

Additionally, the projected price of natural gas delivered to the electric power sector declines between the AEO2015 Reference Case (No CPP) and AEO2017 No CPP Case. EIA's Annual Energy Outlook projections of power sector delivered gas price for 2030 has decreased from about $6.64/mcf (2016$) in the AEO2015 Reference Case (No CPP) to about $5.25/mcf (2016$) in the AEO2017 No CPP Case, a 21 percent decrease (Figure 7-4). Lower natural gas price forecasts, resulting largely from an increasing expected supply, have contributed to an increase in the projected competitiveness of natural gas generation.

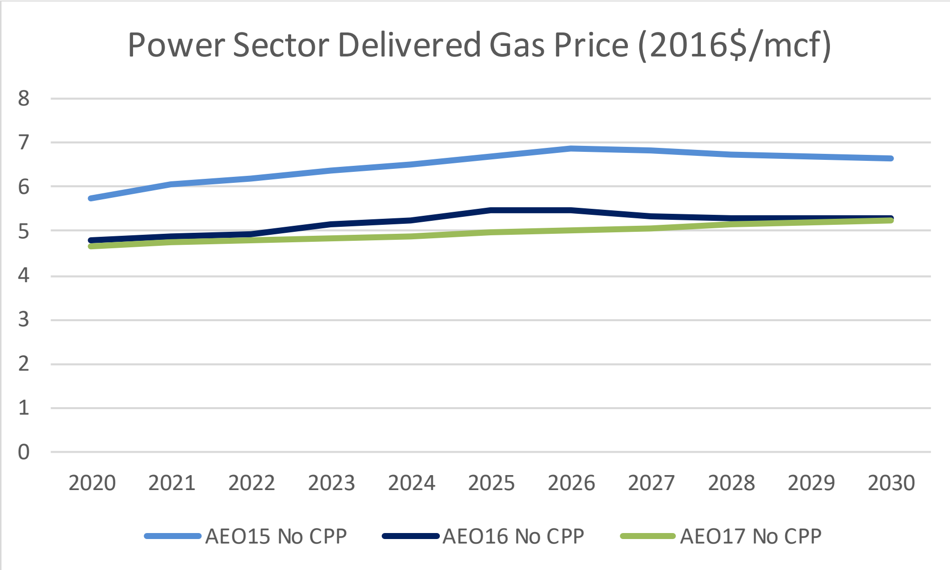

Figure 7-4. Electric Power Sector Delivered Gas Price in Annual Energy Outlook Projections without the CPP (2016$/mcf)

Furthermore, the consumption of coal by the electric power sector declines between the 2015 and 2017 AEO forecasts without the CPP. The AEO projection of total power sector coal consumption for 2030 has decreased from about 930 million short tons in the AEO 2015 Reference Case (No CPP) to 781 million short tons in AEO2017 No CPP Case, a 16 percent decrease (Figure 7-5). Similarly, EIA's projection of coal-fired generation in 2030 has decreased from 1,700 TWh in the AEO2015 Reference Case (No CPP) to 1,410 TWh in the AEO2017 No CPP Case, a 17 percent decrease (Figure 7-6). Consistent with the decreased coal generation, the AEO projection of coal-fired capacity in 2030 has decreased from about 257 GW in AEO2015 Reference Case (No CPP) to 220 GW in AEO2017, a 14 percent decrease (Figure 7-7).

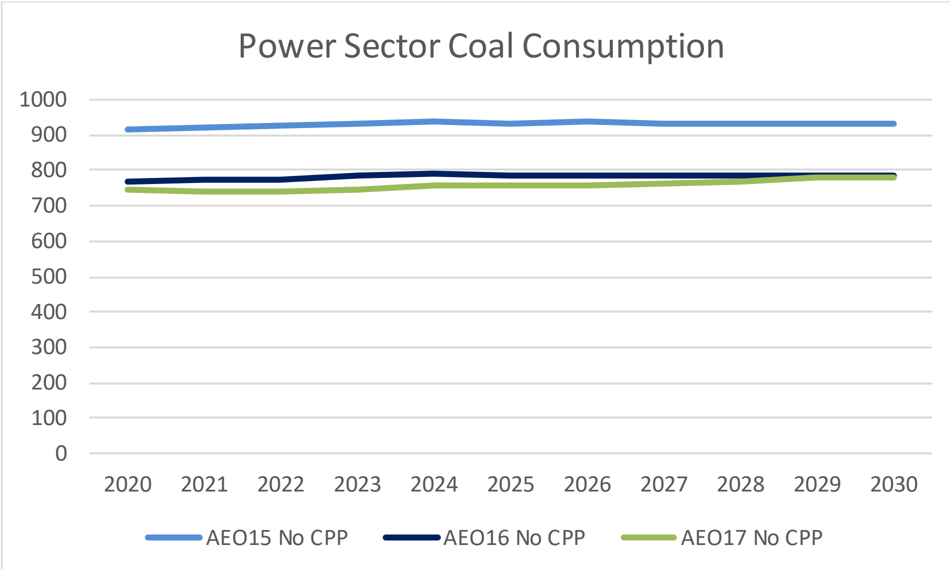

Figure 7-5. Electric Power Sector Coal Consumption in Annual Energy Outlook Projections without the CPP (million short tons)

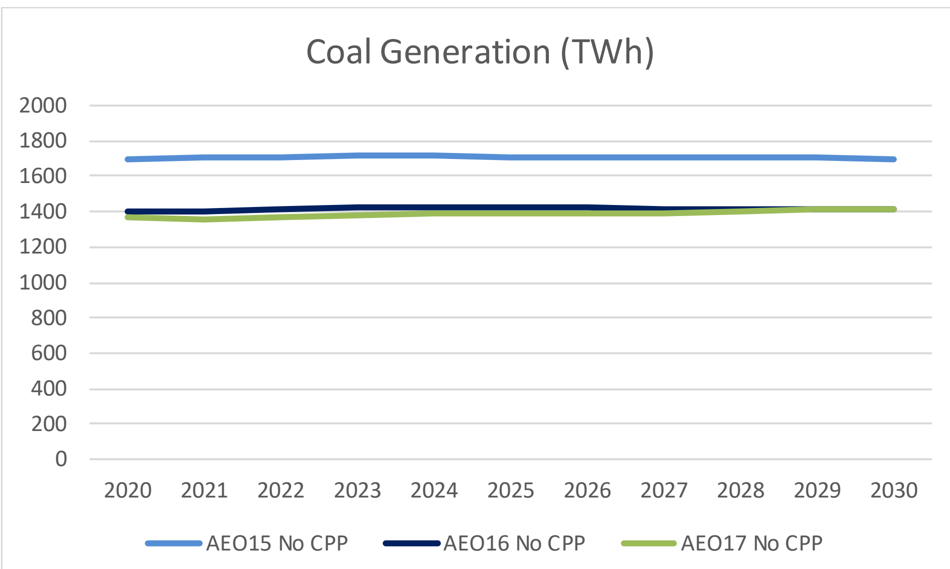

Figure 7-6. Electric Power Sector Coal Generation in Annual Energy Outlook Projections without the CPP (Trillion kWh = TWh)

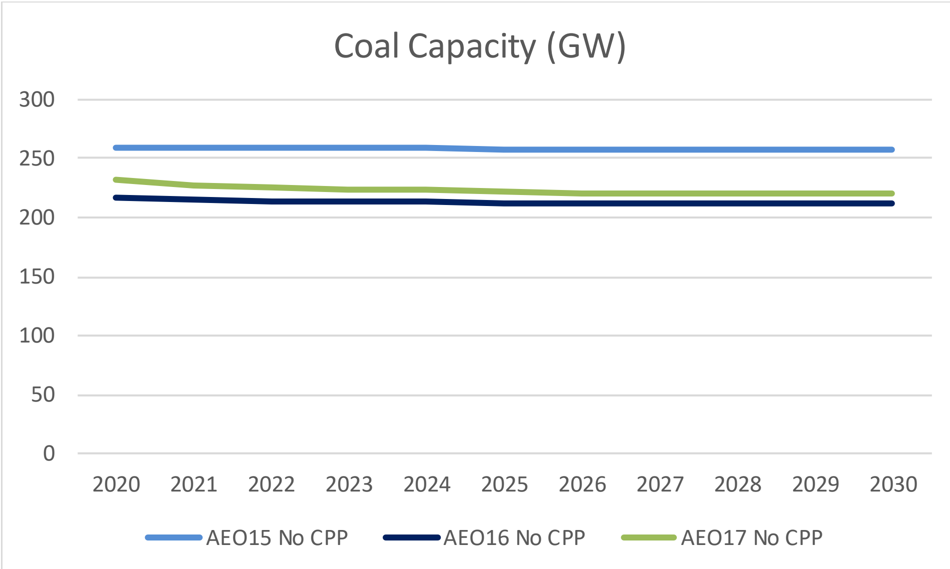

Figure 7-7. Electric Power Sector Coal Capacity in Annual Energy Outlook Projections without the CPP (GW)

The trends in projected emissions from the electric power sector are consistent with the projected shift in generation away from higher-emitting generating sources to lower-emitting generating sources observable in future scenarios that assume no implementation of the CPP. The AEO projection of 2030 power sector CO_2 emissions has decreased from about 2,400 million short tons in the AEO2015 Reference Case (No CPP) to 2,074 million short tons in the 2017AEO No CPP Case, a 14 percent decrease (Figure 7-8). EIA notes that: "in the electric power sector, coal-fired plants are replaced primarily with new natural gas, solar, and wind capacity, which reduces electricity-related CO_2 emissions" (AEO2017). Similarly, EIA's projection of 2030 SO_2 emissions has decreased from 1,440 thousand short tons in the AEO2015 to 1,357 thousand short tons (a 6 percent decrease), and EIA's projection of 2030 NO_X emissions has decreased from 1,564 thousand short tons in the AEO2015 Reference Case (No CPP) to 1,136 thousand short tons, a 27 percent decrease (Figures 7-9 and 7-10).

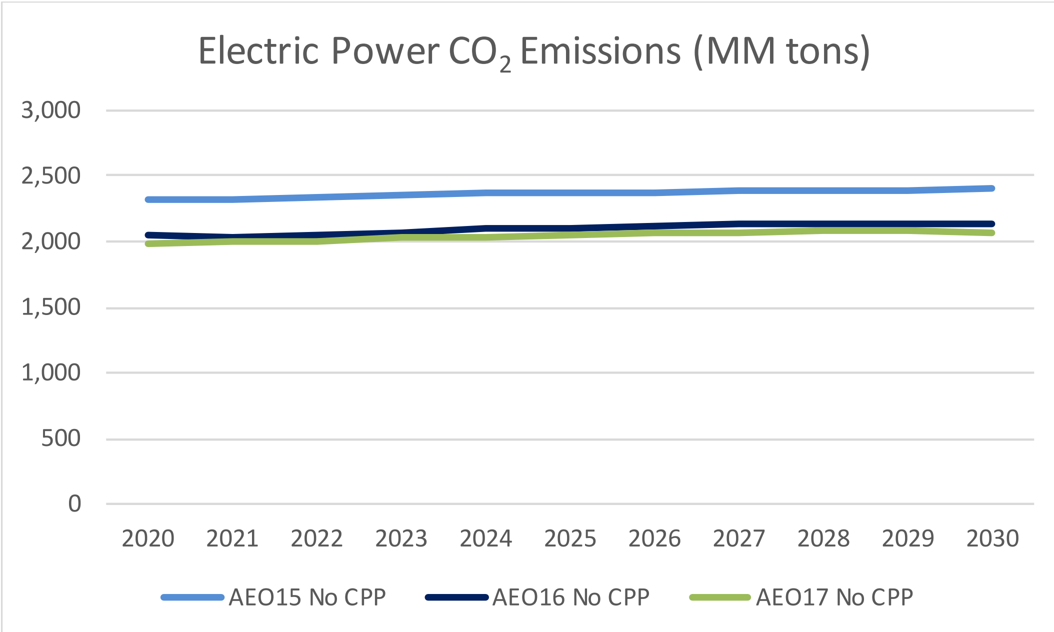

Figure 7-8. Electric Power Sector CO_2 Emissions in Annual Energy Outlook Projections without the CPP (million short tons)

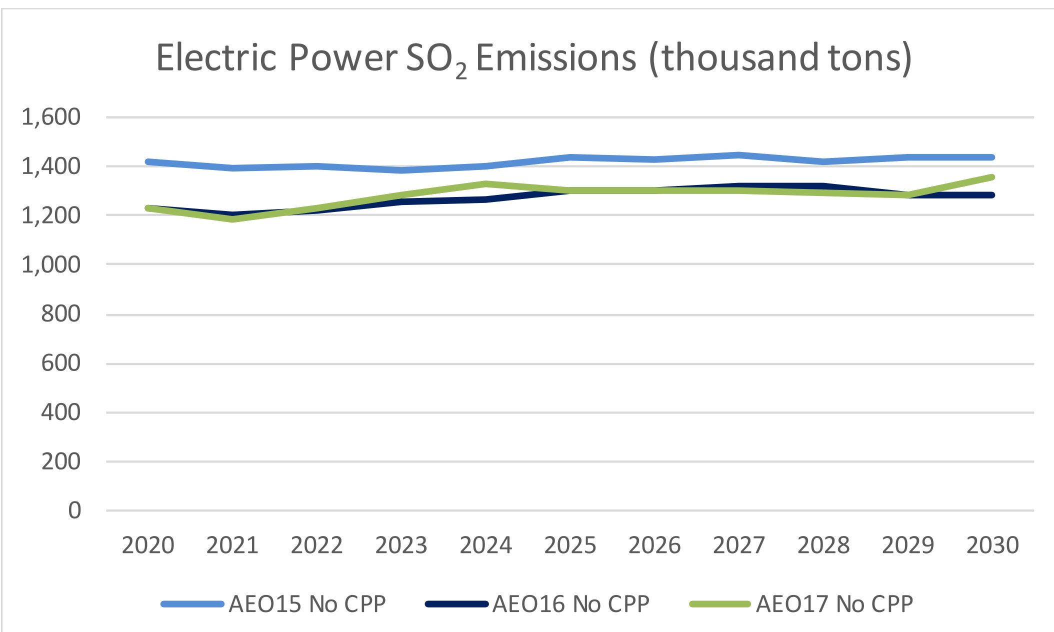

Figure 7-9. Electric Power Sector SO_2 Emissions in Annual Energy Outlook Projections without the CPP (thousand short tons)

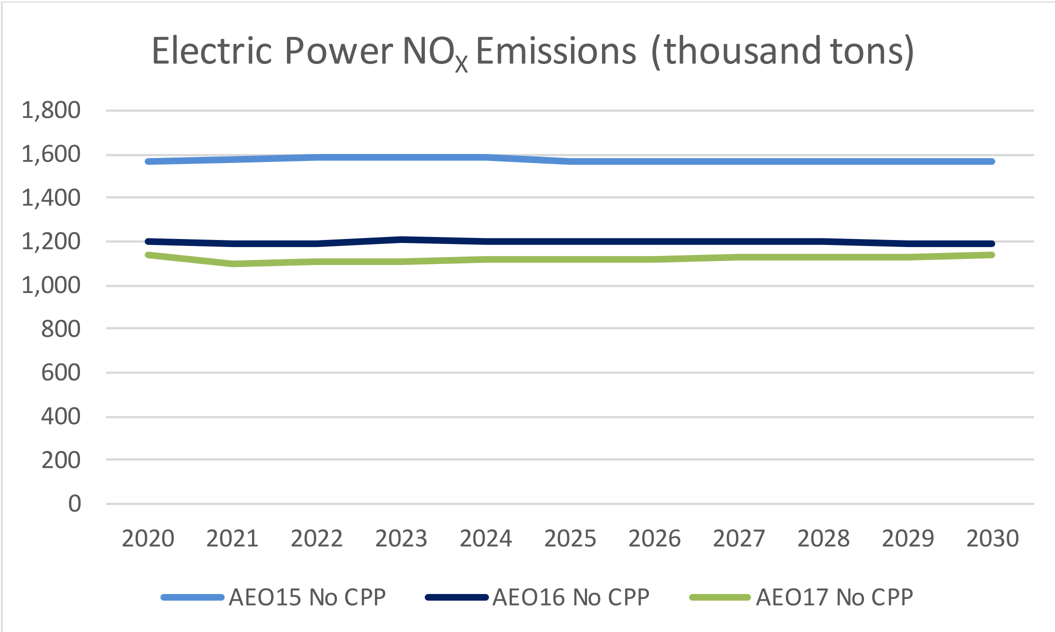

Figure 7-10. Electric Power Sector NO_X Emissions in Annual Energy Outlook Projections without the CPP (thousand short tons)

7.2.2. Trends in Projected Impacts of CPP (AEO2016 vs. AEO2017)

The most recent Annual Energy Outlook projections forecast less incremental new generating capacity to be built as a result of the CPP than was forecast in the previous AEO. Both AEO analyses assume CPP implemented using a mass-based approach including the new-source complement and regional trading. EIA's projection of additional new natural gas combined cycle (NGCC) generation capacity online in 2030 as a result of the CPP has decreased from an incremental 28 GW in the AEO2016 to an incremental 11 GW in the AEO2017, a 61 percent reduction (Figure 7-11). Additionally, EIA's projection of additional new renewable (RE) capacity online in 2030 as a result of the CPP has decreased from an incremental 39 GW in the AEO2016 to an incremental 32 GW in the AEO2017, an 18 percent reduction (Figure 7-12).

