Technical Comments on the Regulatory Impact Analysis for the U.S. Environmental Protection Agency's Proposed Carbon Pollution Emissions Guidelines for Existing Power Plants

Anne E. Smith, Ph.D.[1]
NERA Economic Consulting
Washington, DC
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In June 2014, the U.S. Environmental Protection Agency (EPA) released its Proposed Carbon Pollution Emissions Guidelines for Existing Power Plants, also called the "Clean Power Plan" (called the "CPP" hereafter).[2] Accompanying this proposed rule is a Regulatory Impact Analysis (referred to as the "RIA" hereafter)[3] that is required under Executive Orders 12866 and 13563 for all major rulemakings of Executive Branch agencies. The RIA contains estimates of the benefits and costs of the regulation, their implications for net societal benefits, as well as information on other aspects of regulatory impact.

My comments focus on technical issues with the RIA's benefits calculations, and its net benefits calculations. I conclude that when technical flaws are corrected, the net benefits of this rule far less than reported in the RIA.

The first section below provides a short synopsis of the benefits and net benefits reported in the RIA, and summarizes findings of my review of the RIA. Section II provides detailed explanation of the findings related to climate benefits and net benefits. Section III provides details supporting the findings about co-benefits estimates. Appendix A documents the derivation of the present value of costs from RIA technical support documents. Appendix B and C provide more detailed results on temporal distribution of costs, benefits, and net benefits under a range of different SCC values and SCC modeling scenarios.

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[2] 79 *Fed. Reg*. 34830, June 18, 2014.

[3] EPA, *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants*. EPA-542/R-14-002, June 2014.

I. Overview of the RIA and Summary of Key Points in My Comments

There are two primary types of benefits calculated in this RIA:

1. Estimates of benefits from CO_2 reductions based on a "social cost of carbon" (SCC) value. The SCC is a present value of damages estimated over a 300-year period into the future from an incremental ton of CO_2 emissions in a given year. The SCC values include far more than health impacts, but the actual set of impacts it includes is not defined, and the portion of the SCC due to individual types of impact known to be included is not possible to determine. This "generic" dollar-per-ton ($/ton) damage estimate is multiplied against the RIA's estimate of the CPP's reductions in CO_2 tons emitted to produce the RIA's climate-related benefits estimates.

2. Estimates of health benefits from reductions in ambient $PM_{2.5}$ and ozone that may result coincidentally from the CO_2 reduction measures. These health benefits are not *climate*-related health impacts, and are thus called "co-benefits." For these co-benefits, EPA uses a short-cut approach that also relies on estimates of $/ton damages, with a different $/ton value for each type of $PM_{2.5}$ and ozone precursor emission. The RIA multiplies each of those co-benefit $/ton estimates against the tons of each respective criteria pollutant precursor emission that the RIA estimates will be coincidentally reduced when the electricity system complies with the CPP's limits on CO_2.[4]

The RIA subtracts its estimates of the annualized costs of the rule for each of three years during the rule's implementation phase (2020, 2025, and 2030) from its estimates of the climate benefits plus the co-benefits from emissions reductions in those respective years to estimate net benefits. The RIA reports that net benefits will be large and positive. For example, Tables ES-8 through ES-10 indicate that net benefits of the proposed "Option 1" (using a 3% discount rate for climate and co-benefits) will be between $27 billion and $50 billion in 2020, and increase to $48 billion to $84 billion by 2030.[5] My comments will demonstrate that these statements about the annual benefits of this greenhouse gas regulation are technically flawed, highly misleading, and far more uncertain than the RIA suggests.

[4] The precursor emissions included in the co-benefits calculations are: SO_2, NO_x, and directly-emitted $PM_{2.5}$ (individually) as precursors to ambient $PM_{2.5}$; and NO_x (again) as a precursor to ambient ozone.

[5] RIA, pp. ES-21 to ES-23.

As the remaining sections of my comments will explain in greater detail, I conclude that following about the benefits and net benefits of the CPP:

- The RIA's net benefits make an incorrect comparison of a *present value* of climate benefits to *annualized* cost estimates. <u>When corrected, EPA's estimates of the costs of the CPP are found to vastly exceed its estimates of the climate benefits in the years 2020, 2025 and 2030.</u> For example, using EPA's own costs and climate benefits calculations (for 3% discount rates), I find that:
    - Benefits estimated to occur *in* 2020 will be less than $0.1 billion globally, compared to U.S. CPP compliance spending during 2020 of $46 billion.
    - Estimated benefits *in* 2030 will be in the range of $1.0 to 1.4 billion globally, while U.S. compliance spending in that year is projected to be $9 billion.
- A technically correct net benefits calculation would not consider costs and benefits for individual years but would compare the present value of costs to the present value of benefits. This is particularly important to do correctly when the costs and benefits occur over vastly different time frames, which I show to be the case for the CPP.
    - On a present value basis (using 3% discount rates), the RIA's cost analysis indicates that the U.S. will have spent approximately $204 billion to comply with the CPP through 2030, yet the present value of climate benefits that will have accumulated by that time (globally) are estimated to be only $3.5 to 4.6 billion.
    - Even by 2050, the estimated global benefits from the spending through 2030 are projected to be less than $36 billion, at a point when all $204 billion of spending has been completed.
- Because there are such small climate benefits until long after the spending is sunk, the present value of net benefits (again using 3% discount rates) falls to a nadir of about $190 billion by 2030, and does not become positive until sometime between 2150 and 2180.
    - This implies a payback period of 120 to 150 years on a societal investment of several hundred billions of dollars. Thus the return on the CPP investment is still negative well over a century after its complete phase in.

- The present value of global benefits for all CO_2 tons reduced through 2030 eventually accumulate to $214 billion, which is only $10 billion higher than the present value of costs ($204 billion). This is a rate of return on the cost of the CPP of less than 0.04% per year even 250 years after the $204 billion has been invested.

The statements above use the set of 3% discount rate SCC $/ton estimates that the RIA uses[6] and the same compliance cost estimates that the RIA uses.[7] They differ from the RIA only because I have corrected the mismatch of units (present value benefits *vs.* annualized costs) used in the RIA, and I have assigned the stream of costs and climate benefits to the years in which they are projected to actually accrue to society.

Any RIA that involves large up-front spending with delayed benefits should report the temporal patterns in the estimated benefits and costs. Figure 1 presents that temporal pattern showing the timing of the spending and the timing of the benefits (both discounted to 2014). Figure 2 combines these into cumulative net benefits over time, as visible in the figure, the net benefits only become positive after 2100. Section II explains how I derived these results using an SCC model, and their robustness to alternative modeling assumptions.

The above shows the importance of the temporal distribution of benefits and costs. Additional distributional impacts that the RIA does not explain – but should – include:

- <u>Domestic vs. Global Benefits</u>. The values for the SCC are for *global* benefits, even though all of the costs of the regulation will be borne domestically. Rough estimates of the climate benefits that will be gained by U.S. populations (now and in the future) are so much smaller that even the worst case set of SCC values would not result in net benefits greater that zero for the U.S., even by the year 2300.

- <u>Economic Burdens by Income Level</u>. There is also a distributional question of who pays and who gains from the regulation from an income distribution perspective. Typically policies that affect energy prices such as the CPP are found to disproportionately impact lower income groups. The RIA is silent on this matter, but a good RIA would also address this issue.

[6] These are listed in RIA Table 4-2 (RIA, p. 4-12). I refer to them as a "set of values" because the value varies with the year of each avoided ton of CO_2 emission.

[7] The above cost estimates are derived from the same IPM output files that produce the annualized cost estimates for Option 1 "state compliance" in RIA Table ES-4 (RIA, p. ES-8), and which EPA has made available in the Greenhouse Gas Abatement Measures Technical Support Document (TSD). See Appendix A for more details.

Figure 1. Present Value of Spending (blue) and Climate Benefits (red) by Year ($ billions per year, 2011$)

(For Option 1 "state compliance," using costs from IPM runs used in RIA and for climate benefits based on the 3% SCC values in Table 4-2 of the RIA. Benefits' timing is based on DICE using the MERGE-Optimistic Scenario (the scenario with the shortest projected payback period), and climate sensitivity = 3.)

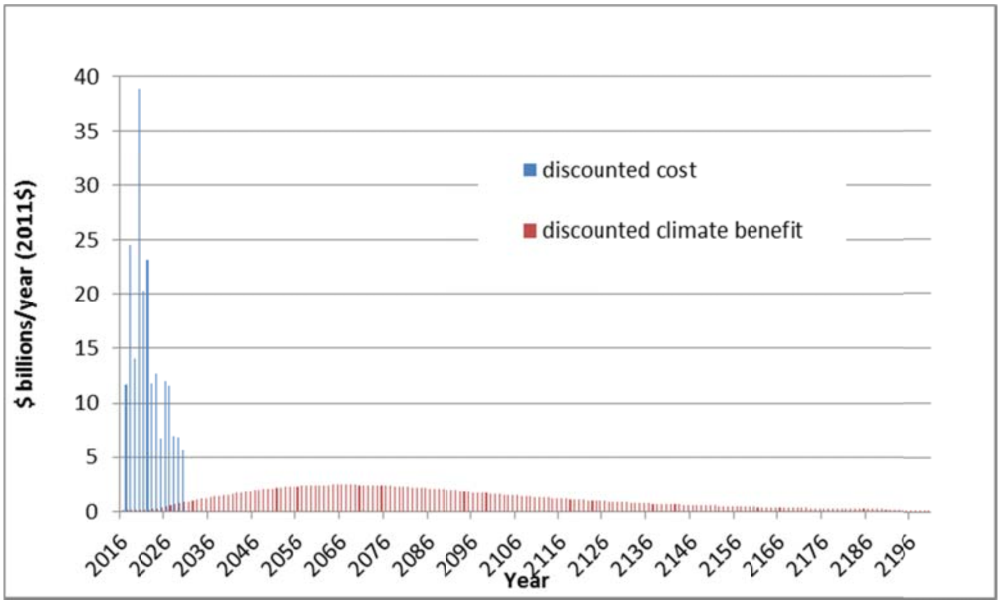
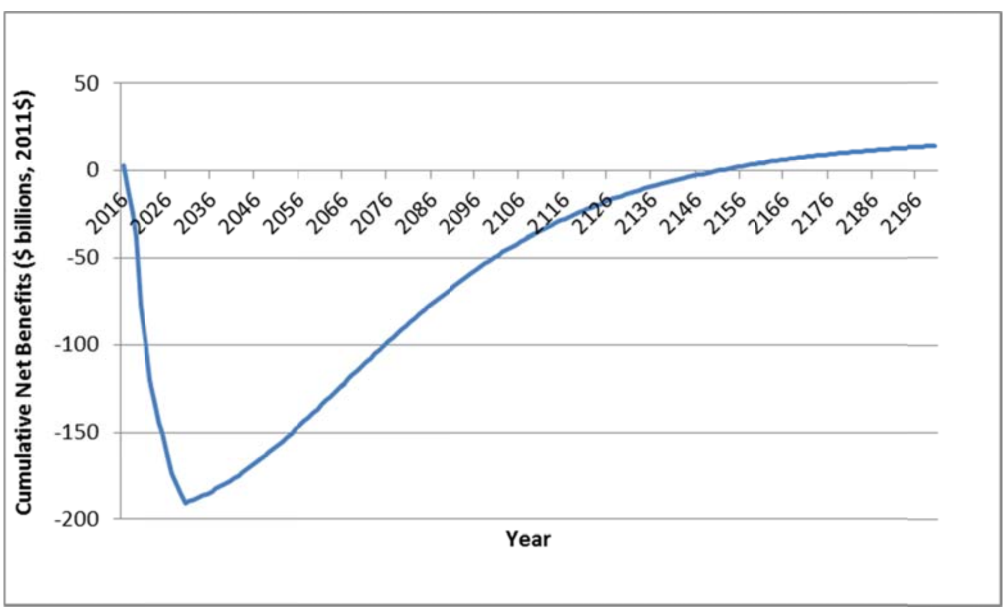


Figure 2. Cumulative Net Benefits over Time (billions of 2011$)

(For Option 1 "state compliance," using costs from IPM runs used in RIA and for climate benefits based on the 3% SCC values in Table 4-2 of the RIA. Benefits' timing is based on DICE using the MERGE-Optimistic Scenario, the scenario with the shortest projected payback period, and climate sensitivity =3.)



Estimated Global Temperature Impacts. Much has been written about the uncertainties and unknowns in estimates of SCC values. These are valid concerns, as the range of uncertainty is much wider than implied by the already wide range of SCC values that the RIA uses. One interesting indicator of the degree of tenuousness of the climate benefits estimates for the CPP is found in the estimated temperature changes that drive its benefits estimates. The RIA is silent on the amount by which global temperature increases would be avoided by the CPP. However, analyses NERA performed in the course of preparing these comments indicate that the maximum temperature increase avoided by the CPP is about 0.003^{o}C, which occurs several decades after the CPP's emission reductions. This is about a 0.2% change in the baseline temperature increase projected by that time; it falls to less than 0.05% of the projected baseline temperature increase in later years, when much of the climate benefit is still accumulating.

This sort of very small deviation from baseline temperature change must be viewed as a very tenuous basis for any projected amount of global damage – and yet that is the nature of the computation that the integrated assessment models are using to produce the SCC values that are being used in RIAs such as this one. In light of these results, one should view the cumulative net benefits calculations above with much circumspection. The risks of no climate benefits from the CPP policy itself should be considered as likely as the possibility that they will be positive.

Co-Benefits Not Related to Climate Change or Greenhouse Gases. The RIA also presents a case that the rule will have near-term benefits exceeding its costs due to estimated benefits that have nothing to do with climate change. These are the "co-benefits" estimated to be derived from coincidental reductions in criteria pollutants. According to the RIA estimates, co-benefits from Option 1 will range from $16 billion to $40 billion in 2020 and rise to the range of $25 billion to $62 billion by 2030.[8] Taken at face value, these co-benefits alone exceed the estimated cost of the rule; one might attempt to make a case that the regulation has positive net benefits even if it would create no climate benefits at all.

These co-benefits estimates are overstated. As Section III explains in more detail:

- All of these estimated health benefits are associated with minor reductions in ambient concentrations of criteria pollutants ($PM_{2.5}$ and ozone) that are already at levels below their Federal health standards (the "NAAQS"), which are set at a level that protects the public health with an adequate margin of safety. The majority of the co-benefits estimates are due to changes in areas already below

[8] RIA, pp. ES-21 to ES-23.

their health-based NAAQS limits – locations where the EPA Administrator has concluded she has no confidence that the health-relationships continue to exist. The RIA is only able to generate these large co-benefits estimates by assuming that EPA does have full confidence in the existence of the health-effects associations all the way to zero ambient concentrations, inconsistent with the Administrator's stated judgment.

- 75% to 78% of the co-benefits are due to estimated co-incidental reductions of SO_2 emissions, which convert to one of the many different physical and chemical forms of $PM_{2.5}$. EPA acknowledges that there is no basis for determining which types of $PM_{2.5}$ represent the causal factor (if any) in the ambient $PM_{2.5}$ mix. Rather than quantify this uncertainty, EPA simply assumes all $PM_{2.5}$ constituents are equally potent[9] – an assumption that sensitivity analyses have shown overstates likely risks from $PM_{2.5}$ changes.

Co-benefits estimates for already-regulated pollutants such as $PM_{2.5}$ and ozone should not be included in benefits estimates for other types of pollutant regulations:

- Any of the $PM_{2.5}$ and ozone co-benefits that result from exposures to baseline pollutant levels that are not below NAAQS will be eliminated by compliance programs to ensure attainment with that NAAQS; this portion of the co-benefits (if it exists at all) should be attributed to the NAAQS rules, because they will be enforced without the CPP (even if current baseline regulations to do so are not yet promulgated).

- Even if one were to have confidence in the continued existence of such substantial health effects associations for $PM_{2.5}$, including the co-benefits of already-regulated pollutants to justify regulations that are intended to manage altogether different risks, such as climate change, promotes unnecessarily complex and inefficient environmental risk management.

In conclusion, the RIA's benefits estimates for climate benefits are presented in a misleading and technically incorrect manner. When the technical issues are corrected and the results presented in a more informative manner, it is clear that a benefit-cost case for the CPP based on its intended climate benefits is extremely tenuous. It will impose significant near-term costs, with almost no near-term benefits. The net benefits case that remains for the CPP is founded on very unreliable estimates of co-benefits from changes that have nothing to do with climate benefits, which are overstated even

[9] See footnote (c) on Tables ES-8 through ES-10 (RIA, pp. ES-21 to ES-23).

against the EPA Administrator's established judgments about those pollutant risks, and which should – at best – be assigned to future NAAQS-mandated regulations for criteria pollutants; such estimates should not be used to bolster a weak benefit-cost case for a totally unrelated regulation of greenhouse gases.

II. Detailed Assessment and Reanalysis of Climate Benefits in the RIA

This section explains the technical problems associated with the way the SCC values are being used to compare climate benefits to compliance costs in the RIA and provides details on how a more valid analysis that accounts for the timing of the costs and the benefits produces a much more uncertain sense that the climate benefits of the CPP outweigh its costs. It also explains other distributional considerations that affect the comparison of climate benefits to compliance costs.

Timing of Climate Benefits.

The SCC is an estimate of the total benefits through 2300 of a ton of avoided incremental CO_2 emissions in any given year, stated as a present value in the year of emission. For example, if the SCC is $50/ton for 2020 emissions and 1 million tons of CO_2 emissions are avoided in 2020, the SCC implies that the present value of future climate-related benefits from that action would be $50 million. This does *not* however, mean that in the year 2020, the world will actually experience the $50 million estimated benefits. This present value reflects benefits that are projected to accrue over the long time span from 2020 through 2300 using "integrated assessment models" (IAMs) of climate change. Following are a few basic aspects of the IAM calculations that cause most of that present value to be associated with benefits far in the future:

- There are time lags of decades between when emissions occur and when most of the global temperature is expected to respond.

- Also, small changes in temperature that are projected to occur in the near term have relatively little projected climate effect because they occur against a baseline temperature that is not much different from today's. The baseline assumptions in the IAMs result in projections of rising temperature levels. Because the IAMs also assume that a given incremental change in temperature causes a larger percentage impact on GDP when it occurs against a higher baseline temperature, an emissions reduction in 2020 has much less benefit in years just after 2020 than much later in the analysis period.

- Finally, climate damages are tied to global GDP levels, which IAM model inputs assume to be rising year over year. A given percentage impact on GDP in 2020 and years soon thereafter produces much less benefit than the same percentage impact in years toward the end of the period 2020 through 2300.

Thus, before any consideration of discounting (a step essential to estimating a present value), the vast majority of the IAM-estimated benefits from a ton of incremental emissions avoided in years 2020 through 2030 occur not decades, but centuries in the future. Even after discounting is applied, one finds that the only a very small fraction of the present value of that ton (*i.e.*, of the SCC value) is projected to occur before 2050. In contrast, the compliance costs associated with tons reduced during the period 2020-2030 must, by definition, occur before or during the year of avoided emission. Thus there is a conceptual mismatch of units in any RIA that compares the present value of largely future projected climate benefits (using the RIA's SCC-based method) to costs that occur contemporaneously.

It is certainly reasonable to compare benefits and costs on a present value basis, but the economic risk of a policy with net benefits that depend on far-future benefits from large up-front spending may be large. For that reason, RIAs should provide information on the timing of their present values of costs and benefits. In the case of this RIA, there is a strong potential that readers may be misled into thinking that the climate benefits of tens of billions of dollars per year that it attributes to 2020, 2025 and 2030 are benefits that will actually be experienced in those years, or at least within the average readers' lifetimes. This is not the case.

To estimate the timing of the global climate benefits reported in the RIA, I have gone back to original IAM calculations that replicate the SCC values used in this RIA and extracted the year by year benefits that add up to those SCC values. To do this, I used the same version of DICE 2010 that was used by the Federal Interagency Working Group (IWG) to produce those SCC values.[10] First, I replicated the 2020 SCC values attributed to the DICE model in an appendix to the IWG's reports, confirming that I could replicate DICE's SCC values for every combination of of the five socioeconomic scenarios and three discount rates. I did this for the median equilibrium climate sensitivity parameter (ECS) of 3, and also for the 95th percentile ECS of 7.14. Then, I used the IAM's projected undiscounted benefits in each year of the modeled time period to construct the temporal distribution of when the total benefits are projected to occur from the year of the emission through 2300. This temporal distribution differs with the socioeconomic

[10] That is, the version of DICE that produces the SCC values in IWG (2013).

scenario and with the ECS. Since the summary tables of net benefits in the RIA use the average SCC (roughly equivalent to the SCC with an ECS of 3) and the 3% discount rate, I applied the five temporal distributions from the DICE runs performed with the median ECS of 3 to the tons of avoided emissions in each year under the CPP.[11] For each year, starting in 2016 when the RIA cost analysis assumes CO_2 control measures are initiated, I accounted for the benefits ensuing over time from that year's CO_2 reductions. I then calculated the total undiscounted benefits in each individual future year through 2030 as the sum of the undiscounted benefits continuing to accrue from each of the prior years' reductions, plus the additional benefit *in* that year from that year's additional emission reductions. When these total benefits by year are discounted at 3% and summed through 2300, one obtains the full present value of benefits from the CPP that is associated with the SCC values that are used by the RIA – and one also obtains a timeline of the accrual over time of that present value. The same was done using other discount rates and for the 95th percentile ECS case (for a 3% discount rate).

A summary of the results is provided in Table 1 below for the 3% discount rate case that is the focus of the RIA net benefits comparisons. The RIA states that the climate benefits of the CPP would be $18 billion for 2020 reductions, $25 billion for 2025 reductions, and $31 billion for 2030 reductions.[12] Using my more complete analysis (which replicates the RIA's values when stated in the RIA format), I find that the present value of all the reductions under the CPP through 2030 is $214 billion, but that the benefits actually accrued through 2030 are only $3.5 billion to $4.6 billion.[13] Other temporal aspects of these net benefits are shown in Table 1. It is this timeline of climate benefits that should be compared to the timeline of CPP compliance spending over the same period 2016-2030 (which, as explained in Appendix A, EPA estimates to have a present value of $204 billion through 2030). The climate benefits estimates in Table 1 are global benefits; the portion that the U.S. population will gain is smaller, as discussed later in these comments.

[11] These tons are reported for 2020, 2025 and 2030 in Table ES-2 of the RIA (RIA, p. ES-7). I obtained reductions for earlier years from the IPM model output files (see Appendix A), and I interpolated the tons for individual years between the modeled years.