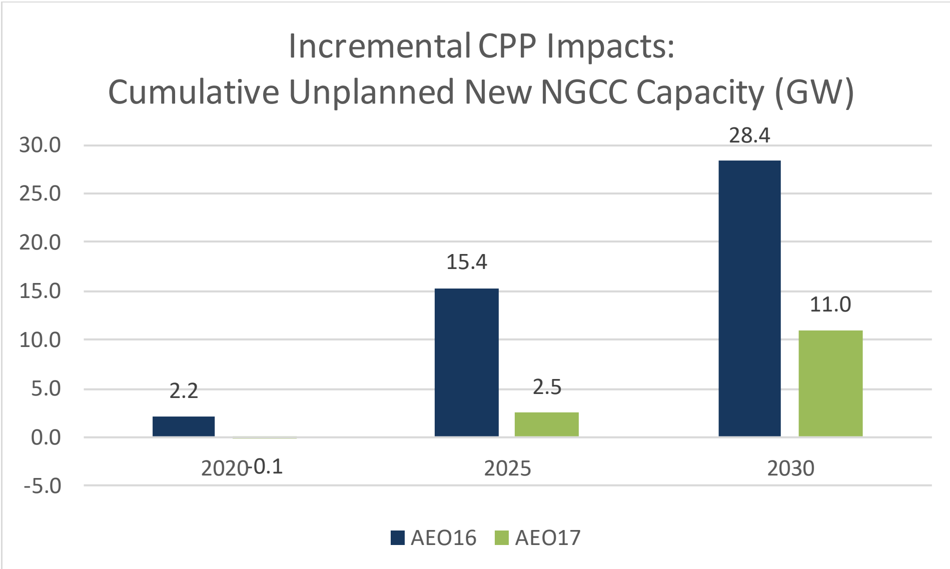

Figure 7-11. Incremental CPP Impacts in Annual Energy Outlook Projections: Cumulative Unplanned New Natural Gas Combined Cycle Capacity (GW)

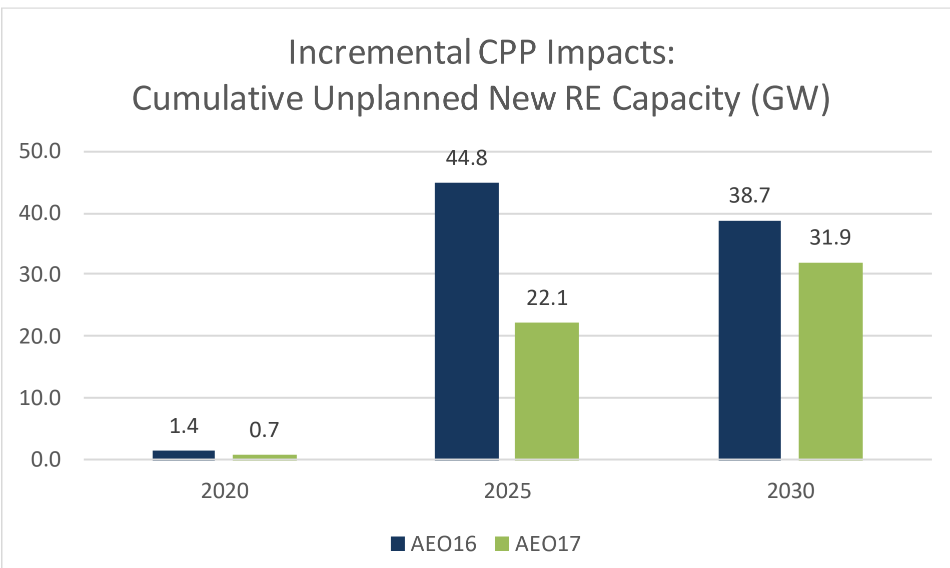

Figure 7-12. Incremental CPP Impacts in Annual Energy Outlook Projections: Cumulative Unplanned New Renewable Energy Capacity (GW)

Furthermore, relative to the previous Annual Energy Outlook, the most recent projections forecast a muted impact on the price of natural gas as a result of the CPP. EIA projected a $0.54/mcf increase in delivered natural gas prices in 2030 as a result of the CPP in the AEO2016, and a $0.22/mcf increase in delivered natural gas prices in 2030 as a result of the CPP in the AEO2017. This represents a 59 percent decrease in the projected impact of the CPP on delivered natural gas prices in 2030 (Figure 7-13).

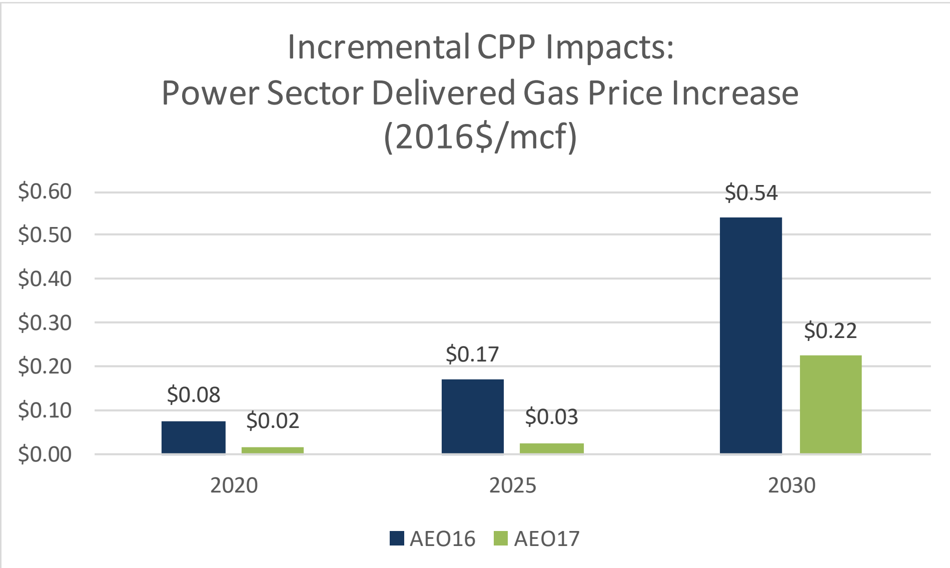

Figure 7-13. Incremental CPP Impacts in Annual Energy Outlook Projections: Power Sector Delivered Gas Price Increase (2016$/mcf)

Finally, the most recent Annual Energy Outlook projects that the CPP will have less of an impact on air emissions than was forecasted in the previous AEO. EIA projects over time that the CPP will result in fewer CO_2 emissions reductions. In the AEO2016, EIA projected a 422 million short ton CO_2 reduction due to the CPP in 2030. In the AEO2017, EIA projected a 385 million short ton CO_2 reduction due to the CPP in 2030, representing a 9 percent decrease in the projected impact when compared to AEO2016 projections (Figure 7-14). Similarly, EIA projected in the AEO2016 that the CPP would result in a 510 thousand short ton reduction of SO_2 in 2030, and in the AEO2017 projected that the CPP would result in a 423 thousand short ton reduction in SO_2 in 2030, representing a 17 percent decrease in the projected impact (Figure 7-15). EIA projections reflect a similar trend with NO_X emissions reductions: EIA projected in the AEO2016 that the CPP would result in a 282 thousand short ton reduction of NO_X in 2030, and in the AEO2017 projected that the CPP would result in a 261 thousand short ton reduction in NO_X in 2030, representing a 7 percent decrease in the projected impact (Figure 7-16).

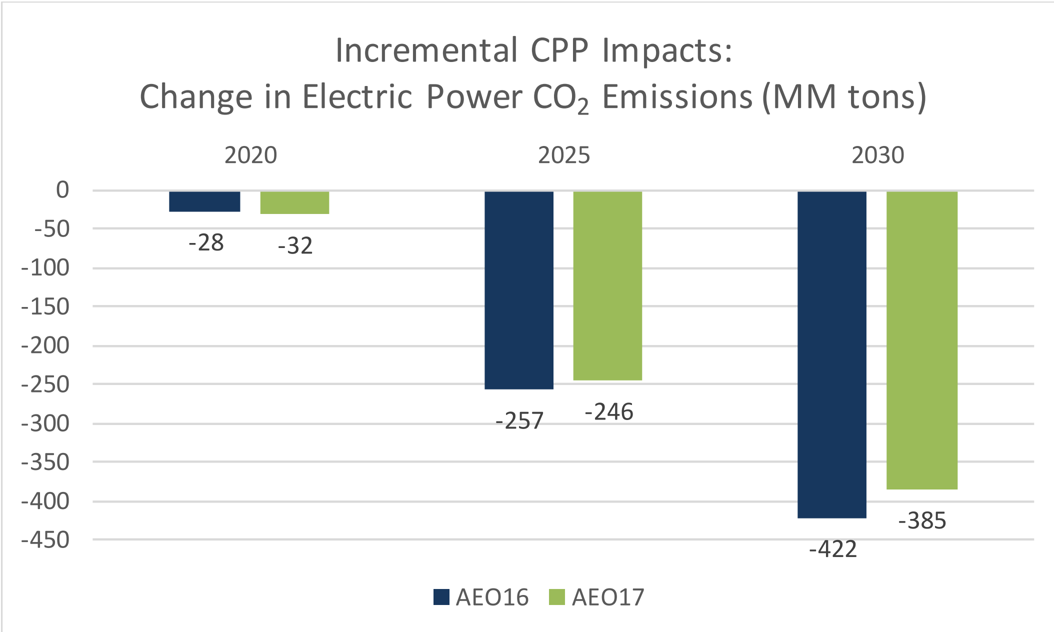

Figure 7-14. Incremental CPP Impacts in Annual Energy Outlook Projections: Electric Power Sector CO_2 Reductions (million short tons)

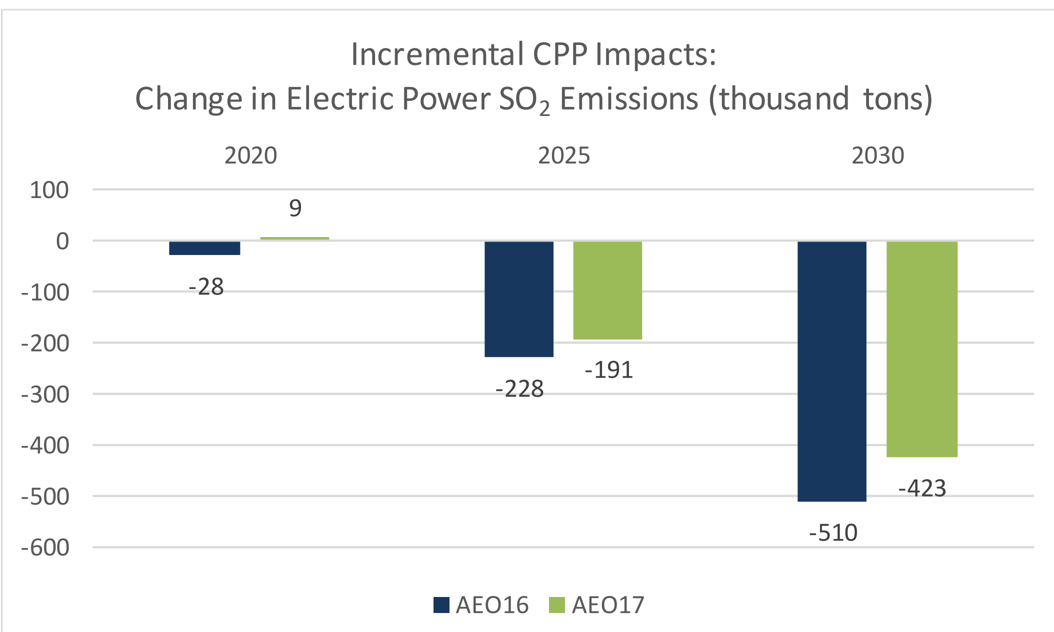

Figure 7-15. Incremental CPP Impacts in Annual Energy Outlook Projections: Electric Power Sector SO_2 Reductions (thousand short tons)

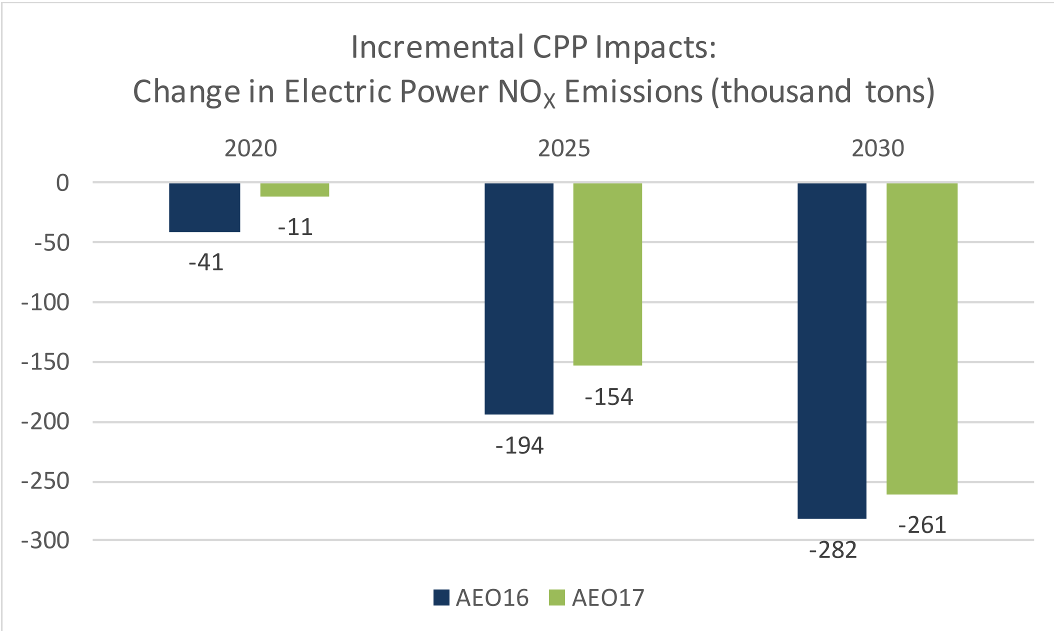

Figure 7-16. Incremental CPP Impacts in Annual Energy Outlook Projections: Electric Power Sector NO_X Reductions (thousand short tons)

7.2.3. Implications for Updating EPA's RIA Projections

These trends suggest that the projected cost of complying with the CPP would be lower than was estimated by EPA in 2015. This finding is based on several factors. One factor is construction of new lower-emitting generating capacity. Industry trends towards the construction of new renewable generating capacity have resulted in an increase in such capacity since 2015, as well as increased forecasts for the construction of such capacity in future years. The increase in renewable generating capacity suggests that less capacity of any type would need to be constructed specifically to facilitate compliance with the CPP, and thus the overall cost of the rule would be lower. The projections made in the Annual Energy Outlooks demonstrate that, relative to the AEO2015 Reference Case (No CPP), over 62 percent of the new renewable capacity projected to occur in the AEO2017 Reference (CPP) case are observed in the updated AEO2017 (No CPP) case (Figure 7-17).

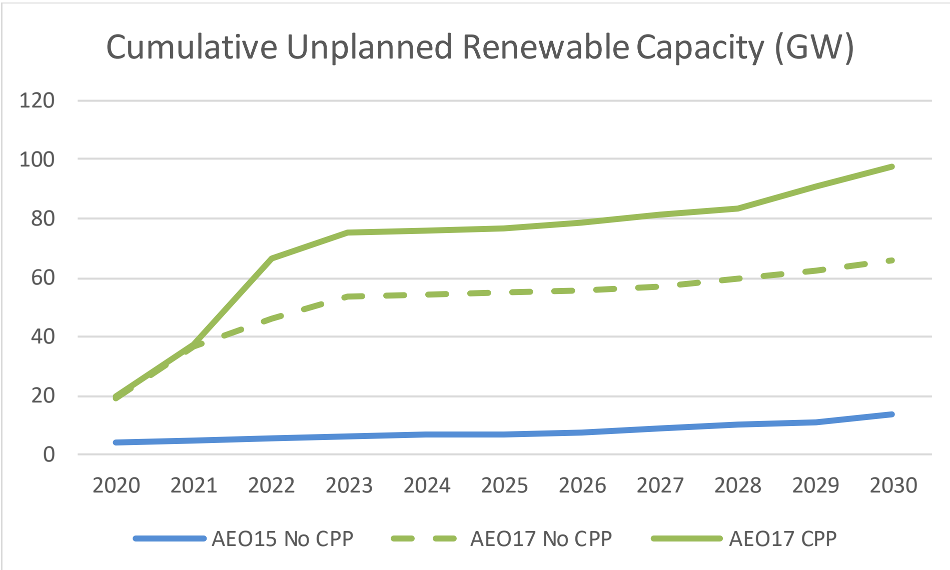

Figure 7-17. Cumulative Unplanned Renewable Capacity in Annual Energy Outlook Projections (GW)

Another factor is the delivered natural gas price for the electric power sector. The increasing supply and pipeline capacity have resulted in consistently lower delivered natural gas prices, which provide a relative economic advantage to lower-emitting NGCC generators relative to higher-emitting coal-fired generators. This factor contributes directly to coal-fired generation as discussed below. This factor also contributes indirectly to decreased CO_2 emissions in the absence of the CPP, as well as decreased costs to comply with the rule, all else equal.

Recent industry trends have resulted in a decrease in coal-fired generation from historical levels, as well lowering projections of future levels of coal-fired generation. In 2030, the AEO2017 (No CPP) case projects a 17 percent decrease in net generation from coal relative to the AEO2015 Reference (No CPP) case. This decrease in projected 2030 coal-fired generation (related solely to an updated economic outlook independent of CPP implementation) is more than 42 percent of the corresponding decrease in 2030 coal-fired generation projected to occur as a result of implementing the CPP (Figure 7-18).