[12] RIA, pp. ES-21 to ES-23.

[13] My range reflects the different temporal distributions of benefits associated with each of the five IWG socioeconomic scenarios. The DICE scenarios were run using the IWG's median equilibrium climate sensitivity parameter of 3. I also ran a sensitivity test using the timing profile from the 95th percentile climate sensitivity (*i.e.*, 7.14) to see if higher climate sensitivity might alter the temporal distribution of benefits. It actually reduced near-term benefits, thus making the payback period longer than those estimated for the median ECS. The reason is that while a higher ECS generates higher present values of SCC, it also shifts the proportion of the total climate damages farther into the future.

Table 1. Estimated Global Climate Benefits of CPP Reductions through 2030
(Using 3% discount rate SCC values, and temporal patterns from DICE run with ECS=3, ranges reflecting results from all five socioeconomic projections)

Time Period	**Present value in 2014 ($billions, 2011$)**	**Undiscounted Value in that Year ($billions, 2011$)**
Benefit occurring <u>in 2020</u> from reductions in 2016 - 2020	$0.06 to $0.08	$0.08 to $0.1
Benefit occurring <u>in 2025</u> from reductions in 2016 -2025	$0.3 to $0.4	$0.4 to $0.5
Benefit occurring <u>in 2030</u> from reductions in 2016 - 2030	$0.6 to $0.8	$1.0 to $1.4
Cumulative benefits through 2030	$3.5 to $4.6	not applicable
Cumulative benefits through 2050	$27 to $36	not applicable
Cumulative benefits through 2100	$119 to $144	not applicable
Cumulative benefits through 2300 (full period modeled to estimate $/ton SCCs used in RIA)	$215	not applicable

Table 1 shows that a large fraction of the climate benefits that the RIA attributes to the CPP occur far in the future under the 3% discount rate SCC values that are emphasized in the RIA's net benefits summaries. The RIA does note that the climate benefits are highly dependent on the choice of discount rate or if a pessimistic view ("95th percentile") is taken of the climate impact assumptions. Although the present value of climate benefits is highly dependent on these alternative (largely judgmental) discount rate and other assumptions, our analysis shows that these variations have very little impact on benefits that would be experienced before 2050. Table 2 shows the climate benefits over time associated with all four alternative sets of SCC values. These cases are all based on the socioeconomic scenario that produces the highest share of benefits in the early years (*i.e.*, the "MERGE-optimistic" projection). In all four cases, total climate benefits experienced between 2016 and 2030 (the period over which U.S. costs of $204 billion are being incurred) are less than $10 billion globally. While a larger portion of the ultimate climate benefits is accrued by 2050 under the 5% discount rate, the full present value of benefits under that assumption never exceeds the present values of the CPP costs (*i.e.*, $204 billion). Only the very pessimistic set of climate impact assumptions results in benefits that exceed costs before 2100.

Table 2. Timing of Global Climate Benefit Accrual for Four Alternative Sets of SCC Values in RIA. ($ billions 2011$, present value in 2014)
(For CPP Option 1, "state compliance" case; timing of benefits based on DICE model using the "MERGE-Optimistic" case. For average SCC values, ECS=3 was assumed; for "95th percentile SCC values" ECS=7.14 was assumed.)

Time Period	**5% Discount Rate**	**3% Discount Rate**	**2.5% Discount Rate**	**95th %ile (3% DR)**
Cumulative benefits through 2030	$3	$5	$5	$9
Cumulative benefits through 2050	$18	$36	$43	$77
Cumulative benefits through 2100	$46	$145	$198	$395
Cumulative benefits through 2300 (the full period used to estimate SCCs used in RIA)	$52	$215	$335	$656

Net Benefits.

The above benefits reflect the total benefits from compliance with the CPP during the years 2020-2030, including benefits to populations outside of the U.S. To assess the net benefits of the rule, the present values of those benefits should be compared to the *present values* of the CPP compliance spending. The RIA has not presented the present value of costs at all. Instead, the RIA presents only estimates of annualized costs in the three years 2020, 2025 and 2030. These values, in essence, reflect that year's payoff of a societal debt incurred by compliance spending up to that year. In fact, the tons of reduction that are achieved in those years result from the full expenditure of the capital investments that enable those reductions, and that capital spending occurs entirely in the years before, not after, the emissions reductions can be achieved. Thus, while individual companies and consumers who must undertake the capital investments will be able to pay off their costs over time, via loans, actual spending – and its impact to society as a whole – are not spread over time. The present value of the *societal* cost of a policy must recognize the spending in the years in which the society actually makes those investments of capital and labor.

Fortunately, Technical Support Documents released with the RIA provide more complete details of the actual capital and operations spending that occur to comply with the CPP. These are estimated by the IPM model. Appendix A explains how we used the raw results from EPA's IPM model runs to assess the actual timing and present value of the compliance costs that are reported in annualized form in RIA Table ES-4.[14] In brief, we find that the present value of spending from 2016 through 2030 to reduce CO_2 emissions in the amounts that serve as the basis for the climate benefits estimates is $204 billion (2011$, present value in 2014). This is the present value of the Option 1 "state compliance" scenario, discounted by 3% as are the central climate benefit estimates.[15]

Combining this cost estimate with the climate benefits based on the 3% discount rate set of SCC values, the present value of net benefits of Option 1 (for "state compliance") is about $10 billion (2011$, present value in 2014), once computed through the year 2300. <u>However, it will be many years before that return on the $204 billion regulation is achieved</u>. When considering the respective timings of the estimated costs and their associated estimated climate benefits, the CPP regulation appears to provide far less net benefit than the tens of billions of dollars per year that the RIA suggests will occur for 2020, 2025 and 2030. For example:

- Benefits estimated to occur *in* 2020 are less than $0.1 billion globally, compared to U.S. CPP compliance spending <u>during</u> 2020 of $46 billion.

- Estimated benefits in 2030 will be in the range of $1.0 to 1.4 billion globally, while U.S. compliance spending in that year is projected to be $9 billion.

Because there are such small climate benefits until long after the spending is sunk, the present value of net benefits (again using the 3% discount rate SCC values) falls to a nadir of about $190 billion by 2030 (2011$, present value in 2014), and does not become positive until sometime between 2150 and 2180.

- This implies a payback period of 120 to 150 years on a societal investment of several hundreds of billions of dollars when using the discount rate of 3%. Thus

[14] RIA, p. ES-8.

[15] Total spending before discounting is $260 billion through 2030.

the return on the CPP investment is still negative well over a century after its complete phase-in.

- The present value of global benefits for all CO_2 tons reduced through 2030 eventually accumulate to $214 billion, which is only $10 billion higher than the present value of costs ($204 billion). This is a rate of return on the cost of the CPP of less than 0.04% per year even 250 years after the $204 billion has been invested.

The statements above use the same set of 3% discount rate SCC $/ton values that the RIA uses and the same compliance cost estimates that the RIA uses.[16] In other words, these statements are based on EPA's own set of cost and benefit estimates. I have not attempted to present any alternative SCC estimates, nor to present alternative cost estimates. I have only corrected the mismatch of units (present value *vs*. annualized) used in the RIA and assigned the costs and benefits to the years in which they will actually accrue to society.

Any RIA that involves large up-front spending with delayed benefits should report the temporal patterns in the estimated benefits and costs in this manner. Figure 1 (in Section I above) presented that temporal pattern showing the timing of the spending and the timing of the benefits (both discounted to 2014). Figure 2 (also in Section I) combined them into cumulative net benefits over time, which showed that the net benefits only become positive after 2100. Those two figures were based on the timing pattern of benefits associated with the socioeconomic scenario used by the IWG that produces the shortest payback period of all five of those scenarios. The results vary only slightly for the other four socioeconomic scenarios, which Appendix B provides for completeness. As Table 2 showed, the ultimate net present value by 2300 does vary for different sets of SCC values, but the timing of those benefits remains predominantly in the far future too. Appendix C provides the same summary figures as Figures 1 and 2, but for the remaining three of the four different sets of SCC values used in the RIA.

Other Distributional Impacts.

After correcting the mismatch of units being compared, and taking into account the very different temporal distribution of costs and climate benefits, the net benefit case for the

[16] The absolute SCC values from each DICE run vary around, but are not exactly equal to the Federal SCC values, which are averages over many IAM runs, however, DICE's SCC estimates were not used for this analysis. Rather, the DICE model was used only to develop the temporal distribution of the benefits, which was then applied to the RIA's own SCC $/ton values.

CPP appears much weaker than the RIA summary would suggest. There are additional types of distributional impacts that the RIA does not explain but should:

- Another important distributional impact that RIAs should report is the relationship between who bears the regulation's costs and who receives the benefit. This has special relevance when the central benefits calculations are based on the social cost of carbon. The values for the SCC used in the RIA are based on estimates of global benefits. Although those values have not been formally disaggregated to parts of the globe, even the working group that produced those estimates noted that the portion of the benefits that would accrue to U.S. residents could be between 7% and 23%.[17] Even using the worst case (95th percentile) SCC value, if domestic damages are 23% of the estimated global damages, the net benefits of the CPP will be negative even through 2300. The RIA should present these facts to its readers as well.[18]

- There is also a distributional question of who pays and who gains from the regulation from an income distribution perspective that the RIA is silent on. It is, however, common knowledge that regulations that affect the delivered prices of electricity and natural gas, as the CPP will do, impose a disproportionate burden on lower income than average and higher income families. Since the domestic climate benefits will be smaller than domestic policy spending, as noted above, almost all U.S. residents currently alive will experience net welfare losses, regardless of income level. However, lower income families will probably feel the unrequited costs more heavily than others.

Temperature Changes underlying These Climate Benefit Estimates.

It is also a relevant point that the very small climate benefits that accrue in the first decades of the policy are highly dubious because they are based in miniscule changes in projected global temperatures. The RIA is silent on the amount by which global temperature increases would be decreased. Relying on the same version of the DICE model that was used in developing the SCC values (and using the median equilibrium climate sensitivity), the temperature increase avoided per 1 billion metric ton (1 gigaton, 1 Gt) of avoided carbon emissions in 2020 or 2030 is 0.0019^{o}C. The cumulative tons removed by 2030 under the CPP is about 6 Gt CO_2, which is 1.64 Gt carbon. This

[17] See IWG (2010), p. 11.

[18] Also, the developers of the SCC estimates should do more to identify the likely geographical disaggregation of those estimates to enable RIAs to do this.

suggests the temperature increase avoided by the CPP will be about 0.003°C.[19] This avoided increase peaks about 35 years after the year of an avoided emission, when projected global temperature increase would otherwise be between 1.8°C and 2.3 °C, or about a 0.2% change in projected temperature change at most. In later years, when the projected temperatures are much higher (they rise in some of the ECS=3 cases to as high as 4°C by 2100 and 7°C by 2200), the temperature differences due to the CPP reductions have declined, and they at that time represent less than 0.05% of the overall temperature change.

This sort of very small deviation from baseline temperature change must be viewed as a very tenuous basis for any projected amount of global damage – and yet that is the nature of the computation that the integrated assessment models are using to produce the SCC values that are being used in RIAs such as this one. In light of these results, one should view the cumulative net benefits calculations above with much circumspection. The risks of no climate benefits from the CPP should be considered as likely as the possibility that they will be positive.