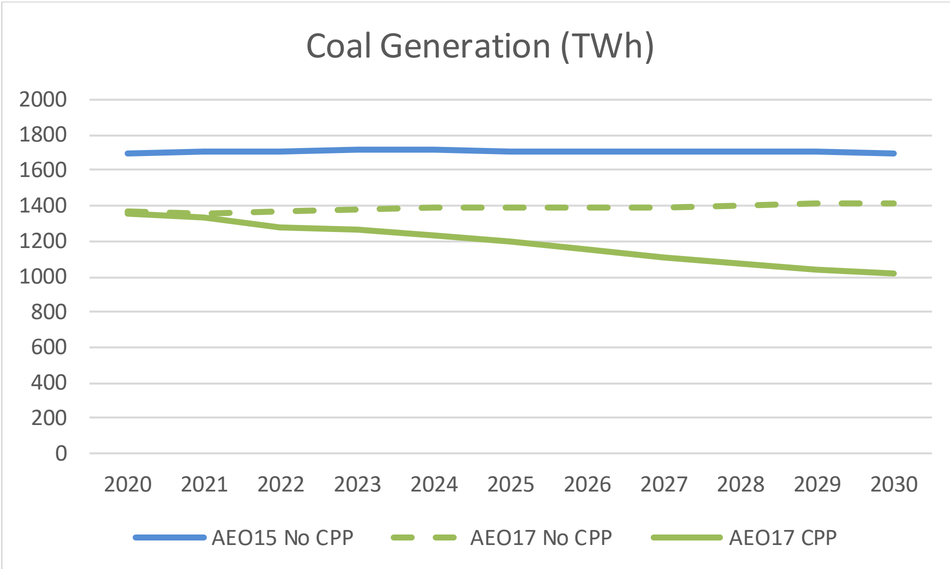

Figure 7-18. Coal Generation in Annual Energy Outlook Projections (Trillion kWh = TWh)

Together, these factors contribute to an expectation that updated EPA analysis would project fewer CO_2 emissions in the absence of the CPP than was projected in the 2015 RIA. It follows that, on average, compliance with CPP mass-based emissions targets would be less costly since fewer reductions would be required. The CO_2 emissions projections in the Annual Energy Outlooks demonstrate that, relative to the AEO2015 Reference (no CPP) case, 46 percent of the 2030 CO_2 emissions reductions projected to occur in the AEO2017 Reference (CPP) case are observed in the AEO2017 No CPP case (Figure 7-19); in other words, almost half of the CO_2 reductions AEO2015 projected the CPP to obtain are now projected to occur in AEO2017 without the CPP.

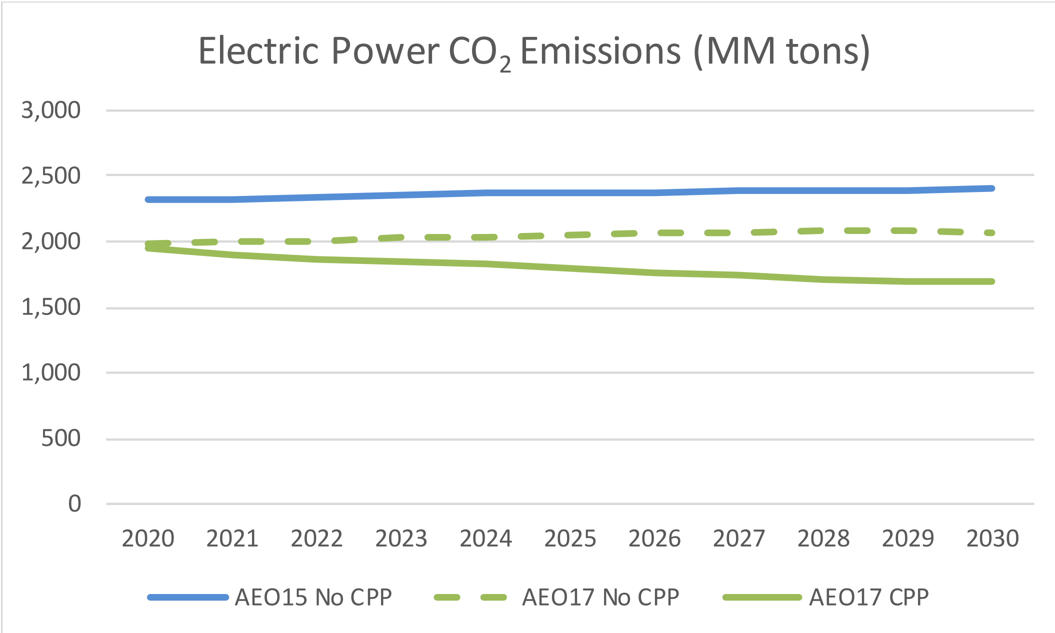

Figure 7-19. Electric Power Sector CO_2 Emissions in Annual Energy Outlook Projections (million short tons)

7.3. Avoided Compliance Costs using AEO2017

EPA obtained the AEO Report "Table 116, Total Resource Costs in the Electric Power Sector" from EIA to provide estimates of the change in electric power sector resource costs associated with implementing the CPP. EPA used outputs from the AEO Reference Case (CPP) and the AEO2017 No CPP Case. The total resource costs also include utility expenditures on demand-side energy efficiency. Resource costs in the tables below represent annual expenses and capital payments, where the capital payments are calculated as an investment recovered as an annual payment. Table 7-1 presents these cost differences between the two AEO2017 cases with and without the CPP for the analysis years of 2020, 2025, and 2030, respectively.

Table 7-1. Avoided Compliance Costs in 2020, 2025, and 2030 from Repealing CPP using the AEO2017 (billions 2011$)

	2020	2025	2030
Total Resource Costs in the Electric Power Sector [1,2]			
Installed Capacity	$0.1	$3.7	$5.4
Transmission	$0.0	$0.2	$0.3
Retrofits	$0.0	$0.0	$0.0
Fixed O&M Costs	-$0.2	-$0.3	-$0.9
Capital Additions	-$0.1	-$0.5	-$0.8
Non-Fuel Variable O&M	-$0.1	-$0.3	-$0.4
Fuel Expenses	-$0.4	-$4.3	-$4.5
Purchased Power	$0.0	$0.1	$0.4
Energy Efficiency Expenditures	$0.7	$17.5	$17.7
Total	**$0.0**	**$16.2**	**$17.1**
Change in residential investments[3]	**-$0.1**	**$1.0**	**$0.4**
Change in commercial investments[3]	**-$0.3**	**-$2.6**	**-$3.2**
Total[4]	**-$0.3**	**$14.5**	**$14.4**

Note: Sums may not total due to independent rounding. Dollar years adjusted from 2016 to 2011 using GDP-IPD.
[1] Resource costs in this table represent annual expenses and capital payments, where the capital payments are calculated as an investment recovered as an annual payment.
[2] The AEO2017 Reference Case (CPP) features a mass-based implementation of the CPP assuming states adopt the new-source complement.
[3] Represents change in building shell (residential only) and equipment investments net of utility rebates. Negative values represent instances where rebate levels exceed incremental capital costs.
[4] These avoided compliance costs are not directly comparable to the avoided compliance costs presented in Section 3.3 above due to differing accounting treatments of the reduction in power sector generating costs due to demand-side energy efficiency programs.

“Installed capacity”, “transmission”, and “retrofits” reflect capital-related expenses. The transmission costs reported only represent the additional electric transmission-related costs incurred to connect a new plant to the grid, not other costs related to investment in electric transmission system upgrades or new electric transmission lines. “Capital additions” track ongoing investments at existing plants, which are based on an assumed annual $/kW cost. “Fixed”, “non-fuel variable O&M”, and ‘fuel expenses’ reflect total annual costs based on model dispatch decisions. “Purchased power” represents costs to buy power from cogenerators, or net imports.

“Energy efficiency (EE) expenditures” represent costs the utilities incur for EE programs that are incremental to a baseline, so they primarily represent the additional EE costs spurred by the Clean Power Plan. As described in Section 7.7, AEO model energy efficiency policies as rebates for energy efficient technologies for commercial and residential energy consumers. For AEO2017, the EE costs also represent incremental EE in California to meet SB32 carbon reduction requirements. Therefore, the AEO2017 No CPP Case will also reflect EE costs, but only for California. Because these utility expenditures on demand-side energy efficiency would likely influence consumer investment decisions, EPA also obtained information from EIA on residential and building shell and residential and commercial sector equipment investments consistent with the two AEO2017 cases. These residential and commercial investment totals are net of utility rebates.

Using the AEO2017, the estimated avoided annual compliance costs in 2020, 2025, and 2030 would be approximately -$0.3 billion, $14.5 billion, and $14.4, billion, respectively, in 2011 dollars. It is important to note, however, that because of data limitations, the EPA was unable to estimate the value of reduced electricity demand from demand-side energy efficiency programs, as was presented in Section 5.3 above. Thus, these values are not directly comparable to the avoided compliance costs presented above that are derived from EPA's 2015 RIA.

7.4. Forgone Emissions Reductions using AEO2017

Table 7-2 shows forgone emission reductions from the proposed repeal of the CPP using the AEO2017 Reference Case with CPP and the AEO2017 No CPP Case without the CPP. Forgone CO_2 emission reductions are used to estimate the forgone climate benefits of repealing the CPP. SO_2, and NO_X reductions are relevant for estimating the forgone air quality health co-benefits of the repealing the CPP. Emissions changes in 2020 are smaller than in 2025 and 2030 as affected sources do not need to comply with the CPP until 2022. The 2020 changes are small in percentage terms.

Table 7-2. Forgone Emissions Reductions from Repealing CPP 2020, 2025, and 2030 using the AEO2017

	CO_2 (million short tons)	SO_2 (thousand short tons)	Annual NO_X (thousand short tons)
2020			
Reference Case (CPP)[1]	2,006	1,236	1,094
No CPP Case	2,023	1,227	1,105
Emissions Change	17	-9	10
2025			
Reference Case (CPP)[1]	1,828	1,112	940
No CPP Case	2,039	1,304	1,091
Emissions Change	210	191	150
2030			
Reference Case (CPP)[1]	1,694	934	854
No CPP Case	2,078	1,357	1,109
Emission Change	384	423	255

Source**:** AEO017. Emissions change may not sum due to rounding.
[1] The AEO2017 Reference Case (CPP) a mass-based implementation of the CPP assuming states adopt the new-source complement.

In 2030, according to the AEO2017, CO_2 emissions would have been reduced by 384 million short tons in 2030 according to the AEO2017 had the CPP been implemented. Meanwhile, Table 7-2 also shows forgone emission reductions for criteria air pollutants. Under this proposed action to repeal the CPP, SO_2 emissions are projected to about 423 thousand short tons higher than they would have been, and NO_X emissions about 255 thousand short tons higher than they would have been under the CPP, according to the AEO2017.

7.5. *Forgone Monetized Benefits using AEO2017*

7.5.1. Forgone Monetized Climate Benefits

Table 7-3 below presents the forgone domestic climate benefits in 2020, 2025, and 2030 based on the domestic interim SC-CO_2 estimates shown in Table 3-7 of the RIA and the above energy-related CO_2 emissions reductions attributable to the CPP in AEO2017 projections.

Table 7-3. Estimated Forgone Domestic Climate Benefits in 2020, 2025, and 2030, using the AEO2017 (billions of 2011$)*

Year	Million short tons of CO_2 reduced	Discount rate and statistic	
		3% (average)	7% (average)
2020	17	0.09	0.01
2025	210	1.27	0.21
2030	384	2.53	0.44

* The SC-CO_2 values are dollar-year and emissions-year specific. SC-CO_2 values represent only a partial accounting of domestic climate impacts.

7.5.2. Forgone Monetized Health Co-benefits

The EPA has evaluated the forgone monetized health co-benefits based on AEO2017 under three different models for quantifying the magnitude of the benefits at $PM_{2.5}$ concentration cutpoints, as discussed earlier. Tables 7-4 and 7-5 report the forgone $PM_{2.5}$ and ozone-related benefits for the years 2020, 2025 and 2030. We calculate $PM_{2.5}$-related forgone benefits using a log-linear concentration-response function that quantifies risk from the full range of $PM_{2.5}$ exposures (EPA, 2009; EPA, 2010; NRC, 2002); this approach to calculating and reporting the risk of $PM_{2.5}$-attributable premature death is consistent with recent RIA's (EPA 2009, 2010, 2011, 2012, 2013, 2014,2015, 2016).

Table 7-4. Estimated Forgone $PM_{2.5}$ and Ozone-Related Avoided Premature Mortality Estimates Incorporating Concentration Cutpoints

Year	Foregone Co-Benefits (Total $PM_{2.5}$)	Forgone Co-Benefits ($PM_{2.5}$ Benefits Fall to Zero Below LML[a])	Forgone Co-Benefits ($PM_{2.5}$ Co-Benefits Fall to Zero Below NAAQS[b])
2020	(61) to (30)	(27) to (25)	1 to 9
2025	820 to 1,900	760 to 1,100	67 to 230
2030	1,900 to 4,500	1,800 to 2,400	140 to 450

Notes: Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

[a] The estimates above were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al. 2012; LML = 8 $\mu g/m^3$).

[b] The estimates above were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$.

Table 7-5. Estimated Forgone $PM_{2.5}$ and Ozone-Related Health Co-benefits Incorporating Assumptions Regarding Concentration Cutpoints (billions of 2011$)

Year	Discount Rate	Foregone Co-Benefits (Total $PM_{2.5}$)	Forgone Co-Benefits ($PM_{2.5}$ Benefits Fall to Zero Below LML[a])	Forgone Co-Benefits ($PM_{2.5}$ Benefits Fall to Zero Below NAAQS[b])
2020	3%	($0.5) to ($0.3)	($0.2) to ($0.2)	$0.0 to $0.1
	7%	($0.5) to ($0.2)	($0.2) to ($0.2)	$0.0 to $0.1
2025	3%	$7.7 to $18.3	$7.2 to $10.2	$0.7 to $2.4
	7%	$7.0 to $16.7	$6.5 to $9.4	$0.7 to $2.3
2030	3%	$18.1 to $42.4	$16.8 to $23.3	$1.4 to $4.7
	7%	$16.4 to $38.5	$15.2 to $21.3	$1.4 to $4.6

Notes: Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone PM2.5 and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

[a] The estimates above were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al. 2012; LML = 8 $\mu g/m^3$).

[b] The estimates above were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$.

7.5.3. Total Forgone Benefits

The EPA has evaluated the range of potential forgone impacts reflecting the preceding cost and benefit information based on AEO2017 cases. Table 7-6 and Table 7-7 provide the total forgone benefits, comprised of forgone domestic climate benefits, and health co-benefits estimated for 3 percent and 7 percent discount rates. The tables differ according to the approach for quantifying $PM_{2.5}$-attributable health co-benefits at different cutpoints are quantified, as indicated in the table titles and notes. All dollar estimates are in 2011 dollars. Note that because of limitations of data available from AEO2017, demand-side energy efficiency benefits are not included in this estimate of total forgone benefits and, therefore, these results are not directly comparable to total forgone benefits presented above that are derived from EPA's 2015 RIA.

Table 7-6. Combined Estimates of Forgone Climate Benefits and Health Co-benefits, based on the 2017 Annual Energy Outlook (billions of 2011$)

Year	Discount Rate	Forgone Domestic Climate Benefits	Forgone Health Co-benefits	Total Forgone Benefits
2020	3%	$0.1	($0.5) to ($0.3)	($0.5) to ($0.2)
	7%	$0.0	($0.5) to ($0.2)	($0.5) to ($0.2)
2025	3%	$1.3	$7.7 to $18.3	$9.0 to $19.6
	7%	$0.2	$7.0 to $16.7	$7.2 to $16.9
2030	3%	$2.5	$18.1 to $42.4	$20.6 to $44.9
	7%	$0.4	$16.4 to $38.5	$16.8 to $39.0

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 7-7. Sensitivity Analysis Showing Potential Impact of Uncertainty at $PM_{2.5}$ Levels below the LML and NAAQS on Estimates of Health Co-Benefits, based on the 2017 Annual Energy Outlook (billions of 2011$)

		Forgone $PM_{2.5}$ Co-Benefits Fall to Zero Below LML [a]		Forgone $PM_{2.5}$ Co-Benefits Fall to Zero Below NAAQS (12 µg/m^3) [c]	
Year	Discount Rate	Forgone Health Co-Benefits [a]	Total Forgone Benefits [b]	Forgone Health Co-Benefits [c]	Total Forgone Benefits [b]
2020	3%	($0.2) to ($0.2)	($0.2) to ($0.1)	$0.0 to $0.1	$0.1 to $0.2
	7%	($0.2) to ($0.2)	($0.2) to ($0.2)	$0.0 to $0.1	$0.0 to $0.1
2025	3%	$7.2 to $10.2	$8.4 to $11.5	$0.7 to $2.4	$2.0 to $3.6
	7%	$6.5 to $9.4	$6.7 to $9.6	$0.7 to $2.3	$0.9 to $2.5
2030	3%	$16.8 to $23.3	$19.3 to $25.8	$1.4 to $4.7	$4.0 to $7.3
	7%	$15.2 to $21.3	$15.6 to $21.7	$1.4 to $4.6	$1.8 to $5.0

Notes: All forgone benefit estimates are rounded to one decimal point and may not sum due to independent rounding. The forgone climate benefit estimates in this summary table reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. Forgone health-related co-benefits are calculated using benefit-per-ton estimates corresponding to three regions of the U.S. Forgone ozone co-benefits occur in analysis year, so they are the same for all discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The monetized forgone health co-benefits do not include reduced health effects from reductions in directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

[a] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 µg/m^3; Lepeule et al. 2012; LML = 8 µg/m^3).

[b] Total forgone benefits is calculated by adding the total forgone targeted pollutant benefits and the forgone health co-benefits.
[c] Estimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Annual $PM_{2.5}$ NAAQS of 12 µg/m^3.

7.6. Net Benefits using AEO2017

In Table 7-8 we offer one perspective on the costs and benefits of this rule by presenting a comparison of the forgone benefits from the targeted pollutant – CO_2 – (the costs of this proposed rule) with the avoided compliance cost (the benefits of this proposed rule).[69] Excluded from this comparison are the forgone benefits from the SO_2 and NO_X emission reductions that were also projected to accompany the CO_2 reductions. However, had those SO_2 and NO_X reductions been achieved through other means, then they would have been represented in the baseline for this proposed repeal (as well as for the 2015 Final CPP), which would have affected the estimated costs and benefits of controlling CO_2 emissions alone.

Table 7-8. Avoided Compliance Costs, Forgone Domestic Climate Benefits, and Net Benefits of Repeal Associated with Targeted Pollutant, based on the 2017 Annual Energy Outlook (billions of 2011$)

Year	Discount Rate	Avoided Compliance Costs	Forgone Domestic Climate Benefits	Net Benefits Associated with Targeted Pollutant
2020	3%	($0.3)	$0.1	($0.4)
2020	7%		$0.0	($0.3)
2025	3%	$14.5	$1.3	$13.2
2025	7%		$0.2	$14.3
2030	3%	$14.4	$2.5	$11.9
2030	7%		$0.4	$14.0

Note: Estimates are rounded to one decimal point and may not sum due to independent rounding. Due to data limitations of AEO2017, these estimates of forgone benefits and avoided compliance costs are not directly comparable to results presented above and derived from EPA's 2015 RIA because of differing accounting treatments of the reduction in power sector generating costs due to demand-side energy efficiency.

When considering whether a regulatory action is a potential welfare improvement (i.e., potential Pareto improvement) it is necessary to consider all impacts of the action. Therefore, Tables 7-9 through 7-11 provide the estimates of the forgone benefits, avoided compliance costs

[69] The forgone benefits estimate also includes the benefits due to demand side energy efficiency programs forecast as a result of the rule.

and net benefits of the CPP in 2020, reflecting the preceding cost and benefit information based on AEO2017 and inclusive of the forgone benefits from the SO_2 and NO_X emission reductions that were also projected to accompany the CO_2 reductions. Note that in reporting the benefits, costs, and net benefits of this proposed action in the rows of Tables 7-9 through 7-11, like we did in Section 4, we modify the relevant terminology to be more consistent with traditional net benefits analysis. In these rows, we refer to the avoided compliance costs discussed elsewhere in this RIA as the "benefits" of the rule and the forgone benefits of the rule discussed elsewhere in the RIA as the "costs" of the rule. Net benefits, then, equals the benefits minus the costs (or, in the terminology applied elsewhere in the RIA, the avoided compliance costs minus the foregone benefits).

There are additional important forgone benefits that the EPA could not monetize. Due to current data and modeling limitations, our estimates of the forgone benefits from reducing CO_2 emissions do not include important impacts like ocean acidification or potential tipping points in natural or managed ecosystems. Unquantified forgone benefits also include climate benefits from reducing emissions of non-CO_2 greenhouse gases and forgone co-benefits from reducing exposure to SO_2, NO_X, and hazardous air pollutants (e.g., mercury), as well as ecosystem effects and visibility impairment. In addition, due to data limitations of AEO2017, these estimates of forgone benefits and avoided compliance costs are not directly comparable to results presented above and derived from EPA's 2015 RIA because of differing accounting treatments of the reduction in power sector generating costs due to demand-side energy efficiency.

Table 7-9. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, based on the 2017 Annual Energy Outlook (billions of 2011$) [a]

	Discount Rate		
	3%		7%
2020			
Cost: Forgone Benefits [b]	($0.5) to ($0.2)		($0.5) to ($0.2)
Benefit: Avoided Compliance Costs		($0.3)	
Net Benefits	($0.2) to $0.1		($0.1) to $0.1
2025			
Cost: Forgone Benefits [b]	$9.0 to $19.6		$7.2 to $16.9
Benefit: Avoided Compliance Costs		$14.5	
Net Benefits	($5.0) to $5.5		($2.3) to $7.3
2030			
Cost: Forgone Benefits [b]	$20.6 to $44.9		$16.8 to $39.0
Benefit: Avoided Compliance Costs		$14.4	
Net Benefits	($30.6) to ($6.3)		($24.6) to ($2.5)
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)		
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits of reductions in ambient NO_2 and SO_2 exposure Health benefits of reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)		

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 7-10. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, based on the 2017 Annual Energy Outlook, assuming that Forgone $PM_{2.5}$ Related Benefits Fall to Zero Below the Lowest Measured Level of Each Long-Term $PM_{2.5}$ Mortality Study (billions of 2011$) [a]

	Discount Rate	
	3%	**7%**
2020		
Cost: Forgone Benefits [b]	($0.2) to ($0.1)	($0.2) to ($0.2)
Benefit: Avoided Compliance Costs	($0.3)	($0.3)
Net Benefits	($0.2) to ($0.2)	($0.2) to ($0.1)
2025		
Cost: Forgone Benefits [b]	$8.4 to $11.5	$6.7 to $9.6
Benefit: Avoided Compliance Costs	$14.5	$14.5
Net Benefits	$3.1 to $6.1	$5.0 to $7.8
2030		
Cost: Forgone Benefits [b]	$19.3 to $25.8	$15.6 to $21.7
Benefit: Avoided Compliance Costs	$14.4	$14.4
Net Benefits	($11.4) to ($4.9)	($7.3) to ($1.3)
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)	
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits of reductions in ambient NO_2 and SO_2 exposure Health benefits of reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)	

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. These estimates of forgone $PM_{2.5}$ co-benefits assume that the risk of PM-related premature death falls to zero at or below the lowest measured levels of the Krewski et al. (2009) and Lepeule et al. (2012) long-term epidemiological studies (5.8 µg/m^3 and 8 µg/m^3, respectively). Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

Table 7-11. Monetized Forgone Benefits, Avoided Compliance Costs, and Net Benefits, based on the 2017 Annual Energy Outlook, assuming that Forgone $PM_{2.5}$ Related Benefits Fall to Zero Below the $PM_{2.5}$ National Ambient Air Quality Standard (billions of 2011$) [a]

	Discount Rate	
	3%	**7%**
2020		
Cost: Forgone Benefits [b]	$0.1 to $0.2	$0.0 to $0.1
Benefit: Avoided Compliance Costs	($0.3)	
Net Benefits	($0.5) to ($0.5)	($0.5) to ($0.4)
2025		
Cost: Forgone Benefits [b]	$2.0 to $3.6	$0.9 to $2.5
Benefit: Avoided Compliance Costs	$14.5	
Net Benefits	$10.9 to $12.6	$12.0 to $13.7
2030		
Cost: Forgone Benefits [b]	$4.0 to $7.3	$1.8 to $5.0
Benefit: Avoided Compliance Costs	$14.4	
Net Benefits	$7.1 to $10.4	$9.4 to $12.6
Avoided Non-Monetized Costs	Costs due to interactions with pre-existing market distortions outside the regulated sector Development of acceptable state plans and EPA approvals, including work with public utility commissions, state legislatures, and state environmental departments and agencies Negative externalities associated with producing the substitute fuels (e.g., methane leakage from natural gas extraction and processing)	
Forgone Non-Monetized Benefits	Non-monetized climate benefits Health benefits of reductions in ambient NO_2 and SO_2 exposure Health benefits of reductions in mercury deposition Ecosystem benefits associated with reductions in emissions of NO_X, SO_2, PM, and mercury Reduced visibility impairment Negative externalities associated with producing the substitute fuels (e.g., methane emissions from coal production)	

[a] All estimates are rounded to one decimal point, so figures may not sum due to independent rounding.
[b] The forgone benefits are comprised of forgone domestic climate benefits, forgone demand-side energy efficiency benefits, and forgone health co-benefits. The forgone climate benefit estimates reflect domestic impacts from CO_2 emission changes and do not account for changes in non-CO_2 GHG emissions. The SC-CO_2 estimates are year-specific and increase over time. These estimates of forgone $PM_{2.5}$ co-benefits assume that the risk of PM-related premature death falls to zero at or below the Annual PM NAAQS (12 µg/m_3). Forgone co-benefits were calculated using a benefit-per-ton estimate corresponding to each of three regions of the U.S. Forgone ozone co-benefits are modeled to occur in analysis year and so are constant across discount rates. The forgone health co-benefits reflect the sum of the forgone $PM_{2.5}$ and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The forgone monetized health co-benefits do not account for forgone emissions of directly emitted $PM_{2.5}$, direct exposure to NO_X, SO_2, and hazardous air pollutants; ecosystem effects; or visibility impairment. See Section 5 and the Appendix of this RIA for more information about these estimates and for more information regarding the uncertainty in these estimates.

7.7. Observations on the Role of Energy Efficiency using AEO 2015 through 2017

EIA has analyzed the impact of the CPP since 2015. The 2015 analysis included sensitivity cases on the effects of energy efficiency levels on the impacts of the proposed rule. AEO2016 and AEO2017 incorporate the final CPP into the Reference case and include side cases without the CPP requirements. The 2016 and 2017 analyses reflect the significant changes that have occurred in the energy sector since EPA's analysis of the final CPP in 2015 including the impact of those changes on the role of energy efficiency in CPP compliance. The following sections present results from the 2015, 2016, and 2017 EIA analyses to provide information on the sensitivity of CPP results to energy efficiency levels and to provide an up-to-date analysis of the role of energy efficiency in CPP compliance.

7.7.1. Sensitivity of Impacts of Proposed CPP to Energy Efficiency Levels (AEO2015)

In EIA's May 2015 analysis of the proposed CPP, EIA conducted two sensitivity cases ("Policy with No EE" and "Policy with High EE") addressing the effects of varying levels of energy efficiency used for compliance. These cases were in addition to their "Base Policy" case which included energy efficiency at a level between the two sensitivity cases. Together with the AEO2015 Reference and Base CPP cases, the results provide information about the effects of varying levels of energy efficiency penetration on CPP compliance. The following sections summarize EIA's methodology and present results from these cases.

7.7.1.1. EIA Methodology for Representing Energy Efficiency in CPP

To provide for energy efficiency as a compliance option under the proposed CPP, EIA developed prototypical portfolios of energy efficiency program measures to represent and distribute energy efficiency program spending in the National Energy Modeling System's (NEMS) Residential and Commercial Demand Modules.[70] Subsidies, in the form of direct rebates, were used to decrease the installed capital cost of select energy-efficient equipment. Providing subsidies in the form of rebates for more energy-efficient equipment is one important strategy used by administrators of energy efficiency programs. Subsidized end uses included

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[70] See pp. 40-41 and Appendix F, pp. 85-86, of "Analysis of the Impacts of Clean Power Plan" (May 2015) for discussion of EIA's methodology. Available at https://www.eia.gov/analysis/requests/powerplants/cleanplan/.

space heating, space cooling, water heating, commercial ventilation, lighting, refrigeration, and residential building envelopes. EIA assumed that energy efficiency portfolios varied by Census division in terms of end-use categories addressed, timing (implementation starting in either 2017, 2020, or 2025), and level of end-use subsidies (ranging from 10 percent to 15 percent of installed capital cost in the Base CPP case and 25 percent in the "Policy with High EE" case).

For the analysis, EIA calculated utility expenditures as the total cost of all equipment rebates plus additional utility program costs (adding 50 percent to the total cost of equipment rebates). The additional utility program costs (but not the 50 percent adder) are reflected as a cost reduction for consumers in the residential and commercial sectors. Within NEMS, the Residential Demand Module and the Commercial Demand Module provided the Electricity Market Module with incremental energy efficiency program savings and costs by sector, Census division, and year for use in the regional compliance calculations and inclusion in electricity rates.

7.7.1.2. Results from Energy Efficiency Sensitivity Cases (EIA's 2015 Analysis of CPP)

Table 7-12 summarizes the national (continental U.S.) demand reduction impacts (billion kWh and percentage reductions relative to the AEO2015 Reference case) of the CPP under three different levels of energy efficiency represented by the Policy with No EE (No EE), Base CPP (CPP), and Policy with High EE (High EE) cases. Reductions in electricity use are 1.0 percent, 2.3 percent, and 3.8 percent in 2030 relative to the Reference case in the No EE, CPP, and High EE cases, respectively. The demand reduction in the No EE case (0.7 percent in 2020, 1.7 percent in 2025, and 1.0 percent 2030) represents only the effect of higher prices under the CPP in a scenario where additional energy efficiency is not incented through rebates for select higher efficiency equipment. The CPP and High EE cases represent scenarios where rebates of 15 to 20 percent and 25 percent, respectively, are provided for select higher efficiency equipment, resulting in increasing levels of electricity savings as rebates offered are increased.

Table 7-12 Impacts on Electricity Demand under Energy Efficiency Sensitivity Cases – EIA Analysis of Proposed CPP, May 2015 (Incremental Changes from Reference Case) [1]

		2020	2025	2030
Policy with No EE (No EE)	billion kWh	-27.4	-73.5	-46.5
	% change	-0.7%	-1.7%	-1.0%
Base Policy (CPP)	billion kWh	-40.2	-106.1	-101.4

	% change	-1.0%	-2.5%	-2.3%
Policy with High EE (High EE)	billion kWh	-53.4	-158.6	-170.0
	% change	-1.3%	-3.7%	-3.8%

Source: Data browser for EIA's "Analysis of the Impacts of the Clean Power Plan" (May 2015). Available at: https://www.eia.gov/analysis/requests/powerplants/cleanplan/

[1] The impacts of energy efficiency measures on electricity demand are reflected in EIA's "electricity use" values. These values are used in this table.

The varying levels of energy efficiency penetration represented by the three policy cases affect the impacts of the CPP on costs. Table 7-13 summarizes these impacts at the national level using the incremental cumulative net present value of select costs for 2020 and 2030. Generation costs are summarized in four categories: new capacity, retrofits, non-fuel operating costs and fuel costs. Energy efficiency costs are divided into utility and consumer costs. At increasing levels of energy efficiency generation costs decline and energy efficiency costs increase. The incremental cumulative net present value of generation costs through 2030 decrease from $99 billion to $80 billion between the No EE to CPP cases, and declines further to $57 billion in the High EE case. The incremental cumulative net present value of energy efficiency costs through 2030 increase from zero to $23 billion between the No EE to CPP cases, and increases further to $53 billion in the High EE case. As levels of energy efficiency increase, the energy efficiency costs increase slightly more than the generation costs decrease, resulting in an increase in total costs. The incremental cumulative net present value of total costs through 2030 increase from $99 billion to $103 billion between the No EE to CPP cases, and increases further to $110 billion in the High EE case. Relative to the CPP case, the No EE case reduces total costs from $103 billion to $99 billion, a 4 percent reduction. Relative to the CPP case, the High EE case increases costs from $103 billion to $110 billion, a 7 percent increase. EIA characterizes the role energy efficiency plays (within the analysis framework of their study) as "important yet limited" in CPP compliance.[71]

[71] P. 69, EIA's "Analysis of the Impacts of the Clean Power Plan" (May 2015). Available at: https://www.eia.gov/analysis/requests/powerplants/cleanplan/

Table 7-13. Incremental Cumulative Net Present Value of Selected Costs (billion 2013$), 2014-2030 Relative to AEO2015 Reference Case – EIA Analysis of Proposed CPP (Incremental Changes from Reference Case)

	CPP with No EE		CPP		CPP with High EE	
	2020	**2030**	**2020**	**2030**	**2020**	**2030**
New Capacity	9	131	5	110	4	97
Retrofits	0	6	0	7	0	7
Non-fuel Operating Costs	-3	-6	-4	-9	-5	-12
Fuel Costs	4	-32	7	-28	7	-35
Sub-total - Generation	**10**	**99**	**8**	**80**	**6**	**57**
EE Costs – Utilities	0	0	2	21	8	62
EE Costs – Consumers	0	0	0	2	-1	-9
Sub-total – EE	**0**	**0**	**2**	**23**	**7**	**53**
Total Costs	**10**	**99**	**10**	**103**	**13**	**110**

Source: Table 20, EIA's "Analysis of the Impacts of the Clean Power Plan" (May 2015). Available at: https://www.eia.gov/analysis/requests/powerplants/cleanplan/
Note: NPV calculations using 8 percent discount rate

7.7.2. Updated Analysis of the Final CPP (AEO2016 and AEO2017)

AEO2016 and AEO2017 provide updated analysis of the impacts of the CPP that reflect the significant changes that have occurred in the energy sector since EPA's analysis of the final CPP in 2015. The role of energy efficiency in compliance with the CPP is affected by changes in numerous generation- and fuel-related factors that have occurred in the past two years including: new renewable generation capacity, delivered prices of natural gas, changes in coal capacity, and CO_2 emissions from affected sources. In addition to these factors, there have also been changes in electricity consuming equipment in homes, buildings, and industry that affect the opportunities for increased implementation of energy efficiency measures. Changes in both the generation- and fuel-related factors as well as the end-use of electricity and other fuels have an impact on the economics of energy efficiency investments and their use as a CPP compliance mechanism.

In addition to reflecting changes in the U.S. energy sector, AEO2017 also incorporate recent changes in how the effects of ongoing utility energy efficiency programs are accounted for in NEMS. These "baseline" impacts are now explicitly represented in a manner similar to the representation of incremental energy efficiency programs as an option for compliance with CPP as discussed above.

Table 7-14 summarizes the impacts of the CPP on electricity demand as reflected in AEO2016 and AEO2017. Electricity demand declines by 0.1 percent, 0.9 percent, and 2.2 percent in 2020, 2025, and 2030, respectively, due to CPP in AEO2016. Electricity demand declines by 0.4 percent, 2.3 percent, and 3.5 percent in 2020, 2025, and 2030, respectively, due to CPP in AEO2017. The contribution of energy efficiency to compliance with CPP changes between AEO2016 and AEO2017 and reflect changes in both electricity generation and use in the U.S. energy sector as modeled in AEO.