Remaining Issues with Climate Benefits Estimates.

As noted, the above weakening of the seemingly large estimates of net climate benefits from the CPP that the RIA provides is based entirely on the assumptions, data, and models that EPA has adopted. There are many other criticisms that can be leveled at the SCC $/ton estimates themselves, and at whether it is appropriate to use such incremental benefits estimates in the case of emissions that are represent a global environmental risk.

In particular, the damage functions that are embedded in the IAM models that have been used to generate the SCC $/ton estimates are at best speculative. They are founded on minimal and highly inconsistent empirical evidence of climate damages associated with very small global average temperature changes (*i.e.*, less than 3°C), combined with assumed functional forms that fit the empirical data very poorly and are complete extrapolations for the higher temperature changes that represent the more pronounced risks from unchecked greenhouse gas emissions. Pindyck (2014) first articulated this concern, while NERA (2014) provides a thorough review of the weakness of the empirical and theoretical basis for the IAM damage functions. Further, Smith (2014a) provides a comprehensive assessment of the many additional sources of

[19] We confirmed this by running DICE to directly calculation temperature changes from the actual tons reduced under the CPP, which produced a maximum temperature change of 0.0032°C.

uncertainty that are not completely represented in the SCC estimates that the RIA relies on.

The evidence presented above regarding the miniscule nature of the temperature changes that generate the hundreds of billions of dollars of present value benefits estimates that the RIA attributes to the CPP's emissions reductions further highlights the questionable reliability of these abstract and speculative IAM damage functions.

III. Technical Issues with Estimates of Co-Benefits and with Their Use in a Climate-Related RIA

The RIA also presents a case that the rule will have near-term benefits exceeding its costs due to estimated benefits that have nothing to do with climate change. These are the "co-benefits" estimated to be derived from coincidental reductions in criteria pollutants. According to the RIA estimates, co-benefits from Option 1 will range from $16 billion to $40 billion in 2020 and rise to the range of $25 billion to $62 billion by 2030.[20] Taken at face value, these co-benefits exceed the estimated cost of the rule but there are many reasons why these estimates should be viewed as overstated. There are also reasons why co-benefits should not be included in an RIA when they are derived from already-regulated pollutants, as is the case in this RIA. Some of the key reasons are discussed in this section, and a more thorough treatment of this issue is found in Smith (2011 and 2014b).

Sources of Overstatement in Co-Benefits Estimates.

Projected co-incidental reductions in ambient ozone and $PM_{2.5}$ account for all of the co-benefits estimates, but all of these estimated health benefits are associated with minor reductions in ambient concentrations of the criteria pollutants $PM_{2.5}$ and ozone that are already at levels below the Federal health standards for those pollutants (*i.e.*, the national ambient air quality standards, or "NAAQS") – standards that are set at a level that protects the public health with an adequate margin of safety.

Although a health-based NAAQS is not considered to be free of any remaining health risk, it *is* considered to be stringent enough that risk estimates associated with further reductions are based on statistical associations that EPA lacks confidence continue to exist at lower levels. The EPA Administrator's articulation of this lack of confidence can

[20] Tables ES-8 to ES-10 in RIA, pp. ES-21 to ES-23.

be found in the preambles for the current $PM_{2.5}$ and ozone NAAQS.[21] The majority of the co-benefits estimates that are due to changes in $PM_{2.5}$ and ozone in areas already attaining their health-based NAAQS are calculated using the very same health risk relationships the existence of which the Administrator has said he/she has no confidence. In essence, this implies the expected value of those co-benefits is *de minimis*. The RIA is only able to generate large co-benefits estimates by assuming that EPA does have full confidence in the existence of the health-effects associations all the way to zero ambient concentrations.

As discussed below, any of the $PM_{2.5}$ and ozone co-benefits that might result from exposures to baseline levels that exceed the NAAQS will be eliminated by compliance programs to ensure attainment with that NAAQS; this portion of the co-benefits (if any exist at all) should be attributed to the NAAQS rules, because they will be enforced without the CPP (even if current baseline regulations may not yet address them).

An additional reason to view the co-benefits estimates as overstated is because 75% to 78% of the co-benefits are due to estimated co-incidental reductions of SO_2 emissions, which convert to the sulfate form of $PM_{2.5}$. EPA acknowledges that there is no basis for determining which $PM_{2.5}$ constituents represent the causal factor (if any) in the ambient $PM_{2.5}$ mix.[22] Rather than quantify this uncertainty, EPA simply assumes all $PM_{2.5}$ constituents are equally potent[23] – an assumption that has the sole virtue of being certain to be incorrect. As shown in quantitative studies,[24] the equal potency assumption overstates likely risks from $PM_{2.5}$ changes. The probability that the

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[21] See 78 Fed. Reg. 3086, January 15, 2013 for PM2.5 NAAQS rationale, and 76 Fed. Reg. 16436, March 27, 2008 for ozone NAAQS rationale. For example, in 78 *Fed. Reg*. 3086 at 3139: "In reaching decisions on alternative standard levels to propose, the Administrator judged that it was most appropriate to examine where the evidence of associations observed in the epidemiological studies was strongest and, conversely, where she had appreciably less confidence in the associations observed in the epidemiological studies;" and at 3161: "The Administrator views this information as helpful in guiding her determination as to where her confidence in the magnitude and significance of the associations is reduced to such a degree that a standard set at a lower level would not be warranted to provide requisite protection that is neither more nor less than needed to provide an adequate margin of safety." Similarly, for the current ozone NAAQS, the District Court for District of Columbia accepted EPA's rationale for the current ozone NAAQS in 76 *Fed. Reg*. 16436 that an ozone NAAQS did not need to be lower than 0.075 ppm despite clinical evidence of some health responses at lower concentrations "because it 'would only result in significant further public health protection if, in fact, there is a continuum of health risks in areas with 8-hour average O3 concentrations that are well below the concentrations observed in the key controlled human exposure studies and if the reported associations observed in epidemiological studies are, in fact, causally related to O3 at those lower levels.' *Id* [at 16,483]. Based on the uncertainties EPA had identified 'in interpreting the evidence from available controlled human exposure and epidemiological studies at very low levels,' EPA was 'not prepared to make these assumptions.' *Id*." (U.S. Court of Appeals for the District of Columbia Circuit, State of Mississippi v. Environmental Protection Agency, No. 08-1200, decided July 23, 2103.)

[22] RIA, p. 4-41.

[23] See footnote (c) on Tables ES-8 through ES-10 (RIA, pp. ES-21 to ES-23).

[24] Smith and Gans (2014); Fraas and Lutter (2013).

overstatement is very large (even 100%) rises when the risk estimate is based on changes in just one of the many possible $PM_{2.5}$ culprits. That is much the situation here, where such a very large portion of the co-benefits are derived from a single $PM_{2.5}$ constituent, sulfate.

The above problems are not possible to completely demonstrate for this RIA because EPA has relied on very simplistic $/ton estimates for the criteria pollutant precursor emissions. These $/ton estimates are unable to account for the level of criteria pollutant in the areas where the tons are reduced.[25] Indeed, EPA does not even develop a baseline projection of the $PM_{2.5}$ and ozone levels against which the CPP-related precursor emissions would occur. These create large uncertainties in an already dubious and uncertain risk analysis process.[26]

In fact, it is highly likely that each of the precursor emissions will increase in some locations, while decreasing in others. This is the standard result of a policy like the CPP that allows the electricity generation system (which is a network of many individually-located electricity generating units) to find the least-cost compliance strategy with flexibility in where the compliance actions will occur. That is, as some generating units are shut down to meet the CPP, others that do not shut down may increase their generation to make up for the lost load. This pattern of geographically differential impacts to emissions is a primary concern expressed by advocates for environmental justice.

This geographical distribution of emissions changes could also greatly alter the RIA's total co-benefits estimates – they could potentially be much smaller if the increases in emissions occur in more populated areas than where the decreases occur. However, the RIA does not explore this possibility. Instead, the RIA states that it has no ability to determine where the air quality changes will occur,[27] which a substantial overstatement of the problem. The estimates of precursor tons reduced that are the basis for the co-benefits estimates come from IPM model outputs. The IPM model has unit-specific detail, which means that locational information on the emissions reductions also could be obtained from its outputs.[28] At a minimum, the RIA should provide maps showing the

[25] RIA, pp. 4-23 to 4-24.

[26] See Smith and Gans (2014) for a detailed exploration of the uncertainties in the $PM_{2.5}$ risk analyses that are used to generate the $/ton estimates used to generate the benefits estimates in this RIA, as well as in EPA's other, more sophisticated criteria pollutant benefits analyses.

[27] RIA, p. 4-40.

[28] The main complication for estimating the location of emissions increases would apply only to NO_x, which is the only precursor emission that would come from future new generating capacity. The IPM model does not identify the precise location of new capacity, but only where it would be within one of 64 electricity market regions of the

location of increases and decreases of emissions from existing generating units, even though EPA's short cut of using $/ton benefits values does not allow the benefits calculation to be more refined. Environmental justice advocates would be particularly interested in this aspect of the co-benefits, as they might reveal inequities that can be traced to locations of disadvantaged populations. However, EPA only reports the net CO_2, NO_x, and directly emitted $PM_{2.5}$ reductions in three large regions of the country ("East", West", and California),[29] and does not note that these net reductions are made up of emissions increases in some locations and decreases in others.

Although it would be possible for EPA to map the locations of the emissions changes for its specific implementation assumptions, there are many additional uncertainties with those estimates due to uncertainty on how compliance with the CPP might be achieved. EPA's analysis considers only two alternative implementation strategies even though the array of compliance options is vast and highly uncertain. Small differences in issues such as whether end-use energy efficiency programs will be a major element of compliance activities or whether greater changes in the generation mix will be required can vastly change the number of tons of SO_2 that may be reduced under the CPP. It can also change the location of where reductions will occur. These have not been considered in the RIA, although they are eminently amenable to analytical evaluation through additional IPM runs. If explored, it is likely that the range of uncertainty on the co-benefits estimates would be much greater.

Reasons Co-Benefits of Already-Regulated Pollutants Should Not Justify Regulations of Other Types of Pollutants.

As noted above, most of the co-benefits in the RIA would be attributed to changes in the criteria pollutants in areas already in compliance with the health-based NAAQS. Those co-benefits must be viewed as overstated and potentially non-existent. That leaves the question of what should be done with co-benefits in areas that the baseline regulatory scenario does not find to be attaining the NAAQS. First, although the RIA does not provide the requisite data, this must be an exceedingly small portion of the co-benefits, if any, because the baseline for the CPP contains all existing regulations. Since the annual $PM_{2.5}$ NAAQS of 12 $\mu g/m^3$ is already promulgated, its compliance should be

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U.S. However, because all of the SO_2 emissions changes under the CPP will be from currently existing coal-fired power plants, the precise location of the SO_2 changes can easily be identified from IPM model results, including where the increases occur and where the decreases occur.

[29] RIA, Tables 4-10 to 4-12, pp. 4-28 to 4-30.

mostly assured already.[30] Second, although the ozone NAAQS is currently under review and may be set more stringently by the time that the CPP is being implemented, only a tiny fraction of the co-benefits are due to ozone rather than $PM_{2.5}$. Nevertheless, whatever small quantity of the co-benefits that the RIA attributes to the CPP are associated with changes in areas not already attaining each NAAQS, those reductions are going to occur even if the CPP were not to be implemented. State implementation plans (SIPs) will be required and enforced in those areas during the same time period, whether or not the CPP exists. Thus, that fraction of those so-called co-benefits should not be attributed to the CPP – they will occur as direct benefits of NAAQS, both present and future. The CPP should not take credit for those estimated eventual NAAQS-related health benefits merely because the RIA for the CPP precedes some of the eventual NAAQS-mandated controls on criteria pollutant precursor emissions.