Table 7-14. Impacts on Electricity Demand of CPP – AEO2016 and AEO2017 (Incremental Changes from No CPP Case to Reference Case with Final CPP)

		Incremental Change in Electricity Demand [1] (No CPP Case to Reference Case with Final CPP)		
		2020	**2025**	**2030**
AEO2016	billion kWh	-5.1	-38.0	-98.8
	% change	-0.1%	-0.9%	-2.2%
AEO2017	billion kWh	-15.4	-98.8	-152.6
	% change	-0.4%	-2.3%	-3.5%

Source: Data browser for EIA's Annual Energy Outlook 2016 and 2017. Available at: https://www.eia.gov/outlooks/aeo/data/browser/
[1] The impacts of energy efficiency measures on electricity demand are reflected in EIA's "electricity use" values. These values used in this table.

Table 7-15 provides a summary of the cost of CPP compliance as reflected in AEO2016 and AEO2017, highlighting changes in energy efficiency expenditures (by utilities and consumers) and power system costs. For each AEO vintage, the costs of CPP compliance are affected by the level of incremental change in electricity demand as presented above. As the level of energy efficiency used for compliance increases from AEO2016 to AEO2017, the incremental power system costs decline and incremental utility energy efficiency expenditures increase. For example, the change in power system costs due to the CPP decline between AEO2016 and AEO2017 from $7.7 billion to -$0.7 billion in 2030 while the change in utility energy efficiency expenditures due to the CPP increase from $6.9 billion to $19.1 billion. The decline in power system costs at higher levels of energy efficiency-driven demand reduction reflect changes in both variable costs, such as fuel and variable O&M, as well as fixed costs such as costs for new generation and transmission, and fixed O&M. The total incremental costs of CPP compliance in 2030 increase from AEO2016 to AEO2017 from $14.1 billion to $15.5 billion, respectively.

Table 7-15. Impacts of Energy Efficiency on Cost of CPP – AEO2016 and AEO2017 (Incremental Changes from No CPP Case to Reference Case with Final CPP)

	Incremental Cost of CPP Compliance (billions 2016$)					
	AEO2016			AEO2017		
	2020	**2025**	**2030**	**2020**	**2025**	**2030**
Total Resource Costs in the Electric Power Sector [1]						
Power System Costs [2]	$0.5	$6.0	$7.7	-$0.8	-$1.4	-$0.7
Energy Efficiency Expenditures - Utility	$0.0	$5.5	$6.9	$0.8	$18.8	$19.1
Sub-Total	**$0.5**	**$11.5**	**$14.6**	**$0.0**	**$17.4**	**$18.5**
Total Energy Efficiency Expenditures - Consumer[3]						
Change in residential investments	$0.3	$1.0	$0.1	-$0.1	$1.1	$0.4
Change in commercial investments	$0.0	-$0.6	-$0.6	-$0.3	-$2.8	-$3.4
Sub-Total	**$0.2**	**$0.4**	**-$0.5**	**-$0.4**	**-$1.8**	**-$3.0**
Total	**$0.7**	**$11.9**	**$14.1**	**-$0.4**	**$15.7**	**$15.5**

Note: Sums may not total due to independent rounding.

Source: Annual Energy Outlook 2016 and 2017, NEMS output Tables: 116 and "Residential and Commercial Investments."

[1] Resource costs in this table represent annual expenses and capital payments, where the capital payments are calculated as an investment recovered as an annual payment.

[2] Includes installed capacity, transmission, retrofits, fixed O&M, capital additions, non-fuel variable O&M, fuel, and purchased power.

[3] Includes residential and consumer investments. Represents change in building shell (residential only) and equipment investments net of utility rebates. Negative values represent instances where rebate levels exceed incremental capital costs.

8. Alternative Impact Estimates from Recent Studies by Non-Governmental Institutions

In the 2015 Final CPP RIA the EPA analyzed the benefits, costs and impacts of two illustrative implementation scenarios of the CPP, a mass-based and rate-based implementation. The EPA did not analyze how the benefits, costs and impacts of these implementation scenarios vary with different assumptions about the future uncertain economic conditions, such as the availability of natural gas, the level of energy efficiency adopted, and demand growth. Furthermore, as discussed in Section 5.1 and 7.2 of this RIA, recent analyses demonstrate that the expected market conditions influence estimates of the benefits, costs and impacts of the CPP.

To gain insight into how differences in CPP implementation and future economic and technological conditions may affect the cost of the CPP, for this RIA EPA reviewed non-governmental studies of the CPP. We focused our review on studies that provide national estimates of the rule's cost and impacts and were conducted since May, 2016, when EIA published its Early Release of the AEO2016, and therefore may incorporate and be interpreted within the context of updated information about baseline economic conditions from EIA. The studies identified to meet these criteria have not necessarily been subjected to peer review and certain specifics of the analysis are unclear due to limited documentation.[72] These studies analyzed different methods of implementation of the CPP, including the mix of states adopting mass-based or rate-based programs and multiple ways to address leakage (as defined in the final CPP). Scenarios with and without CPP were analyzed over various economic conditions including a range of possible future gas supply, electricity demand growth, renewable costs, and the cost and availability of energy efficiency. The various scenarios analyzed in each study are summarized below.

EPA is not basing any of its conclusions regarding the potential avoided cost and forgone benefits of repealing the CPP on these studies. Additionally, EPA does not consider these studies to represent a reasonable range of potential avoided costs and forgone benefits. However, within each study and across the studies, EPA observes that they forecast a range of costs and potential

[72] Two of these studies use a commercial version of IPM, which is not the version that EPA uses for its regulatory analysis.

benefits of the CPP given various assumptions about the way CPP would be implemented and possible economic conditions, and that these ranges are quite large. Therefore, these studies suggest that, had EPA analyzed a range of economic conditions and implementation assumptions, EPA would likely have projected a meaningful range of potential avoided costs and forgone benefits of this proposed rule.

Table 8-1 reports the range of cost of the CPP as reported in these studies and, when available, the forecast reduction in CO_2 emissions from the electricity sector. Changes in the level of pollutants other than CO_2 are generally not reported in these studies. Furthermore, none of the studies estimate the benefits of CO_2 reductions. The range of costs reflects the two scenarios analyzed with the highest and lowest cost from the study for those scenarios with reported cost data. For each study along the range, the scenarios are all measured from a consistent baseline, with the possibility that low-cost EE may only be adopted in the scenario with CPP but not in the baseline (i.e., without CPP). The range of CO_2 reductions does not necessarily correspond with the scenarios with the lowest and highest cost.

Table 8-1. Non-Peer Reviewed Analyses of Clean Power Plan Since May, 2016.

	Publication Date	Range of National Cost of the CPP (Billion $)[a]	Format of Reported Cost	National CO_2 Reduction (Million Short Tons)
Bipartisan Policy Center	June, 2016	$0 to $9[b]	Annualized cost from 2022 to 2032	Not reported with precision. See text for further details.
M.J. Bradley and Associates	June, 2016	$-1.8 to $1.7; $-4.3 to $2.0; $-2.8 to $3.7 (2012$)	Annual cost for 2020, 2025 and 2030.	-3 to 119 in 2020; 15 to 231 in 2025; 57 to 330 in 2030
Duke Nicholas School (Ross et al.)	July, 2016	$1.9 to $15.4	Present discounted value of total costs from 2020 to 2040	Not reported with precision. See text for further details.

[a] The dollar year for reported costs is not identified in the Bipartisan Policy Center and Duke Nicholas School studies.
[b] The reported costs are from EPA's read to the nearest $1 billion from graphs provided in this study.

The accounting of costs in these studies is similar to the one used in the 2015 Final CPP RIA, in that they include the net increase in the capital cost of new generating technologies, fuel costs, fixed and variable operating and maintenance (O&M) costs, and the cost of energy efficiency programs, including both the program and participant costs.[73] These studies report costs over different time periods, however. Some of them report the present discounted value costs over a range of years, while another reports the annual change in costs for three different analyses years (similar to EPA's approach in the 2015 final CPP RIA). The EPA was unable to convert these cost estimates into similar formats since the studies do not provide all of the requisite information that would be necessary (e.g., discount rate).

The studies also do not provide the necessary information for the EPA to adjust these cost in order to account for consumers' energy efficiency savings as a benefit, rather than as a reduction in the cost of producing and delivering electricity from CPP. The range of costs does suggest a broad distribution. Often, each of the studies evaluated combinations of implementation and cost scenarios. For each of the studies the costs were generally concentrated at the lower end of the range reported in Table 8-1.

These studies differ in their central assumptions in baseline economic and regulatory conditions. The reader is referred to these studies for a fuller explanation of the scenarios analyzed, their modeling assumptions, and reported results. The June 2016 Bipartisan Policy Center (BPC) study includes four different baseline scenarios with fourteen different implementation scenarios, with sensitivities over natural gas costs and the level of energy efficiency adopted in the baseline and policy cases for certain implementation scenarios.[74] The costs are only reported for a few scenarios, and the range of costs reported in Table 8-1 are from those scenarios where costs were reported. Furthermore, BPC reports the cost of these scenarios in histograms incremented in billions of dollars, and the precise cost estimates (to the $100 million) were not published with the study. The costs reported in Table 8-1 are from EPA's read

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[73] EPA refers to the sum of the costs to produce electricity as "system costs". Also, like the EPA, these costs only include real social resources and not significant transfers, such as the value of allowances under mass-based programs. For example, the market value of allowances from mass-based implementation approaches is not an accounting of the use of real resources in the economy, and is instead a transfer. The distribution of the allowance value may affect economic behavior, and that effect on behavior is captured in some of these studies. However, the system costs do include the value of producer taxes which are also a transfer and are not adjusted for producer subsidies.

[74] Macedonia, Jennifer, Blair Beasley, and Erin Smith. 2016. *Modeling the Evolving Power Sector and Impacts of the Final Clean Power Plan.* Bipartisan Policy Center. https://bipartisanpolicy.org/library/clean-power-plan-analysis/ . Accessed September 21, 2017.

of these histograms to the nearest $1 billion. BPC (2016) reports CO_2 emissions over time for various scenarios in line graphs which do not allow EPA to summarize annual or cumulative reductions in CO_2 with precision.

The study by Michael J. Bradley and Associates analyzed two different baseline scenarios with differing levels of assumed energy efficiency beyond AEO2015 levels, with each accounting for the investment tax credit (ITC) and production tax credits (PTC) for new renewable technologies.[75] The study analyzed eight different implementation scenarios, and the change in costs and emissions from each baseline for each implementation scenario can be calculated for each implementation scenario and baseline pair. The range of costs and CO_2 changes for each reported model year is determined separately based on the scenario and baseline pair that has the highest and lowest annual cost in that model year. Therefore, in each year, the range of costs and emission reductions may reflect different baselines and implementation scenarios.

The study by Nicholas Institute at Duke University analyzed five different implementation scenarios and for each evaluated their costs and impacts assuming different levels of natural gas supply, renewable cost, electricity demand growth, and availability of energy efficiency.[76] The study also evaluated additional implementation scenarios with a mix of rate and mass-based implementation by the states using the central economic and technological assumptions. For most scenarios the study reports the cost of the rule only as a percentage change from baseline system costs, and the baseline system costs for the different economic baselines are not reported. However, the absolute change in cost is reported for some scenarios and the range of costs a provided are reported in Table 8-1. The national percentage range in the increase from baseline system costs varies from zero percent to 3.6 percent (with percentage increases concentrated at the lower end of the range). Like the BPC study, total CO_2 emission are

[75] Van Atten, Christopher. 2016. *EPA's Clean Power Plan Summary of IPM Modeling Results With ITC/PTC Extension.* M.J. Bradley & Associates, LLC. http://www.mjbradley.com/reports/updated-modeling-analysis-epas-clean-power-plan Accessed September 21, 2017.

[76] Ross, Martin T., David Hoppock, and Brian Murray. 2016."Ongoing Evolution of the Electricity Industry: Effects of Market Conditions and the Clean Power Plan on States." NI WP 16-07. Durham, NC: Duke University. https://nicholasinstitute.duke.edu/climate/publications/ongoing-evolution-electricity-industry-effects-market-conditions-and-clean-power-plan Accessed September 21, 2017.

reported over time for certain baseline and implementation scenarios in a line graph, and it is not possible to report a precise range of changes in CO_2 emissions.

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Appendix A. Detailed Calculation of Demand-Side Energy Efficiency Savings

Table A-1. Calculation of Demand-Side Energy Efficiency Savings in 2020

Integrated Planning Model (IPM) Region	Reduction in Production attributable to Demand-Side EE [GWh]	Wholesale Price [2011$/MWh]		Demand-Side EE Savings [Billion 2011$]	
		Rate-Based	Mass-Based	Rate-Based	Mass-Based
ERCOT_Tenaska Frontier Generating Station	0	44.15	0.00	0.00	0.00
ERCOT_Tenaska Gateway Generating Station	0	0.00	0.00	0.00	0.00
ERCOT_Rest	661	48.20	47.75	0.03	0.03
ERCOT_West	26	46.53	46.09	0.00	0.00
FRCC	396	52.22	51.78	0.02	0.02
MAPP_WAUE	20	40.16	40.14	0.00	0.00
MISO_Iowa	169	43.51	43.79	0.01	0.01
MISO_Illinois	396	44.71	44.47	0.02	0.02
MISO_Indiana (including parts of Kentucky)	834	45.92	45.76	0.04	0.04
MISO_Lower Michigan	1,063	50.47	49.05	0.05	0.05
MISO_MT, SD, ND	16	39.98	39.96	0.00	0.00
MISO_Iowa-MidAmerican	365	42.97	43.23	0.02	0.02
MISO_Minnesota and Western Wisconsin	851	45.99	45.87	0.04	0.04
MISO_Missouri	233	44.44	45.87	0.01	0.01
MISO_Wisconsin- Upper Michigan (WUMS)	691	46.49	46.37	0.03	0.03
ISONE_Connecticut	320	51.51	51.55	0.02	0.02
ISONE_Maine	127	48.90	49.10	0.01	0.01
ISONE_MA, VT, NH, RI (Rest of ISO New England)	755	50.96	51.17	0.04	0.04
NY_Zones A&B	271	48.83	48.42	0.01	0.01
NY_Zone C&E	152	49.62	49.26	0.01	0.01
NY_Zones D	26	48.24	47.89	0.00	0.00
NY_Zone F (Capital)	109	50.77	50.70	0.01	0.01
NY_Zone G-I (Downstate NY)	221	52.84	52.77	0.01	0.01
NY_Zone J(NYC)	660	54.69	54.62	0.04	0.04
NY_Zone K(LI)	133	55.07	55.01	0.01	0.01
PJM_AP	390	47.50	46.96	0.02	0.02
PJM_ATSI	829	48.93	48.07	0.04	0.04
PJM_ComEd	1,135	45.78	44.77	0.05	0.05
PJM_Dominion	41	47.84	47.24	0.00	0.00
PJM_EMAAC	1,279	48.19	48.02	0.06	0.06
PJM_PENELEC	143	45.53	45.00	0.01	0.01
PJM_SWMAAC	632	55.81	54.89	0.04	0.03
PJM West	1,253	47.75	46.80	0.06	0.06
PJM_Western MAAC	300	47.04	46.84	0.01	0.01
SERC_Central_Kentucky	168	43.15	41.43	0.01	0.01

Integrated Planning Model (IPM) Region	Reduction in Production attributable to Demand-Side EE [GWh]	Wholesale Price [2011$/MWh]		Demand-Side EE Savings [Billion 2011$]	
		Rate-Based	**Mass-Based**	**Rate-Based**	**Mass-Based**
SERC_Central_TVA	526	49.70	48.39	0.03	0.03
SERC_Delta_Amite South (including DSG)	9	46.99	45.85	0.00	0.00
SERC_Delta_Northern Arkansas (including AECI)	151	44.48	44.61	0.01	0.01
SERC_Delta_Rest of Delta (Central Arkansas)	55	45.88	44.76	0.00	0.00
SERC_Delta_WOTAB (including Western)	36	47.69	47.16	0.00	0.00
SERC_Southeastern	513	49.04	48.23	0.03	0.02
SERC_VACAR	1,245	48.90	48.54	0.06	0.06
SPP_Kiamichi Energy Facility	0	43.90	43.93	0.00	0.00
SPP North- (Kansas, Missouri)	182	42.92	43.37	0.01	0.01
SPP Nebraska	52	41.40	41.91	0.00	0.00
SPP Southeast- (Louisiana)	7	43.40	43.59	0.00	0.00
SPP SPS (Texas Panhandle)	116	41.72	42.02	0.00	0.00
SPP West (Oklahoma, Arkansas, Louisiana)	327	44.29	44.34	0.01	0.01
WECC_Northern California (including SMUD)	1,018	56.85	54.97	0.06	0.06
WECC_LADWP	723	55.03	54.03	0.04	0.04
WECC_San Diego Gas and Electric	243	61.16	59.41	0.01	0.01
WECC_Arizona	858	42.06	41.61	0.04	0.04
WECC_Colorado	556	37.80	37.54	0.02	0.02
WECC_Idaho	122	40.90	39.72	0.01	0.00
WECC_Imperial Irrigation District (IID)	46	47.58	45.53	0.00	0.00
WECC_Montana	80	36.59	34.63	0.00	0.00
WECC_New Mexico	137	40.92	41.35	0.01	0.01
WECC_Northern Nevada	59	42.05	40.55	0.00	0.00
WECC_Pacific Northwest	1,642	41.45	39.29	0.07	0.06
WECC_Southern California Edison	783	61.55	59.39	0.05	0.05
WECC_San Francisco	95	55.62	53.79	0.01	0.01
WECC_Southern Nevada	138	42.94	42.36	0.01	0.01
WECC_Utah	281	39.60	38.59	0.01	0.01
WECC_Wyoming	36	31.11	29.96	0.00	0.00
Contiguous U.S.	**24,701**			**1.19**	**1.17**

Table A-2. Calculation of Demand-Side Energy Efficiency Savings in 2025

Integrated Planning Model (IPM) Region	Reduction in Production attributable to Demand-Side EE [GWh]	Wholesale Price [2011$/MWh]		Demand-Side EE Savings [Billion 2011$]	
		Rate-Based	Mass-Based	Rate-Based	Mass-Based
ERCOT_Tenaska Frontier Generating Station	0	0.00	0.00	0.00	0.00
ERCOT_Tenaska Gateway Generating Station	0	43.27	48.50	0.00	0.00
ERCOT_Rest	13,494	50.63	51.29	0.68	0.69
ERCOT_West	526	48.89	49.54	0.03	0.03
FRCC	9,212	49.93	54.41	0.46	0.50
MAPP_WAUE	268	38.66	43.28	0.01	0.01
MISO_Iowa	1,002	41.03	46.27	0.04	0.05
MISO_Illinois	2,341	42.25	46.57	0.10	0.11
MISO_Indiana (including parts of Kentucky)	5,635	43.37	48.73	0.24	0.27
MISO_Lower Michigan	6,260	47.47	50.24	0.30	0.31
MISO_MT, SD, ND	748	38.25	42.69	0.03	0.03
MISO_Iowa-MidAmerican	2,164	40.92	45.34	0.09	0.10
MISO_Minnesota and Western Wisconsin	5,134	43.57	49.36	0.22	0.25
MISO_Missouri	2,386	41.44	47.38	0.10	0.11
MISO_Wisconsin- Upper Michigan (WUMS)	4,076	43.53	49.56	0.18	0.20
ISONE_Connecticut	1,889	42.63	44.63	0.08	0.08
ISONE_Maine	751	41.04	43.17	0.03	0.03
ISONE_MA, VT, NH, RI (Rest of ISO New England)	4,791	42.21	44.41	0.20	0.21
NY_Zones A&B	1,584	42.48	42.56	0.07	0.07
NY_Zone C&E	888	42.45	43.30	0.04	0.04
NY_Zones D	151	41.29	42.12	0.01	0.01
NY_Zone F (Capital)	635	43.02	43.99	0.03	0.03
NY_Zone G-I (Downstate NY)	1,290	44.71	45.85	0.06	0.06
NY_Zone J(NYC)	3,854	46.33	47.50	0.18	0.18
NY_Zone K(LI)	778	46.72	48.56	0.04	0.04
PJM_AP	3,028	44.05	48.35	0.13	0.15
PJM_ATSI	4,911	45.13	49.33	0.22	0.24
PJM_ComEd	6,702	42.39	46.62	0.28	0.31
PJM_Dominion	3,229	45.15	48.54	0.15	0.16
PJM_EMAAC	9,399	41.11	43.46	0.39	0.41
PJM_PENELEC	914	40.08	41.75	0.04	0.04
PJM_SWMAAC	3,992	47.75	51.12	0.19	0.20
PJM West	8,869	44.38	48.73	0.39	0.43
PJM_Western MAAC	1,925	41.73	43.19	0.08	0.08
SERC_Central_Kentucky	2,050	40.73	41.79	0.08	0.09
SERC_Central_TVA	8,102	47.32	49.75	0.38	0.40
SERC_Delta_Amite South (including DSG)	1,187	45.45	47.62	0.05	0.06

Integrated Planning Model (IPM) Region	Reduction in Production attributable to Demand-Side EE [GWh]	Wholesale Price [2011$/MWh]		Demand-Side EE Savings [Billion 2011$]	
		Rate-Based	Mass-Based	Rate-Based	Mass-Based
SERC_Delta_Northern Arkansas (including AECI)	1,567	41.58	46.58	0.07	0.07
SERC_Delta_Rest of Delta (Central Arkansas)	1,462	44.05	45.96	0.06	0.07
SERC_Delta_WOTAB (including Western)	865	49.58	52.04	0.04	0.05
SERC_Southeastern	10,102	46.81	50.24	0.47	0.51
SERC_VACAR	11,973	48.33	48.79	0.58	0.58
SPP_Kiamichi Energy Facility	0	44.05	49.10	0.00	0.00
SPP North- (Kansas, Missouri)	3,207	42.70	48.78	0.14	0.16
SPP Nebraska	1,289	41.19	47.10	0.05	0.06
SPP Southeast- (Louisiana)	933	42.67	46.18	0.04	0.04
SPP SPS (Texas Panhandle)	1,876	41.50	43.74	0.08	0.08
SPP West (Oklahoma, Arkansas, Louisiana)	4,780	44.27	49.55	0.21	0.24
WECC_Northern California (including SMUD)	6,061	51.24	55.91	0.31	0.34
WECC_LADWP	4,304	49.44	56.82	0.21	0.24
WECC_San Diego Gas and Electric	1,446	55.27	61.40	0.08	0.09
WECC_Arizona	5,163	37.44	44.96	0.19	0.23
WECC_Colorado	3,563	31.10	41.04	0.11	0.15
WECC_Idaho	1,179	35.75	45.86	0.04	0.05
WECC_Imperial Irrigation District (IID)	271	38.83	42.90	0.01	0.01
WECC_Montana	774	30.77	40.08	0.02	0.03
WECC_New Mexico	1,631	37.28	44.48	0.06	0.07
WECC_Northern Nevada	617	40.71	48.69	0.03	0.03
WECC_Pacific Northwest	9,868	36.04	41.23	0.36	0.41
WECC_Southern California Edison	4,663	55.86	61.08	0.26	0.28
WECC_San Francisco	567	49.49	54.03	0.03	0.03
WECC_Southern Nevada	1,423	38.16	44.91	0.05	0.06
WECC_Utah	1,998	34.74	45.88	0.07	0.09
WECC_Wyoming	835	26.10	35.94	0.02	0.03
Contiguous U.S.	**206,584**			**9.20**	**10.01**

Table A-3. Calculation of Demand-Side Energy Efficiency Savings in 2030

Integrated Planning Model (IPM) Region	Reduction in Production attributable to Demand-Side EE [GWh]	Wholesale Price [2011$/MWh]		Demand-Side EE Savings [Billion 2011$]	
		Rate-Based	Mass-Based	Rate-Based	Mass-Based
ERCOT_Tenaska Frontier Generating Station	0	0.00	54.62	0.00	0.00
ERCOT_Tenaska Gateway Generating Station	0	53.42	0.00	0.00	0.00
ERCOT_Rest	27,175	55.29	56.52	1.50	1.54
ERCOT_West	1,059	53.42	54.62	0.06	0.06
FRCC	18,996	61.04	59.45	1.16	1.13
MAPP_WAUE	527	48.72	50.95	0.03	0.03
MISO_Iowa	1,484	50.53	55.22	0.08	0.08
MISO_Illinois	3,447	53.19	55.24	0.18	0.19
MISO_Indiana (including parts of Kentucky)	8,612	55.21	56.72	0.48	0.49
MISO_Lower Michigan	9,194	57.33	56.14	0.53	0.52
MISO_MT, SD, ND	1,696	48.38	50.43	0.08	0.09
MISO_Iowa-MidAmerican	3,204	50.40	54.68	0.16	0.18
MISO_Minnesota and Western Wisconsin	7,674	53.11	57.83	0.41	0.44
MISO_Missouri	3,983	51.66	56.50	0.21	0.23
MISO_Wisconsin- Upper Michigan (WUMS)	5,997	52.89	58.50	0.32	0.35
ISONE_Connecticut	2,779	53.54	50.99	0.15	0.14
ISONE_Maine	1,105	50.38	49.03	0.06	0.05
ISONE_MA, VT, NH, RI (Rest of ISO New England)	7,311	52.16	50.38	0.38	0.37
NY_Zones A&B	2,300	51.95	50.68	0.12	0.12
NY_Zone C&E	1,290	51.63	50.04	0.07	0.06
NY_Zones D	220	50.21	48.66	0.01	0.01
NY_Zone F (Capital)	922	52.02	50.42	0.05	0.05
NY_Zone G-I (Downstate NY)	1,874	53.99	52.40	0.10	0.10
NY_Zone J(NYC)	5,597	55.87	54.23	0.31	0.30
NY_Zone K(LI)	1,130	56.19	54.97	0.06	0.06
PJM_AP	4,916	54.83	53.77	0.27	0.26
PJM_ATSI	7,237	56.11	54.70	0.41	0.40
PJM_ComEd	9,871	53.09	52.57	0.52	0.52
PJM_Dominion	7,623	56.62	55.40	0.43	0.42
PJM_EMAAC	14,616	49.28	48.99	0.72	0.72
PJM_PENELEC	1,360	48.79	48.72	0.07	0.07
PJM_SWMAAC	5,993	59.05	57.25	0.35	0.34
PJM West	14,155	55.32	54.76	0.78	0.78
PJM_Western MAAC	2,863	50.42	50.13	0.14	0.14
SERC_Central_Kentucky	3,643	51.74	49.99	0.19	0.18
SERC_Central_TVA	15,380	57.13	55.71	0.88	0.86
SERC_Delta_Amite South (including DSG)	2,852	56.12	56.99	0.16	0.16

Integrated Planning Model (IPM) Region	Reduction in Production attributable to Demand-Side EE [GWh]	Wholesale Price [2011$/MWh]		Demand-Side EE Savings [Billion 2011$]	
		Rate-Based	Mass-Based	Rate-Based	Mass-Based
SERC_Delta_Northern Arkansas (including AECI)	2,652	51.74	55.08	0.14	0.15
SERC_Delta_Rest of Delta (Central Arkansas)	3,129	54.60	55.42	0.17	0.17
SERC_Delta_WOTAB (including Western)	1,803	58.82	59.25	0.11	0.11
SERC_Southeastern	20,279	57.88	58.22	1.17	1.18
SERC_VACAR	19,803	57.04	55.47	1.13	1.10
SPP_Kiamichi Energy Facility	-	54.23	56.28	0.00	0.00
SPP North- (Kansas, Missouri)	6,400	52.86	56.67	0.34	0.36
SPP Nebraska	2,671	51.50	55.57	0.14	0.15
SPP Southeast- (Louisiana)	2,241	52.42	53.83	0.12	0.12
SPP SPS (Texas Panhandle)	3,621	51.58	54.29	0.19	0.20
SPP West (Oklahoma, Arkansas, Louisiana)	8,993	54.92	57.37	0.49	0.52
WECC_Northern California (including SMUD)	9,003	59.88	64.38	0.54	0.58
WECC_LADWP	6,393	57.71	64.78	0.37	0.41
WECC_San Diego Gas and Electric	2,148	63.62	68.60	0.14	0.15
WECC_Arizona	7,774	46.95	55.08	0.37	0.43
WECC_Colorado	5,403	42.01	51.32	0.23	0.28
WECC_Idaho	1,947	44.55	54.83	0.09	0.11
WECC_Imperial Irrigation District (IID)	403	38.46	41.53	0.02	0.02
WECC_Montana	1,279	39.42	47.58	0.05	0.06
WECC_New Mexico	2,921	46.77	54.66	0.14	0.16
WECC_Northern Nevada	1,045	51.25	55.40	0.05	0.06
WECC_Pacific Northwest	14,749	44.39	48.95	0.65	0.72
WECC_Southern California Edison	6,927	63.91	68.40	0.44	0.47
WECC_San Francisco	843	57.88	62.26	0.05	0.05
WECC_Southern Nevada	2,402	47.58	54.28	0.11	0.13
WECC_Utah	3,068	43.23	54.50	0.13	0.17
WECC_Wyoming	1,712	34.66	44.65	0.06	0.08
Contiguous U.S.	**347,695**			**18.84**	**19.34**

Appendix B. Additional Information on Forgone Benefits

Table B-1. Forgone Quantified and Unquantified Benefits

Benefits Category	Specific Effect	Effect Has Been Quantified	Effect Has Been Monetized	More Information
Improved Environment				
Reduced climate effects	Climate impacts from CO_2	—[1]	✔	Section 3.4.1
	Climate impacts from ozone and black carbon (directly emitted PM)	—	—	Ozone ISA, PM ISA[2]
	Other climate impacts (e.g., other GHGs such as methane, aerosols, other impacts)	—	—	IPCC[2]
Increased Demand-Side Energy Efficiency				
	Cost savings from increased demand-side energy efficiency	✔	✔	U.S. EPA 2015a,b
Improved Human Health (co-benefits)				
Reduced incidence of premature mortality from exposure to $PM_{2.5}$	Adult premature mortality based on cohort study estimates and expert elicitation estimates (age >25 or age >30)	✔	✔	PM ISA
	Infant mortality (age <1)	✔	✔	PM ISA
Reduced incidence of morbidity from exposure to $PM_{2.5}$	Non-fatal heart attacks (age > 18)	✔	✔	PM ISA
	Hospital admissions—respiratory (all ages)	✔	✔	PM ISA
	Hospital admissions—cardiovascular (age >20)	✔	✔	PM ISA
	Emergency room visits for asthma (all ages)	✔	✔	PM ISA
	Acute bronchitis (age 8-12)	✔	✔	PM ISA
	Lower respiratory symptoms (age 7-14)	✔	✔	PM ISA
	Upper respiratory symptoms (asthmatics age 9-11)	✔	✔	PM ISA
	Asthma exacerbation (asthmatics age 6-18)	✔	✔	PM ISA
	Lost work days (age 18-65)	✔	✔	PM ISA
	Minor restricted-activity days (age 18-65)	✔	✔	PM ISA
	Chronic Bronchitis (age >26)	—	—	PM ISA[2]
	Emergency room visits for cardiovascular effects (all ages)	—	—	PM ISA[2]
	Strokes and cerebrovascular disease (age 50-79)	—	—	PM ISA[2]
	Other cardiovascular effects (e.g., other ages)	—	—	PM ISA[3]
	Other respiratory effects (e.g., pulmonary function, non-asthma ER visits, non-bronchitis chronic diseases, other ages and populations)	—	—	PM ISA[3]
	Reproductive and developmental effects (e.g., low birth weight, pre-term births, etc)	—	—	PM ISA[3,4]
	Cancer, mutagenicity, and genotoxicity effects	—	—	PM ISA[3,4]
Reduced incidence of mortality from exposure to ozone	Premature mortality based on short-term study estimates (all ages)	✔	✔	Ozone ISA
	Premature mortality based on long-term study estimates (age 30–99)	—	—	Ozone ISA[2]
Reduced incidence of morbidity from exposure to ozone	Hospital admissions—respiratory causes (age > 65)	✔	✔	Ozone ISA
	Hospital admissions—respiratory causes (age <2)	✔	✔	Ozone ISA
	Emergency department visits for asthma (all ages)	✔	✔	Ozone ISA
	Minor restricted-activity days (age 18–65)	✔	✔	Ozone ISA
	School absence days (age 5–17)	✔	✔	Ozone ISA
	Decreased outdoor worker productivity (age 18–65)	—	—	Ozone ISA[2]
	Other respiratory effects (e.g., premature aging of lungs)	—	—	Ozone ISA[3]
	Cardiovascular and nervous system effects	—	—	Ozone ISA[3]
	Reproductive and developmental effects	—	—	Ozone ISA[3,4]

Table B-1. Continued

Reduced incidence of morbidity from exposure to NO_2	Asthma hospital admissions (all ages)	—	—	NO_2 ISA[2]
	Chronic lung disease hospital admissions (age > 65)	—	—	NO_2 ISA[2]
	Respiratory emergency department visits (all ages)	—	—	NO_2 ISA[2]
	Asthma exacerbation (asthmatics age 4–18)	—	—	NO_2 ISA[2]
	Acute respiratory symptoms (age 7–14)	—	—	NO_2 ISA[2]
	Premature mortality	—	—	NO_2 ISA[2,3,4]
	Other respiratory effects (e.g., airway hyperresponsiveness and inflammation, lung function, other ages and populations)	—	—	NO_2 ISA[3,4]
Reduced incidence of morbidity from exposure to SO_2	Respiratory hospital admissions (age > 65)	—	—	SO_2 ISA[2]
	Asthma emergency department visits (all ages)	—	—	SO_2 ISA[2]
	Asthma exacerbation (asthmatics age 4–12)	—	—	SO_2 ISA[2]
	Acute respiratory symptoms (age 7–14)	—	—	SO_2 ISA[2]
	Premature mortality	—	—	SO_2 ISA[2,3,4]
	Other respiratory effects (e.g., airway hyperresponsiveness and inflammation, lung function, other ages and populations)	—	—	SO_2 ISA[2,3]
Reduced incidence of morbidity from exposure to methylmercury	Neurologic effects—IQ loss	—	—	IRIS; NRC, 2000[2]
	Other neurologic effects (e.g., developmental delays, memory, behavior)	—	—	IRIS; NRC, 2000[3]
	Cardiovascular effects	—	—	IRIS; NRC, 2000[3,4]
	Genotoxic, immunologic, and other toxic effects	—	—	IRIS; NRC, 2000[3,4]
Improved Environment (co-benefits)				
Reduced visibility impairment	Visibility in Class 1 areas	—	—	PM ISA[2]
	Visibility in residential areas	—	—	PM ISA[2]
Reduced effects on materials	Household soiling	—	—	PM ISA[2,3]
	Materials damage (e.g., corrosion, increased wear)	—	—	PM ISA[3]
Reduced PM deposition (metals and organics)	Effects on individual organisms and ecosystems	—	—	PM ISA[3]
Reduced vegetation and ecosystem effects from exposure to ozone	Visible foliar injury on vegetation	—	—	Ozone ISA[2]
	Reduced vegetation growth and reproduction	—	—	Ozone ISA[2]
	Yield and quality of commercial forest products and crops	—	—	Ozone ISA[2]
	Damage to urban ornamental plants	—	—	Ozone ISA[3]
	Carbon sequestration in terrestrial ecosystems	—	—	Ozone ISA[2]
	Recreational demand associated with forest aesthetics	—	—	Ozone ISA[3]
	Other non-use effects			Ozone ISA[3]
	Ecosystem functions (e.g., water cycling, biogeochemical cycles, net primary productivity, leaf-gas exchange, community composition)	—	—	Ozone ISA[3]
Reduced effects from acid deposition	Recreational fishing	—	—	NO_x SO_x ISA[2]
	Tree mortality and decline	—	—	NO_x SO_x ISA[3]
	Commercial fishing and forestry effects	—	—	NO_x SO_x ISA[3]
	Recreational demand in terrestrial and aquatic ecosystems	—	—	NO_x SO_x ISA[3]
	Other non-use effects			NO_x SO_x ISA[3]
	Ecosystem functions (e.g., biogeochemical cycles)	—	—	NO_x SO_x ISA[3]

Table B-1. Continued

Reduced effects from nutrient enrichment	Species composition and biodiversity in terrestrial and estuarine ecosystems	—	—	NO_x SO_x ISA[3]
	Coastal eutrophication	—	—	NO_x SO_x ISA[3]
	Recreational demand in terrestrial and estuarine ecosystems	—	—	NO_x SO_x ISA[3]
	Other non-use effects			NO_x SO_x ISA[3]
	Ecosystem functions (e.g., biogeochemical cycles, fire regulation)	—	—	NO_x SO_x ISA[3]
Reduced vegetation effects from exposure to SO_2 and NO_x	Injury to vegetation from SO_2 exposure	—	—	NO_x SO_x ISA[3]
	Injury to vegetation from NO_x exposure	—	—	NO_x SO_x ISA[3]
Reduced ecosystem effects from exposure to methylmercury	Effects on fish, birds, and mammals (e.g., reproductive effects)	—	—	Mercury Study RTC[3]
	Commercial, subsistence and recreational fishing	—	—	Mercury Study RTC[2]

[1] The climate and related impacts of CO_2 emissions changes, such as sea level rise, are estimated within each integrated assessment model as part of the calculation of the domestic SC-CO_2. The resulting monetized damages, which are relevant for conducting the benefit-cost analysis, are used in this RIA to estimate the domestic welfare effects of quantified changes in CO_2 emissions.