Finally, even if individuals other than the EPA Administrator were to have confidence in the continued existence of such substantial health effects associations for $PM_{2.5}$ and ozone, to let a climate-related regulation take credit for those reductions is a recipe for unnecessary regulations that result in economically inefficient management of the public health. For this reason, the co-benefits of already-regulated pollutants such as the criteria pollutants should not be included as benefits in regulations that are intended to manage altogether different risks, such as climate change.

IV. Conclusion

In conclusion, the RIA's benefits estimates for climate benefits are presented in a misleading and technically incorrect manner. When the technical issues are corrected and the results presented in a more informative manner, it is clear that a benefit-cost case for the CPP based on its intended climate benefits is extremely tenuous, and will impose significant near-term costs, with almost no near-term benefits. The net benefits case that remains is founded on very unreliable estimates of co-benefits from changes in pollution that have nothing to do with climate benefits. Further, they are overstated even against the EPA Administrator's established judgments about those pollutant risks, and should – at best – be assigned to future NAAQS-mandated regulations for criteria pollutants; such co-benefits estimates should not be used to bolster a weak benefit-cost case for a totally unrelated regulation of greenhouse gases.

[30] Further, the RIA for that NAAQS (EPA, 2012) indicated that only a few areas in California would not attain that NAAQS by 2020. Additional analyses by Smith (2014b) show that only a very small geographic portion of those areas would actually be above the NAAQS level.

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Appendix A

Deriving the Present Value of Total Compliance Costs that Summarized in the RIA Only As Annualized Values for the Years 2020, 2025, and 2030

The EPA's annual compliance costs presented in this report are derived from EPA's IPM Model outputs,[31] along with input assumptions from EPA's *Documentation for EPA Base Case v.5.13 Using the Integrated Planning Model*,[32] selected Technical Support Documents, and other assumptions as described below.

The starting point for the annual incremental costs associated with the CPP are the EPA's "SSR" output files, which include a range of results for each model year (2016, 2018, 2020, 2025, 2030, 2040, and 2050). These outputs include "Total Annual Production Costs," with the costs broken down between Variable O&M, Fixed O&M, Fuel, Capital, Pollutant Transport & Storage, and Total.[33] EPA outputs for the Base Case and Option 1 – State have been reproduced in Table A1 and Table A2.

Table A1: Base Case Annual Production Costs from EPA Output File

Base Case – April 2014 Draft							
	2016	2018	2020	2025	2030	2040	2050
15. Total Annual Production Cost [MMUS$](*)							
Variable O&M	13870	14334	14668	15427	15960	18059	20485
Fixed O&M	50617	52448	53261	56723	59347	54116	45188
Fuel	90035	95899	100214	115005	126656	164619	239103
Capital	4919	8228	9660	15772	22733	32504	48501
Pollutant Transport & Storage	0	0	-27	-27	-27	-27	-27
Total	159441	170908	177777	202901	224670	269270	353250
Sales Revenue	0	0	0	0	0	0	0
(*) Costs include only those items that are important for determining incremental cost of pollution control							

[31] IPM Model Outputs ("SSR" files) are available at: http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html. These costs are from the EPA Base Case for the proposed Clean Power Plan and Option 1- State.

[32] IPM model documentation is available at: http://www.epa.gov/airmarkets/progsregs/epa-ipm/BaseCasev513.html.

[33] These data are included in Table 15 on the Table 1-16_US worksheet for the SSR file for both the Base Case and Option 1- State.

Table A2: Option 1 – State Annual Production Costs from EPA Output File

Option 1 State – April 2014 Draft							
	2016	2018	2020	2025	2030	2040	2050
15. Total Annual Production Cost [Million US2011$](*)							
Variable O&M	13747	13621	13330	13057	13001	14839	17072
Fixed O&M	48706	50302	50156	52687	54667	49193	40151
Fuel	90093	90213	94883	94873	101247	126195	188355
Capital	4696	10884	16694	18929	21807	23291	36471
Pollutant Transport & Storage	0	0	-27	-27	-27	-27	-27
Total	157242	165019	175036	179519	190695	213492	282023
Sales Revenue	0	0	0	0	0	0	0
(*) Costs include only those items that are important for determining incremental cost of pollution control							

It is important to note that Total Annual Production Costs do not include any costs associated with Energy Efficiency. Energy efficiency costs are from a *Technical Support Document for GHG Abatement Measures*.[34] The relevant energy efficiency costs are the Annual first-year costs (including both the program and participant costs of the energy efficiency). These costs are available for each year beginning in 2017 (not just years modeled in IPM), and are reproduced in Table A3. I note that in EPA's Regulatory Impact Analysis, they have used annualized energy efficiency costs as part of their summary of compliance costs (Table ES-4), which has the impact of pushing costs out into the future (undiscounted first-year costs in Table 3 for 2017 through 2030 are $513 billion, while undiscounted annualized energy efficiency costs are $320 billion, or nearly $200 billion lower) and making the compliance spending in 2020, 2025, and 2030 appear lower than they would actually be (even while still using only EPA's cost assumptions).

Table A3: Annual First-Year Energy Efficiency Costs

Table 4A. National level information on costs (2017 - 2050)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual first-year costs (2011 $ M)														
Annual total cost of EE	$14,728	$20,475	$26,054	$30,778	$34,706	$39,118	$41,990	$43,604	$43,750	$43,663	$43,615	$43,605	$43,634	$43,699
Annual program cost of EE	$7,364	$10,238	$13,027	$15,389	$17,353	$19,559	$20,995	$21,802	$21,875	$21,832	$21,807	$21,803	$21,817	$21,850
Annual participant cost of EE	$7,364	$10,238	$13,027	$15,389	$17,353	$19,559	$20,995	$21,802	$21,875	$21,832	$21,807	$21,803	$21,817	$21,850

To translate costs for different model years to each individual year it is necessary to know how EPA maps non-modeled years to model years. This information is included in EPA 5-13_Base_Case DAT Replacement File.xlsx, in the RunUniverse worksheet. Table A4 contains the mapping of non-modeled years to modeled years from this file. Thus, when determining costs for non-modeled years we looked at the Year Map column (*e.g.*, to get the costs for 2017, a non-modeled year, we use the costs for 2016). This methodology was used for the following cost categories: Variable O&M, Fixed O&M, Fuel, and Pollutant Transport & Storage. This approach is not appropriate for capital

[34] Available at: http://www2.epa.gov/sites/production/files/2014-06/20140602tsd-ghg-abatement-measures-appendix5-4.xlsx. The relevant numbers are in the Opt 1 Costs @ 3% or Opt 1 Costs @ 7% worksheet.

costs because they are one-time charges (and not costs that would also appear in non-modeled years once they have been converted to estimated overnight capital spending as opposed to annualized capital charges). This approach is also not used, nor is it relevant for energy efficiency costs, because these costs are available in each year, not just modeled years.

Table A4: EPA IPM Year Mapping

Universe Year	RUN(Y/N)	Year Map
2016	YES	2016
2017	NO	2016
2018	YES	2018
2019	NO	2020
2020	YES	2020
2021	NO	2020
2022	NO	2020
2023	NO	2025
2024	NO	2025
2025	YES	2025
2026	NO	2025
2027	NO	2025
2028	NO	2030
2029	NO	2030
2030	YES	2030

The final step in converting EPA's cost outputs into those used in this report was to convert from the reported annualized capital costs to estimated overnight capital spending. Annualized capital costs are representative of the payments on capital made by the borrowing companies over time, and do not reflect that the capital was actually spent entirely in the few years prior to the emissions reductions that it would enable start to occur. For example, if one were to build a new 500 MW natural gas combined cycle unit that begins commercial operation in 2020 it would cost about $500 million in 2020,[35] rather than a series of payments of $50 million per year for 20 years starting in 2020. Similar to its treatment of energy efficiency costs, EPA also included annualized capital costs as part of its summary of compliance costs (Table ES-4 in the RIA).

Performing these calculations required identifying the different capital investments between the Base Case and Option 1 – State. These investments include differences in new capacity builds and retrofits of energy efficiency on existing capacity. The capacity builds and retrofits for each case are included in the same "SSR" file that includes the

[35] Technically, spending would occur in the several years leading up to the commercial operation of a new unit, but this analysis did not move spending up before the commercial operation date. Not doing this, understates the present value of costs.

Total Annual Production Costs, except that they appear are on the Summary worksheet. First, we calculated the differences in new capacity builds and retrofits by type (*e.g.*, natural gas combined cycle, wind, heat rate improvement). Sometimes the difference was positive (more builds in the Option 1 – State case than in the Base Case) and sometimes the opposite was true. The differences (in GWs) were then multiplied by the overnight capital costs for each type of technology. These overnight capital costs are included in Chapter 4 of the IPM model documentation (for new capacity builds) and in Chapter 5 for the retrofits.

The resulting net estimated overnight capital spending, including both increases and decreases in capital spending between the Base Case and Option 1- State, were then placed only into IPM model years (2016, 2018, 2020, 2025, and 2030) for purposes of the cost analysis prepared in these comments.

Combining the Variable O&M, Fixed O&M, Fuel, and Pollutant Transport & Storage costs with the Energy Efficiency costs (adjusted to be first-year costs) and the Capital costs (adjusted to be overnight costs) produced the total expenditures by year of actual spending that are used in these comments to estimate the timing and present value of CPP compliance costs for 2016-2030. The resulting values are shown in Table A5. All of these estimates are derived from EPA's own modeling and output files. The total spending through 2030 is $260 billion, which has a present value of $204 billion. It is the present values of spending ("discounted costs") that are graphed in Figure 1 of the comments and in the odd-numbered figures in Appendix B and C.

Table A5: Total Real and Discounted Compliance Spending by Year Relative to Baseline Costs (billions of 2011$; 3% discount rate used for row 2)

	Total (2016-2030)	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Spending during each year (billions of 2011$)	**260**	(3)	13	28	16	46	25	29	15	17	9	17	17	11	11	9
Present value in 2014 (billions of 2011$)	**204**	(3)	12	25	14	39	20	23	12	13	7	12	12	7	7	6

Appendix B
Five Alternative Temporal Profiles for Climate Benefits and Net Benefits of CPP

Figure B1. Present Value of Spending (blue) and Climate Benefits (red) by Year ($ billions per year, 2011$)

For Option 1 "state compliance," using costs from IPM runs used in RIA and for climate benefits based on the 3% SCC values in Table 4-2 of the RIA. Benefits' timing is based on DICE with <u>MERGE-Optimistic</u> case.

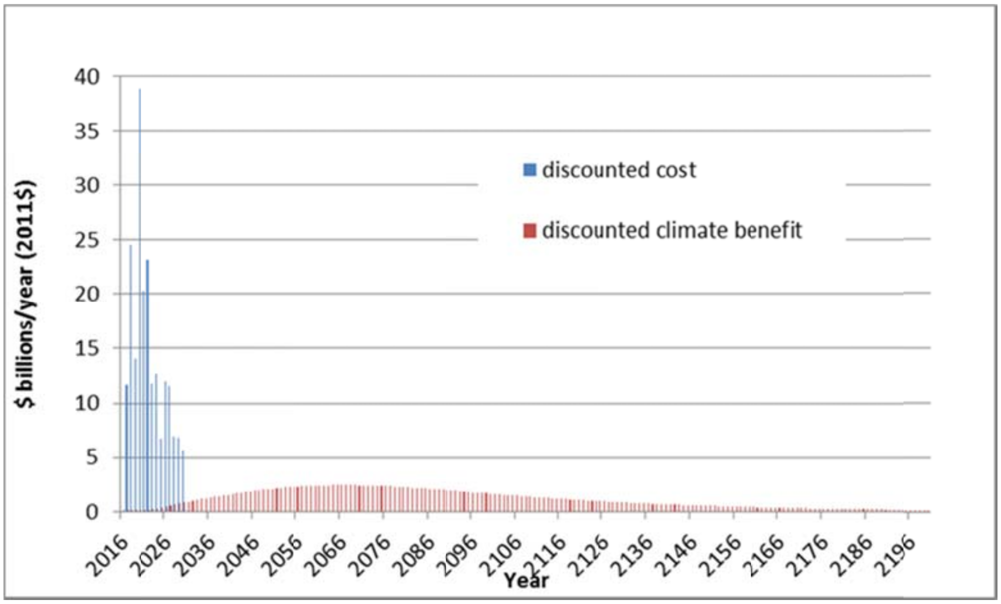


Figure B2. Cumulative Net Benefits over Time (billions of 2011$)

For Option 1 "state compliance," using costs from IPM runs used in RIA and for climate benefits based on the 3% SCC values in Table 4-2 of the RIA. Benefits' timing is based on DICE with <u>MERGE-Optimistic</u> case.

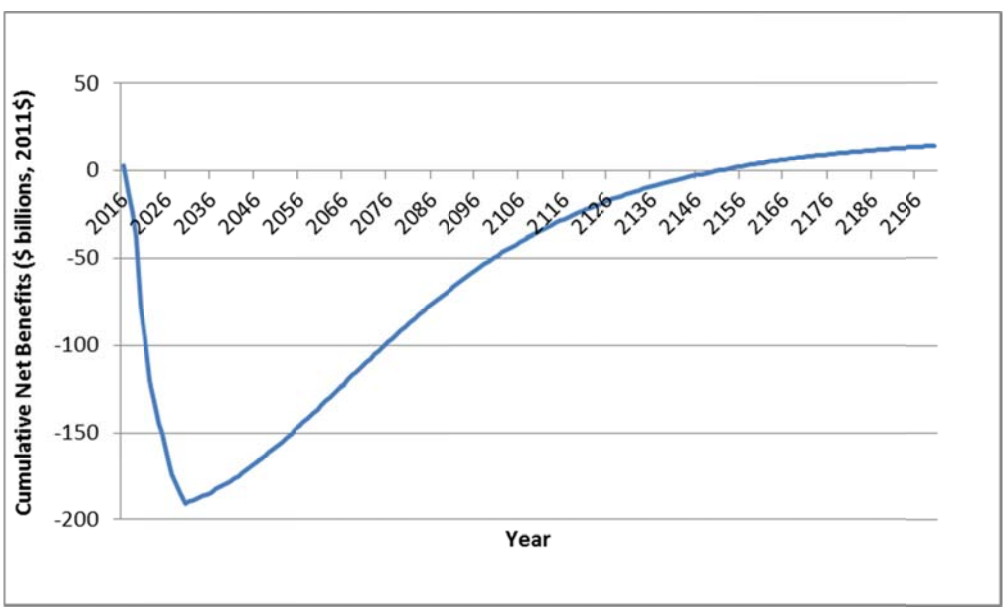


Figure B3. Present Value of Spending (blue) and Climate Benefits (red) by Year ($ billions per year, 2011$)

Benefits' timing is based on DICE using the IMAGE Scenario, climate sensitivity = 3, and discount rate =3%.

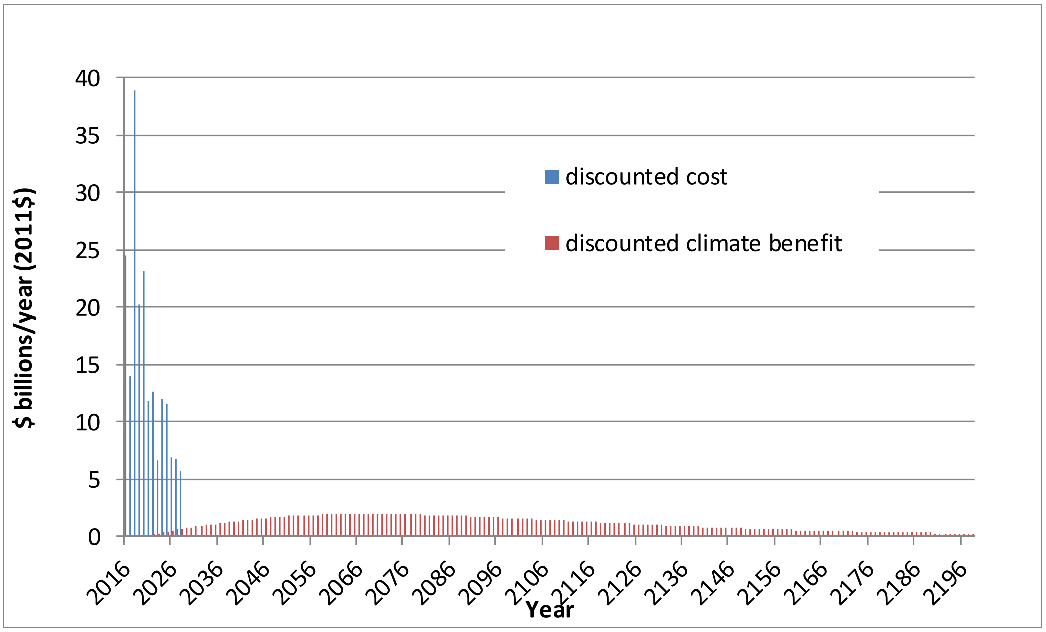


Figure B4. Cumulative Net Benefits over Time (billions of 2011$)

Benefits' timing is based on DICE using the IMAGE Scenario, climate sensitivity = 3, and discount rate =3%.

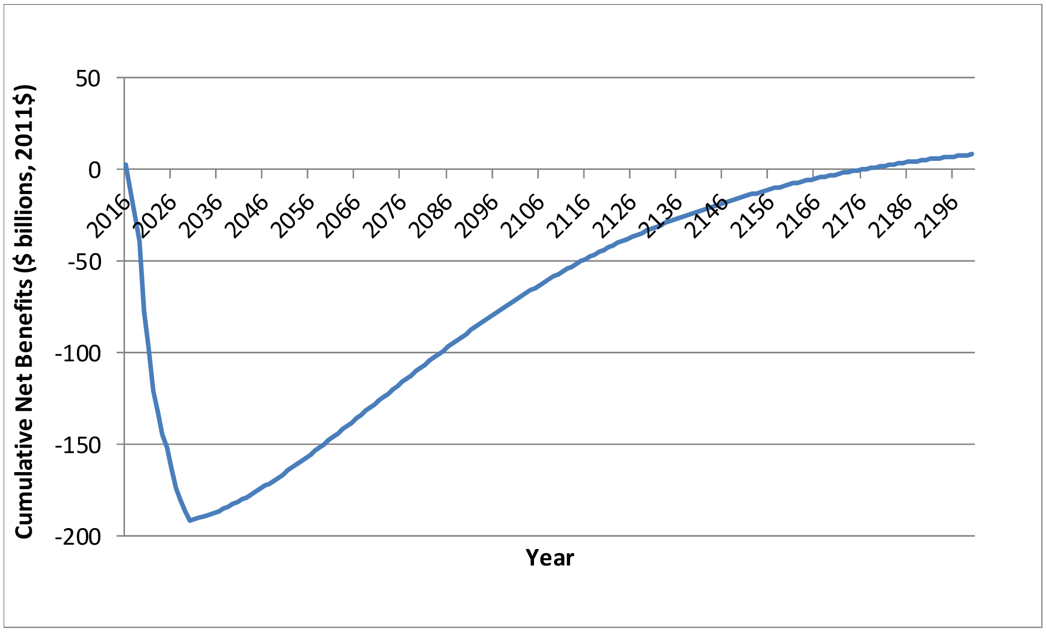


Figure B5. Present Value of Spending (blue) and Climate Benefits (red) by Year ($ billions per year, 2011$)

Benefits' timing is based on DICE using the Message Scenario, climate sensitivity = 3, discount rate =3%.

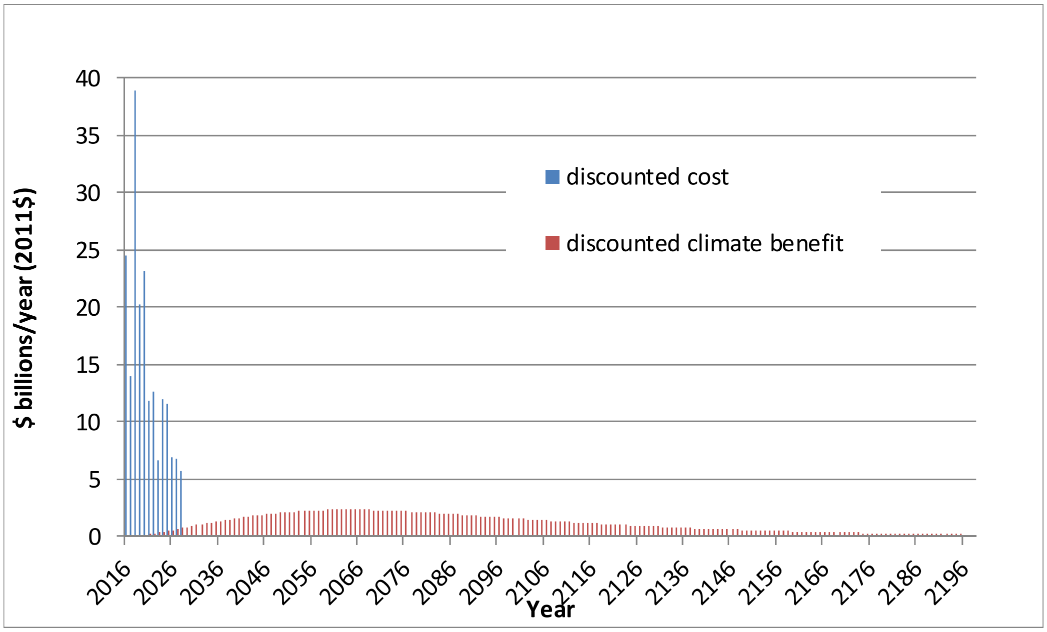


Figure B6. Cumulative Net Benefits over Time (billions of 2011$)

Benefits' timing is based on DICE using the Message Scenario, climate sensitivity = 3, discount rate =3%.