[2] We assess these co-benefits qualitatively, as reported in the Chapter 4 of the 2015 CPP RIA, due to data and resource limitations for this analysis.

[3] We assess these co-benefits qualitatively, as reported in the Chapter 4 of the 2015 CPP RIA, because we do not have sufficient confidence in available data or methods.

[4] We assess these co-benefits qualitatively, as reported in the Chapter 4 of the 2015 CPP RIA, because current evidence is only suggestive of causality or there are other significant concerns over the strength of the association.

Table B-2. Summary of Forgone Avoided Health Incidences from $PM_{2.5}$-Related and Ozone-Related Forgone Co-Benefits for Final Emission Guidelines Rate-Based and Mass-Based Illustrative Plan Approaches in 2020*

Forgone $PM_{2.5}$-related Health Effects	Rate-Based	Mass-Based
Forgone Avoided Premature Mortality		
Krewski et al. (2009) (adult)	64	200
Lepeule et al. (2012) (adult)	140	460
Woodruff et al. (1997) (infant)	0	0
Forgone Avoided Morbidity		
Emergency department visits for asthma (all ages)	34	110
Acute bronchitis (age 8–12)	94	300
Lower respiratory symptoms (age 7–14)	1,200	3,800
Upper respiratory symptoms (asthmatics age 9–11)	1,700	5,500
Minor restricted-activity days (age 18–65)	47,000	150,000
Lost work days (age 18–65)	7,900	25,000
Asthma exacerbation (age 6–18)	4,200	13,000
Hospital admissions—respiratory (all ages)	19	59
Hospital admissions—cardiovascular (age > 18)	23	73
Non-Fatal Heart Attacks (age >18)		
Peters et al. (2001)	73	230
Pooled estimate of 4 studies	8	25
Forgone Ozone-related Health Effects		
Forgone Avoided Premature Mortality		
Bell et al. (2004) (all ages)	11	13
Levy et al. (2005) (all ages)	51	61
Forgone Avoided Morbidity		
Hospital admissions—respiratory causes (ages > 65)	66	78
Hospital admissions—respiratory causes (ages < 2)	33	40
Emergency room visits for asthma (all ages)	37	43
Minor restricted-activity days (ages 18-65)	66,000	78,000
School absence days	23,000	27,000

* All estimates are rounded to whole numbers with two significant figures. Forgone co-benefits for $PM_{2.5}$ precursors are based on regional incidence-per-ton estimates for all precursors. Forgone co-benefits for ozone are based on ozone season NOx emissions. Confidence intervals are unavailable for this analysis because of the incidence-per-ton methodology. In general, the 95th percentile confidence interval for the health impact function alone ranges from approximately ±30 percent for mortality incidence based on Krewski *et al.* (2009) and ±46 percent based on Lepeule *et al.* (2012).

Table B-3. Summary of Forgone Avoided Health Incidences from $PM_{2.5}$-Related and Ozone-Related Forgone Co-Benefits for Final Emission Guidelines Rate-Based and Mass-Based Illustrative Plan Approaches in 2025*

Forgone $PM_{2.5}$-related Health Effects	Rate-Based	Mass-Based
Forgone Avoided Premature Mortality		
Krewski et al. (2009) (adult)	740	700
Lepeule et al. (2012) (adult)	1,700	1,600
Woodruff et al. (1997) (infant)	2	2
Forgone Avoided Morbidity		
Emergency department visits for asthma (all ages)	380	350
Acute bronchitis (age 8–12)	1,100	1,000
Lower respiratory symptoms (age 7–14)	14,000	13,000
Upper respiratory symptoms (asthmatics age 9–11)	20,000	19,000
Minor restricted-activity days (age 18–65)	530,000	500,000
Lost work days (age 18–65)	89,000	84,000
Asthma exacerbation (age 6–18)	48,000	46,000
Hospital admissions—respiratory (all ages)	220	210
Hospital admissions—cardiovascular (age > 18)	270	260
Non-Fatal Heart Attacks (age >18)		
Peters et al. (2001)	860	810
Pooled estimate of 4 studies	93	88
Forgone Ozone-related Health Effects		
Forgone Avoided Premature Mortality		
Bell et al. (2004) (all ages)	44	51
Levy et al. (2005) (all ages)	200	230
Forgone Avoided Morbidity		
Hospital admissions—respiratory causes (ages > 65)	280	320
Hospital admissions—respiratory causes (ages < 2)	130	150
Emergency room visits for asthma (all ages)	140	160
Minor restricted-activity days (ages 18-65)	250,000	290,000
School absence days	87,000	100,000

* All estimates are rounded to whole numbers with two significant figures. Forgone co-benefits for $PM_{2.5}$ precursors are based on regional incidence-per-ton estimates for all precursors. Forgone co-benefits for ozone are based on ozone season NOx emissions. Confidence intervals are unavailable for this analysis because of the incidence-per-ton methodology. In general, the 95th percentile confidence interval for the health impact function alone ranges from approximately ±30 percent for mortality incidence based on Krewski *et al.* (2009) and ±46 percent based on Lepeule *et al.* (2012).

Table B-4. Summary of Forgone Avoided Health Incidences from $PM_{2.5}$-Related and Ozone-Related Forgone Co-Benefits for Final Emission Guidelines Rate-Based and Mass-Based Illustrative Plan Approaches in 2030*

Forgone $PM_{2.5}$-related Health Effects	Rate-Based	Mass-Based
Forgone Avoided Premature Mortality		
Krewski et al. (2009) (adult)	1,400	1,200
Lepeule et al. (2012) (adult)	3,200	2,600
Woodruff et al. (1997) (infant)	3	2
Forgone Avoided Morbidity		
Emergency department visits for asthma (all ages)	540	440
Acute bronchitis (age 8–12)	2,000	1,600
Lower respiratory symptoms (age 7–14)	26,000	21,000
Upper respiratory symptoms (asthmatics age 9–11)	37,000	30,000
Minor restricted-activity days (age 18–65)	970,000	790,000
Lost work days (age 18–65)	160,000	130,000
Asthma exacerbation (age 6–18)	90,000	74,000
Hospital admissions—respiratory (all ages)	440	360
Hospital admissions—cardiovascular (age > 18)	530	430
Non-Fatal Heart Attacks (age >18)		
Peters et al. (2001)	1,700	1,400
Pooled estimate of 4 studies	180	150
Forgone Ozone-related Health Effects		
Forgone Avoided Premature Mortality		
Bell et al. (2004) (all ages)	73	70
Levy et al. (2005) (all ages)	330	320
Forgone Avoided Morbidity		
Hospital admissions—respiratory causes (ages > 65)	500	470
Hospital admissions—respiratory causes (ages < 2)	200	200
Emergency room visits for asthma (all ages)	220	210
Minor restricted-activity days (ages 18-65)	400,000	380,000
School absence days	140,000	130,000

* All estimates are rounded to whole numbers with two significant figures. Forgone co-benefits for $PM_{2.5}$ precursors are based on regional incidence-per-ton estimates for all precursors. Forgone co-benefits for ozone are based on ozone season NOx emissions. Confidence intervals are unavailable for this analysis because of the incidence-per-ton methodology. In general, the 95th percentile confidence interval for the health impact function alone ranges from approximately ±30 percent for mortality incidence based on Krewski *et al.* (2009) and ±46 percent based on Lepeule *et al.* (2012).

Appendix C. Uncertainty Associated with Estimating the Social Cost of Carbon

C.1. Overview of Methodology Used to Develop Interim Domestic SC-CO_2 Estimates

The domestic SC-CO_2 estimates rely on the same ensemble of three integrated assessment models (IAMs) that were used to develop the IWG global SC-CO_2 estimates (DICE 2010, FUND 3.8, and PAGE 2009).[77] The three IAMs translate emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and changes in temperature into economic damages. The emissions projections used in the models are based on specified socio-economic (GDP and population) pathways. These emissions are translated into atmospheric concentrations, and concentrations are translated into warming based on each model's simplified representation of the climate and a key parameter, equilibrium climate sensitivity. The effect of the changes in estimated in terms of consumption-equivalent economic damages. As in the IWG exercise, three key inputs were harmonized across the three models: a probability distribution for equilibrium climate sensitivity; five scenarios for economic, population, and emissions growth; and discount rates.[78] All other model features were left unchanged. Future damages are discounted using constant discount rates of both 3 and 7 percent, as recommended by OMB Circular A-4. The domestic share of the global SC-CO_2 – i.e., an approximation of the climate change impacts that occur within U.S. borders – are calculated directly in both FUND and PAGE. However, DICE 2010 generates only global SC-CO_2 estimates. Therefore, EPA approximated U.S. damages as 10 percent of the global values from the DICE model runs, based on the results from a regionalized version of the model (RICE 2010) reported in Table 2 of Nordhaus (2017).[79]

The steps involved in estimating the social cost of CO_2 are as follows. The three integrated assessment models (FUND, DICE, and PAGE) are run using the harmonized

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[77] The full models names are as follows: Dynamic Integrated Climate and Economy (DICE); Climate Framework for Uncertainty, Negotiation, and Distribution (FUND); and Policy Analysis of the Greenhouse Gas Effect (PAGE).

[78] See the IWG's summary of its methodology in the 2015 Clean Power Plan docket, document ID number EPA-HQ-OAR-2013-0602-37033, "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, Interagency Working Group on Social Cost of Carbon (May 2013, Revised July 2015)". See also National Academies (2017) for a detailed discussion of each of these modeling assumptions.

[79] Nordhaus, William D. 2017. Revisiting the social cost of carbon. *Proceedings of the National Academy of Sciences of the United States,* 114(7): 1518-1523.

equilibrium climate sensitivity distribution, five socioeconomic and emissions scenarios, constant discount rates described above. Because the climate sensitivity parameter is modeled probabilistically, and because PAGE and FUND incorporate uncertainty in other model parameters, the final output from each model run is a distribution over the SC-CO_2 in year t based on a Monte Carlo simulation of 10,000 runs. For each of the IAMs, the basic computational steps for calculating the social cost estimate in a particular year t is 1.) calculate the temperature effects and (consumption-equivalent) damages in each year resulting from the baseline path of emissions; 2.) adjust the model to reflect an additional unit of emissions in year t; 3.) recalculate the temperature effects and damages expected in all years beyond t resulting from this adjusted path of emissions, as in step 1; and 4.) subtract the damages computed in step 1 from those in step 3 in each model period and discount the resulting path of marginal damages back to the year of emissions. In PAGE and FUND step 4 focuses on the damages attributed to the US region in the models. As noted above, DICE does not explicitly include a separate US region in the model and therefore, EPA approximates U.S. damages in step 4 as 10 percent of the global values based on the results of Nordhaus (2017). This exercise produces 30 separate distributions of the SC-CO_2 for a given year, the product of 3 models, 2 discount rates, and 5 socioeconomic scenarios. Following the approach used by the IWG, the estimates are equally weighted across models and socioeconomic scenarios in order to reduce the dimensionality of the results down to two separate distributions, one for each discount rate.

C.2. Treatment of Uncertainty in Interim Domestic SC-CO_2 Estimates

There are various sources of uncertainty in the SC-CO_2 estimates used in this RIA. Some uncertainties pertain to aspects of the natural world, such as quantifying the physical effects of greenhouse gas emissions on Earth systems. Other sources of uncertainty are associated with current and future human behavior and well-being, such as population and economic growth, GHG emissions, the translation of Earth system changes to economic damages, and the role of adaptation. It is important to note that even in the presence of uncertainty, scientific and economic analysis can provide valuable information to the public and decision makers, though the uncertainty should be acknowledged and when possible taken into account in the analysis

(National Academies 2013).[80] OMB Circular A-4 also requires a thorough discussion of key sources of uncertainty in the calculation of benefits and costs, including more rigorous quantitative approaches for higher consequence rules. This section summarizes the sources of uncertainty considered in a quantitative manner in the domestic SC-CO_2 estimates.

The domestic SC-CO_2 estimates consider various sources of uncertainty through a combination of a multi-model ensemble, probabilistic analysis, and scenario analysis. We provide a summary of this analysis here; more detailed discussion of each model and the harmonized input assumptions can be found in the 2017 National Academies report. For example, the three IAMs used collectively span a wide range of Earth system and economic outcomes to help reflect the uncertainty in the literature and in the underlying dynamics being modeled. The use of an ensemble of three different models at least partially addresses the fact that no single model includes all of the quantified economic damages. It also helps to reflect structural uncertainty across the models, which is uncertainty in the underlying relationships between GHG emissions, Earth systems, and economic damages that are included in the models. Bearing in mind the different limitations of each model and lacking an objective basis upon which to differentially weight the models, the three integrated assessment models are given equal weight in the analysis.

Monte Carlo techniques were used to run the IAMs a large number of times. In each simulation the uncertain parameters are represented by random draws from their defined probability distributions. In all three models the equilibrium climate sensitivity is treated probabilistically based on the probability distribution from Roe and Baker (2007) calibrated to the IPCC AR4 consensus statement about this key parameter.[81] The equilibrium climate sensitivity is a key parameter in this analysis because it helps define the strength of the climate response to increasing GHG concentrations in the atmosphere. In addition, the FUND and PAGE models define many of their parameters with probability distributions instead of point estimates. For these two models, the model developers' default probability distributions are maintained for

[80] Institute of Medicine of the National Academies. 2013. Environmental Decisions in the Face of Uncertainty. The National Academies Press.

[81] Specifically, the Roe and Baker distribution for the climate sensitivity parameter was bounded between 0 and 10 with a median of 3 °C and a cumulative probability between 2 and 4.5 °C of two-thirds.

all parameters other than those superseded by the harmonized inputs (i.e., equilibrium climate sensitivity, socioeconomic and emissions scenarios, and discount rates). More information on the uncertain parameters in PAGE and FUND is available upon request.

For the socioeconomic and emissions scenarios, uncertainty is included in the analysis by considering a range of scenarios selected from the Stanford Energy Modeling Forum exercise, EMF-22. Given the dearth of information on the likelihood of a full range of future socioeconomic pathways at the time the original modeling was conducted, and without a basis for assigning differential weights to scenarios, the range of uncertainty was reflected by simply weighting each of the five scenarios equally for the consolidated estimates. To better understand how the results vary across scenarios, results of each model run are available in the docket.

The outcome of accounting for various sources of uncertainty using the approaches described above is a frequency distribution of the SC-CO_2 estimates for emissions occurring in a given year for each discount rate. Unlike the approach taken for consolidating results across models and socioeconomic and emissions scenarios, the SC-CO_2 estimates are not pooled across different discount rates because the range of discount rates reflects both uncertainty and, at least in part, different policy or value judgements; uncertainty regarding this key assumption is discussed in more detail below. The frequency distributions reflect the uncertainty around the input parameters for which probability distributions were defined, as well as from the multi-model ensemble and socioeconomic and emissions scenarios where probabilities were implied by the equal weighting assumption. It is important to note that the set of SC-CO_2 estimates obtained from this analysis does not yield a probability distribution that fully characterizes uncertainty about the SC-CO_2 due to impact categories omitted from the models and sources of uncertainty that have not been fully characterized due to data limitations.