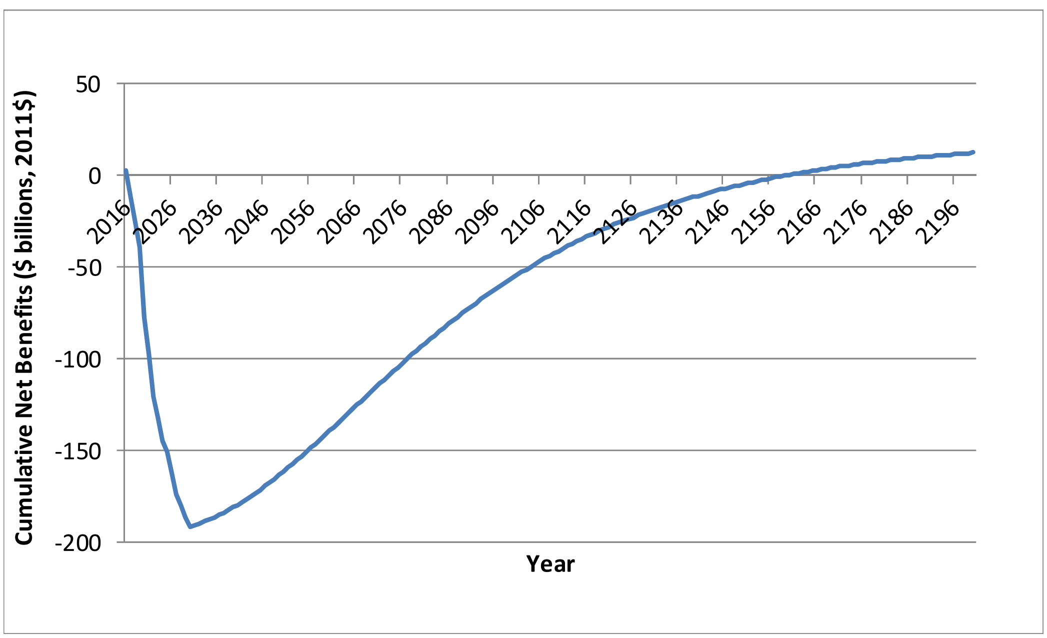


Figure B7. Present Value of Spending (blue) and Climate Benefits (red) by Year ($ billions per year, 2011$)

Benefits' timing based on DICE using MiniCAM base Scenario, climate sensitivity = 3, discount rate =3%.

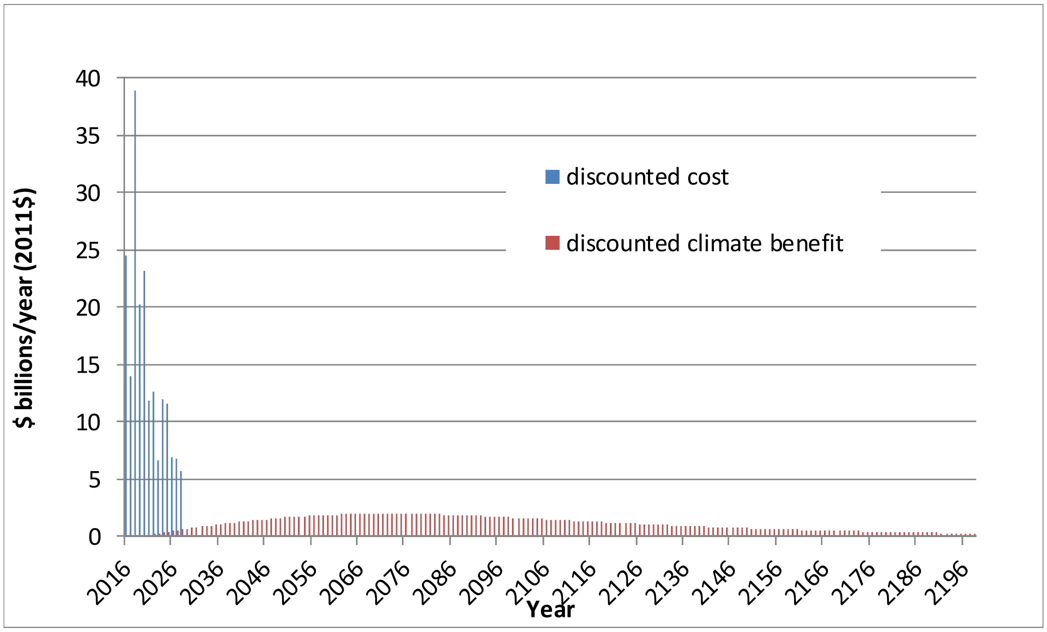


Figure B8. Cumulative Net Benefits over Time (billions of 2011$)

Benefits' timing is based on DICE using MiniCAM base Scenario, climate sensitivity = 3, discount rate =3%.

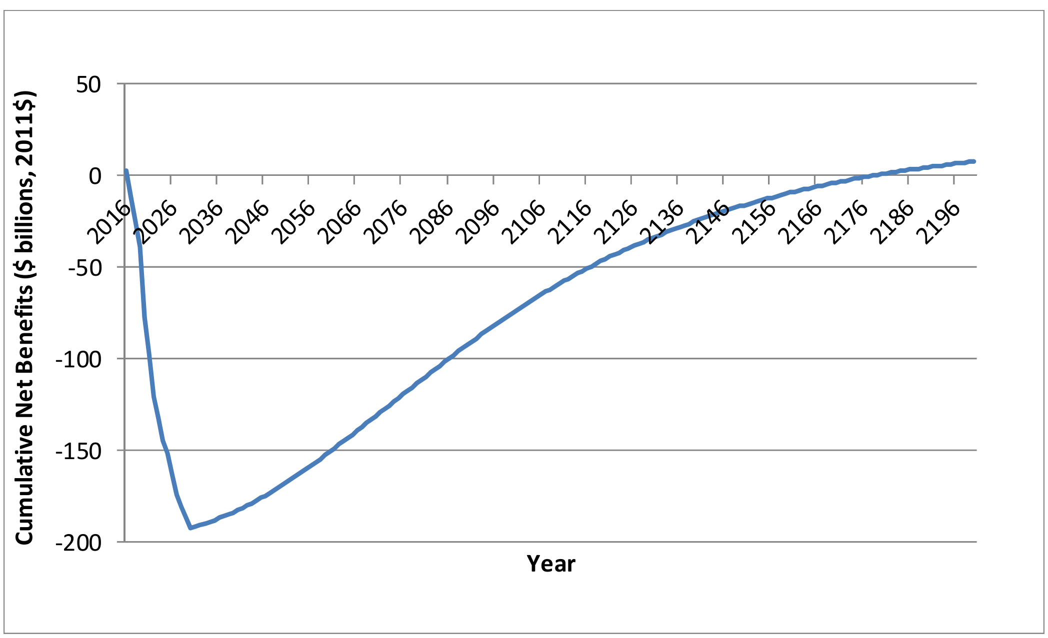


Figure B9. Present Value of Spending (blue) and Climate Benefits (red) by Year ($ billions per year, 2011$)

Benefits' timing is based on DICE using the 5th Scenario, climate sensitivity = 3, and discount rate =3%.

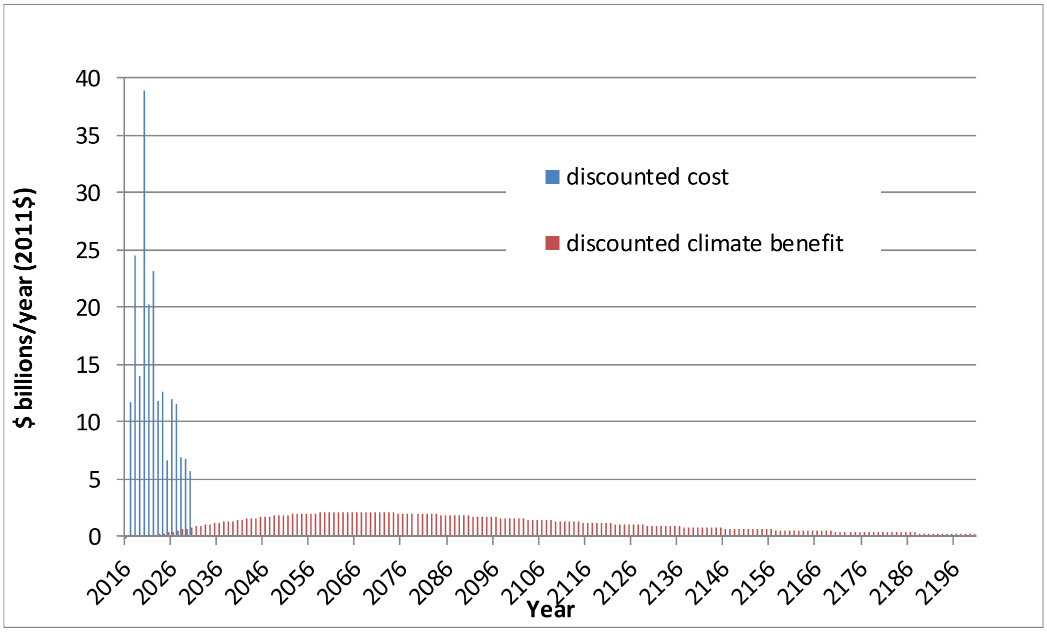
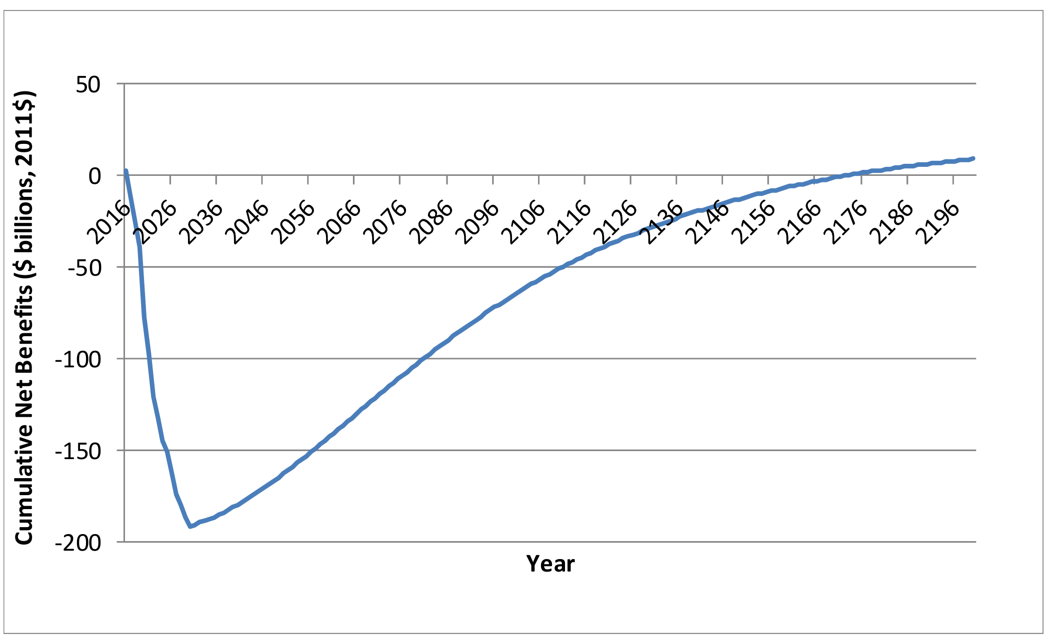


Figure B10. Cumulative Net Benefits over Time (billions of 2011$)

Benefits' timing is based on DICE using the 5th Scenario, climate sensitivity = 3, and discount rate =3%.