Figure C-1 presents the frequency distribution of the domestic SC-CO_2 estimates for emissions in 2030 for each discount rate. Each distribution represents 150,000 estimates based on 10,000 simulations for each combination of the three models and five socioeconomic and emissions scenarios. In general, the distributions are skewed to the right and have long right tails, which tend to be longer for lower discount rates. To highlight the difference between the impact of the discount rate on the SC-CO_2 and other quantified sources of uncertainty, the bars below the frequency distributions provide a symmetric representation of quantified variability in the

$SC\text{-}CO_2$ estimates conditioned on each discount rate. The full set of $SC\text{-}CO_2$ results through 2050 is available in the docket.

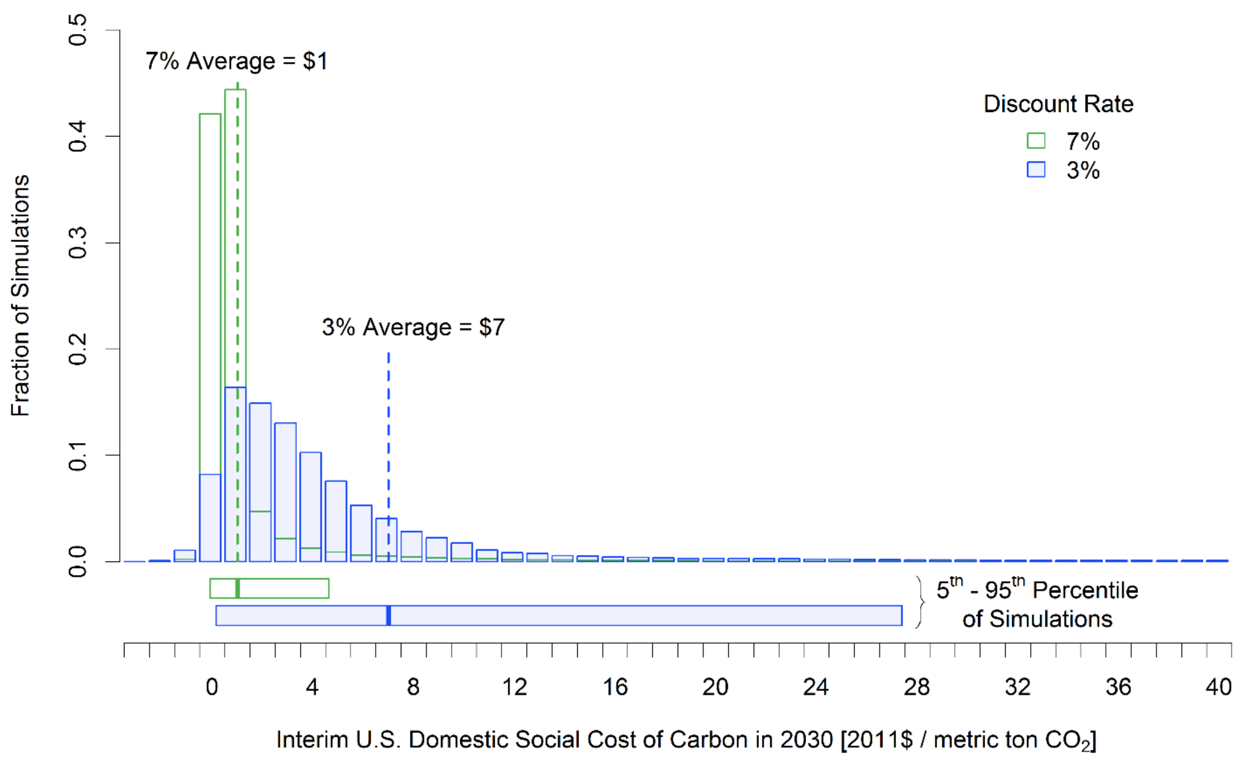

Figure C-1. Frequency Distribution of Interim Domestic $SC\text{-}CO_2$ Estimates for 2030 (in 2011$ per metric ton CO_2)

As illustrated by the frequency distributions in Figure C-1, the assumed discount rate plays a critical role in the ultimate estimate of the social cost of carbon. This is because CO_2 emissions today continue to impact society far out into the future, so with a higher discount rate, costs that accrue to future generations are weighted less, resulting in a lower estimate. Circular A-4 recommends that costs and benefits be discounted using the rates of 3 percent and 7 percent to reflect the opportunity cost of consumption and capital, respectively. Circular A-4 also recommends quantitative sensitivity analysis of key assumptions[82], and offers guidance on what sensitivity analysis can be conducted in cases where a rule will have important intergenerational

[82] "If benefit or cost estimates depend heavily on certain assumptions, you should make those assumptions explicit and carry out sensitivity analyses using plausible alternative assumptions." (OMB 2003, page 42).

benefits or costs. To account for ethical considerations of future generations and potential uncertainty in the discount rate over long time horizons, Circular A-4 suggests "further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefit using discount rates of 3 and 7 percent" (page 36) and notes that research from the 1990s suggests intergenerational rates "from 1 to 3 percent per annum" (OMB 2003). We consider the uncertainty in this key assumption by calculating the domestic SC-CO_2 based on a 2.5 percent discount rate, in addition to the 3 and 7 percent used in the main analysis. Using a 2.5 percent discount rate, the average domestic SC-CO_2 estimate across all the model runs for emissions occurring over 2020-2030 ranges from $9 to $10 per metric ton of CO_2 (2011$). In this case the forgone domestic climate benefits in 2020 are $550 and $650 million under the rate-based and mass-based scenarios, respectively; by 2030, the estimated forgone benefits increase to $3.9 billion and $3.8 billion under the rate-based and mass-based scenarios, respectively.

In addition to the approach to accounting for the quantifiable uncertainty described above, the scientific and economics literature has further explored known sources of uncertainty related to estimates of the SC-CO_2. For example, researchers have published papers that explore the sensitivity of IAMs and the resulting SC-CO_2 estimates to different assumptions embedded in the models (see, e.g., Hope (2013), Anthoff and Tol (2013), and Nordhaus (2014)). However, there remain additional sources of uncertainty that have not been fully characterized and explored due to remaining data limitations. Additional research is needed in order to expand the quantification of various sources of uncertainty in estimates of the SC-CO_2 (e.g., developing explicit probability distributions for more inputs pertaining to climate impacts and their valuation). On the issue of intergenerational discounting, some experts have argued that a declining discount rate would be appropriate to analyze impacts that occur far into the future (Arrow et al., 2013). However, additional research and analysis is still needed to develop a methodology for implementing a declining discount rate and to understand the implications of applying these theoretical lessons in practice. The 2017 National Academies report also provides recommendations pertaining to discounting, emphasizing the need to more explicitly model the uncertainty surrounding discount rates over long time horizons, its connection to uncertainty in economic growth, and, in turn, to climate damages using a Ramsey-like formula (National Academies 2017). These and other research needs are discussed in detail in the 2017 National

Academies' recommendations for a comprehensive update to the current methodology, including a more robust incorporation of uncertainty.

C.3. Forgone Global Climate Benefits

In addition to requiring reporting of impacts at a domestic level, OMB Circular A-4 states that when an agency "evaluate[s] a regulation that is likely to have effects beyond the borders of the United States, these effects should be reported separately" (page 15).[83] This guidance is relevant to the valuation of damages from CO_2 and other GHGs, given that GHGs contribute to damages around the world independent of the country in which they are emitted. Therefore, in this section we present the forgone global climate benefits in 2030 from this proposed rulemaking using the global SC-CO_2 estimates corresponding to the model runs that generated the domestic SC-CO_2 estimates used in the main analysis. The average global SC-CO_2 estimate across all the model runs for emissions occurring over 2020-2030 range from $5 to $7 per metric ton of CO_2 emissions (in 2011 dollars) using a 7 percent discount rate, and $44 to $53 per metric ton of CO_2 emissions (2011$) using a 3 percent discount rate. The domestic SC-CO_2 estimates presented above are approximately 19 percent and 14 percent of these global SC-CO_2 estimates for the 7 percent and 3 percent discount rates, respectively. Applying these estimates to the forgone CO_2 emission reductions results in estimated forgone global climate benefits in 2020 of $300 and $350 million (2011$) under the rate-based and mass-based scenarios, respectively, using a 7 percent discount rate; this increases to $2.8 and $3.3 billion (2011$) under the rate-based and mass-based scenarios, respectively, using a 3 percent discount rate. By 2030, the forgone global climate benefits are estimated to be $2.5 and $20 billion (2011$) under both the rate-based and mass-based scenarios, using 7 and 3 percent discount rates, respectively.

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[83] 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.

Under the sensitivity analysis considered above using a 2.5 percent discount rate, the average global SC-CO_2 estimate across all the model runs for emissions occurring over 2020-2030 ranges from $66 to $77 per metric ton of CO_2 (2011$); in this case the forgone global climate benefits in 2020 are $4.2 and $4.9 billion (2011$) under the rate-based and mass-based scenarios, respectively; by 2030, the forgone global benefits in this sensitivity case increase to $29 billion (2011$) under both the rate-based and mass-based scenarios.

Appendix D. Annual Avoided Compliance Costs used in the Present Value Analysis

Table D-1. Rate-Based Illustrative Plan Scenario: Avoided Compliance Costs from the Proposed Repeal of the CPP, Undiscounted, 2020-2033 (billion 2016$)

	Change in Total Power Sector Generating Costs	Demand-Side Energy Efficiency Costs (annualized at 3%)	Demand-Side Energy Efficiency Costs (annualized at 7%)	Value of Savings from Demand-Side Energy Efficiency Measures	Monitoring, Reporting, and Recordkeeping Costs	Total Avoided Costs (using DS-EE annualized at 3%)	Total Avoided Costs (using DS-EE annualized at 7%)
2020	0.3	2.3	2.8	1.3	0.1	4.0	4.5
2021	0.3	2.3	2.8	1.3	0.1	4.0	4.5
2022	0.3	2.3	2.8	1.3	0.1	4.0	4.5
2023	(17.0)	18.1	22.3	9.9	0.0	11.0	15.2
2024	(17.0)	18.1	22.3	9.9	0.0	11.0	15.2
2025	(17.0)	18.1	22.3	9.9	0.0	11.0	15.2
2026	(17.0)	18.1	22.3	9.9	0.0	11.0	15.2
2027	(17.0)	18.1	22.3	9.9	0.0	11.0	15.2
2028	(19.4)	28.4	35.0	20.3	0.0	29.3	36.0
2029	(19.4)	28.4	35.0	20.3	0.0	29.3	36.0
2030	(19.4)	28.4	35.0	20.3	0.0	29.3	36.0
2031	(19.4)	28.4	35.0	20.3	0.0	29.3	36.0
2032	(19.4)	28.4	35.0	20.3	0.0	29.3	36.0
2033	(19.4)	28.4	35.0	20.3	0.0	29.3	36.0

Table D-2. Mass-Based Illustrative Plan Scenario: Avoided Compliance Costs from the Proposed Repeal of the CPP, Undiscounted, 2020-2033 (billion 2016$)

	Change in Total Power Sector Generating Costs	Demand-Side Energy Efficiency Costs (annualized at 3%)	Demand-Side Energy Efficiency Costs (annualized at 7%)	Value of Savings from Demand-Side Energy Efficiency Measures	Monitoring, Reporting, and Recordkeeping Costs	Total Avoided Costs (using DS-EE annualized at 3%)	Total Avoided Costs (using DS-EE annualized at 7%)
2020	(0.8)	2.3	2.8	1.3	0.1	2.8	3.3
2021	(0.8)	2.3	2.8	1.3	0.1	2.8	3.3
2022	(0.8)	2.3	2.8	1.3	0.1	2.8	3.3
2023	(14.8)	18.1	22.3	10.8	0.0	14.1	18.3
2024	(14.8)	18.1	22.3	10.8	0.0	14.1	18.3
2025	(14.8)	18.1	22.3	10.8	0.0	14.1	18.3
2026	(14.8)	18.1	22.3	10.8	0.0	14.1	18.3
2027	(14.8)	18.1	22.3	10.8	0.0	14.1	18.3
2028	(22.9)	28.4	35.0	20.9	0.0	26.4	33.0
2029	(22.9)	28.4	35.0	20.9	0.0	26.4	33.0
2030	(22.9)	28.4	35.0	20.9	0.0	26.4	33.0
2031	(22.9)	28.4	35.0	20.9	0.0	26.4	33.0
2032	(22.9)	28.4	35.0	20.9	0.0	26.4	33.0
2033	(22.9)	28.4	35.0	20.9	0.0	26.4	33.0

Table D-3. Rate-Based Illustrative Plan Scenario: Present Value of Avoided Compliance Costs from the Proposed Repeal of the CPP, Discounted at 3% and 7%, 2020-2033 (billion 2016$)

	Discounted Values using a 3% Discount Rate					Discounted Values using a 7% Discount Rate				
	Change in Total Power Sector Generating Costs	**Demand-Side Energy Efficiency Costs**	**Value of Savings from Demand-Side Energy Efficiency Measures**	**Monitoring, Reporting, and Recordkeeping Costs**	**Total Avoided Costs**	**Change in Total Power Sector Generating Costs**	**Demand-Side Energy Efficiency Costs**	**Value of Savings from Demand-Side Energy Efficiency Measures**	**Monitoring, Reporting, and Recordkeeping Costs**	**Total Avoided Costs**
2020	0.3	2.0	1.1	0.1	3.5	0.3	2.2	1.0	0.1	3.4
2021	0.3	2.0	1.1	0.1	3.4	0.2	2.0	0.9	0.1	3.2
2022	0.3	1.9	1.1	0.1	3.3	0.2	1.9	0.9	0.0	3.0
2023	(13.8)	14.7	8.1	0.0	9.0	(10.6)	13.9	6.2	0.0	9.5
2024	(13.4)	14.3	7.8	0.0	8.7	(9.9)	13.0	5.8	0.0	8.9
2025	(13.0)	13.8	7.6	0.0	8.5	(9.2)	12.1	5.4	0.0	8.3
2026	(12.6)	13.4	7.4	0.0	8.2	(8.6)	11.3	5.0	0.0	7.8
2027	(12.3)	13.0	7.2	0.0	8.0	(8.1)	10.6	4.7	0.0	7.2
2028	(13.6)	19.9	14.3	0.0	20.6	(8.6)	15.6	9.0	0.0	16.0
2029	(13.2)	19.4	13.8	0.0	20.0	(8.1)	14.5	8.4	0.0	14.9
2030	(12.8)	18.8	13.4	0.0	19.4	(7.5)	13.6	7.9	0.0	13.9
2031	(12.5)	18.2	13.0	0.0	18.8	(7.0)	12.7	7.4	0.0	13.0
2032	(12.1)	17.7	12.7	0.0	18.3	(6.6)	11.9	6.9	0.0	12.2
2033	(11.7)	17.2	12.3	0.0	17.7	(6.1)	11.1	6.4	0.0	11.4
Total	**(140.2)**	**186.4**	**120.9**	**0.3**	**167.4**	**(89.6)**	**146.3**	**75.9**	**0.2**	**132.8**

Table D-4. Mass-Based Illustrative Plan Scenario: Present Value of Avoided Compliance Costs from the Proposed Repeal of the CPP, Discounted at 3% and 7%, 2020-2033 (billion 2016$)

	Discounted Values using a 3% Discount Rate					Discounted Values using a 7% Discount Rate				
	Change in Total Power Sector Generating Costs	**Demand-Side Energy Efficiency Costs**	**Value of Savings from Demand-Side Energy Efficiency Measures**	**Monitoring, Reporting, and Recordkeeping Costs**	**Total Avoided Costs**	**Change in Total Power Sector Generating Costs**	**Demand-Side Energy Efficiency Costs**	**Value of Savings from Demand-Side Energy Efficiency Measures**	**Monitoring, Reporting, and Recordkeeping Costs**	**Total Avoided Costs**
2020	(0.7)	2.0	1.1	0.1	2.5	(0.6)	2.2	1.0	0.1	2.6
2021	(0.7)	2.0	1.1	0.1	2.4	(0.6)	2.0	0.9	0.1	2.4
2022	(0.7)	1.9	1.1	0.1	2.4	(0.5)	1.9	0.8	0.0	2.2
2023	(12.0)	14.7	8.8	0.0	11.4	(9.2)	13.9	6.7	0.0	11.4
2024	(11.7)	14.3	8.5	0.0	11.1	(8.6)	13.0	6.3	0.0	10.6
2025	(11.3)	13.8	8.3	0.0	10.8	(8.1)	12.1	5.9	0.0	9.9
2026	(11.0)	13.4	8.0	0.0	10.5	(7.5)	11.3	5.5	0.0	9.3
2027	(10.7)	13.0	7.8	0.0	10.2	(7.0)	10.6	5.1	0.0	8.7
2028	(16.1)	19.9	14.6	0.0	18.5	(10.2)	15.6	9.3	0.0	14.7
2029	(15.6)	19.4	14.2	0.0	18.0	(9.5)	14.5	8.7	0.0	13.7
2030	(15.1)	18.8	13.8	0.0	17.5	(8.9)	13.6	8.1	0.0	12.8
2031	(14.7)	18.2	13.4	0.0	16.9	(8.3)	12.7	7.6	0.0	12.0
2032	(14.3)	17.7	13.0	0.0	16.5	(7.8)	11.9	7.1	0.0	11.2
2033	(13.9)	17.2	12.6	0.0	16.0	(7.2)	11.1	6.6	0.0	10.5
Total	**(148.5)**	**186.4**	**126.3**	**0.3**	**164.6**	**(94.1)**	**146.3**	**79.5**	**0.2**	**131.9**

United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Impacts Division Research Triangle Park, NC	Publication No. EPA-452/R-17-004 October, 2017