Appendix C

Timing of Net Benefits for the Remaining Three Sets of Federal SCC Values

Note: Results for the 3% discount rate SCC values are Figures B1 and B2 of Appendix B.

Figure C1. Present Value of Spending (blue) and Climate Benefits (red) by Year for 5% SCC Values ($ billions per year, 2011$)

Benefits' timing is based on DICE using the MERGE-Optimistic Scenario, climate sensitivity = 3, and <u>discount rate = 5%</u>.

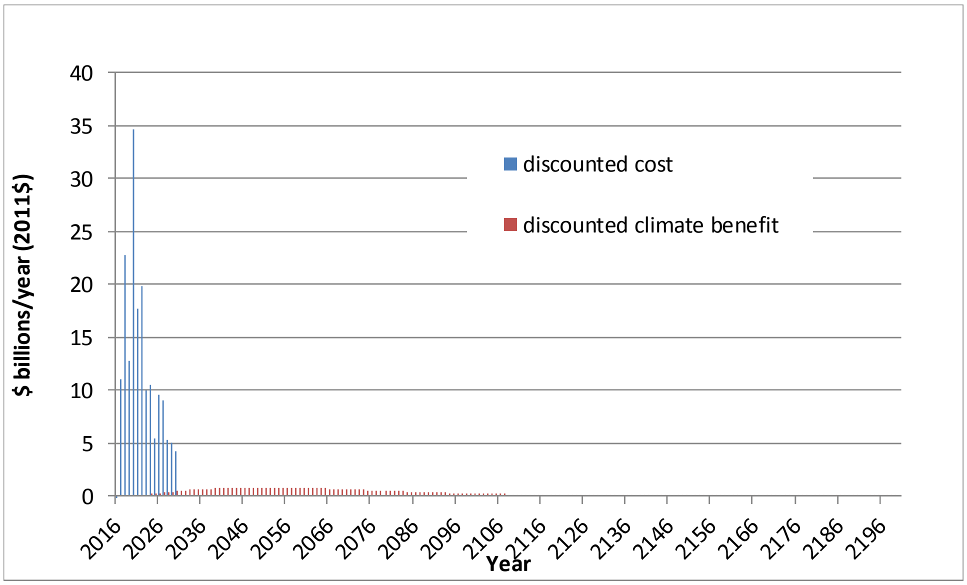


Figure C2. Cumulative Net Benefits over Time (billions of 2011$) for 5% SCC Values

Benefits' timing is based on DICE using the MERGE-Optimistic Scenario, climate sensitivity =3, and <u>discount rate = 5%.</u>

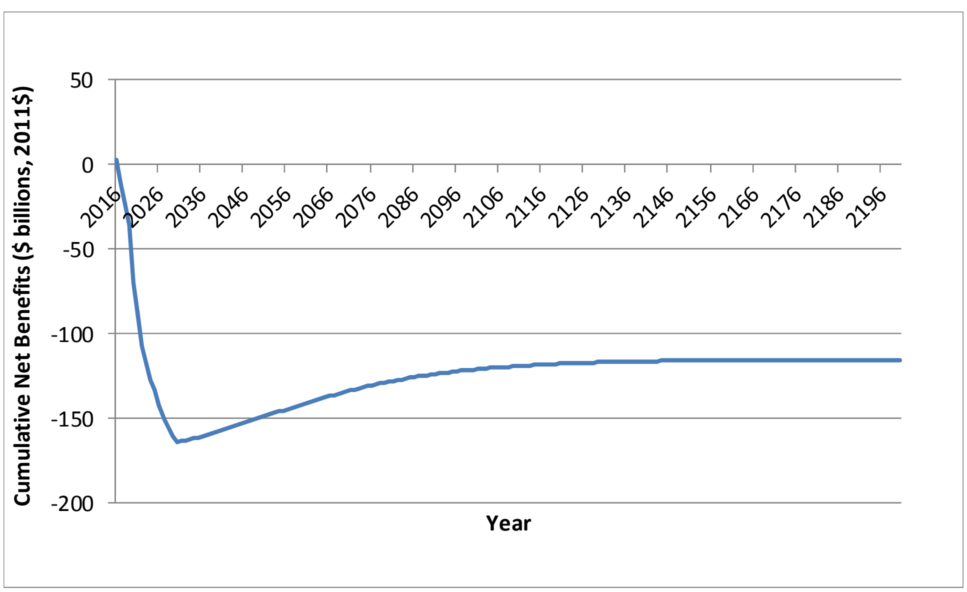


Figure C3. Present Value of Spending (blue) and Climate Benefits (red) by Year for 2.5% SCC Values ($ billions per year, 2011$)

Benefits' timing is based on DICE using the MERGE-Optimistic Scenario (the scenario with the shortest projected payback period), climate sensitivity = 3, and <u>discount rate =2.5%.</u>

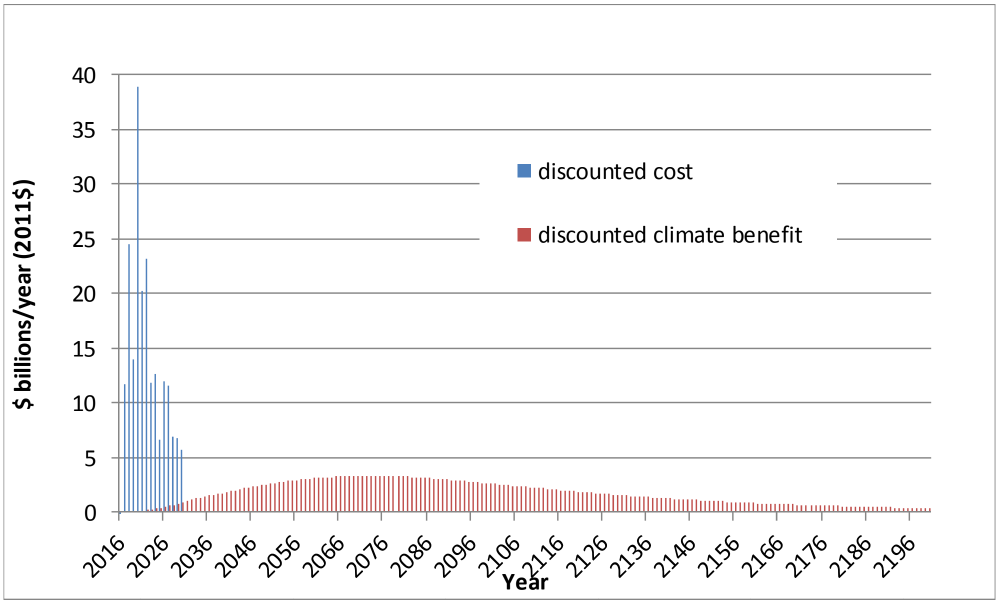


Figure C4. Cumulative Net Benefits over Time (billions of 2011$) for 2.5% SCC Values

Benefits' timing is based on DICE using the MERGE-Optimistic Scenario, the scenario with the shortest projected payback period, climate sensitivity =3, and <u>discount rate = 2.5%.</u>

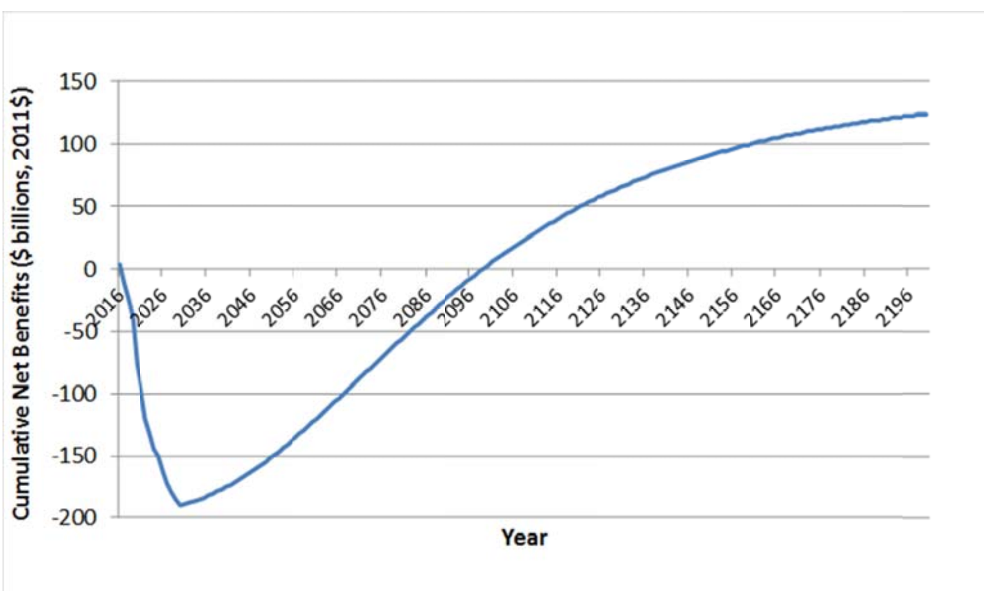


Figure C5. Present Value of Spending (blue) and Climate Benefits (red) by Year for 95th Percentile SCC Values ($ billions per year, 2011$)

Benefits' timing is based on DICE using the MERGE-Optimistic Scenario, <u>climate sensitivity = 7.14, and discount rate = 3%</u>, *i.e.*, the 95th percentile pessimistic SCC value

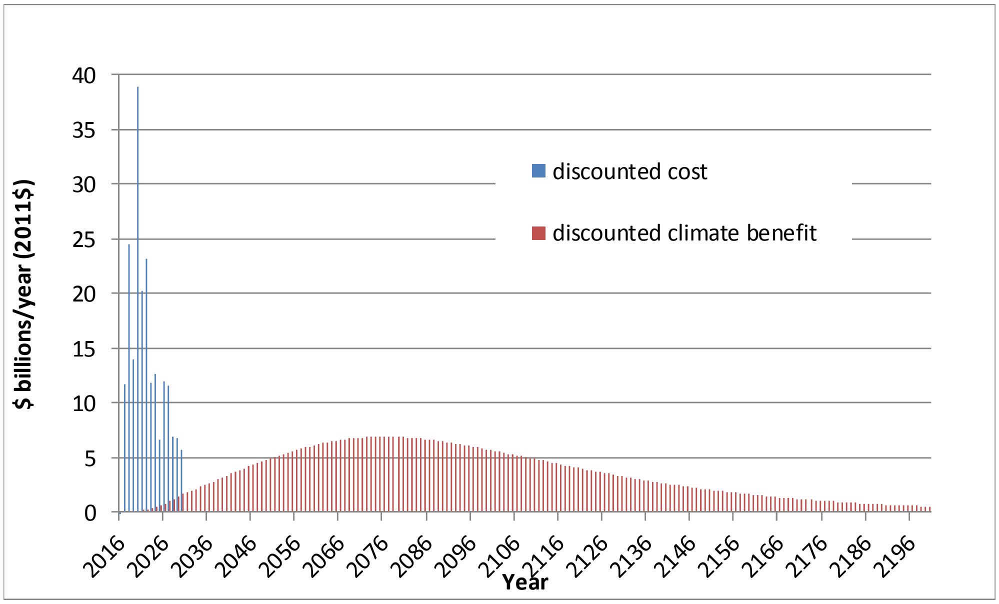


Figure C6. Cumulative Net Benefits over Time (billions of 2011$) for 95th Percentile SCC Values.

Benefits' timing is based on DICE using the MERGE-Optimistic Scenario, <u>climate sensitivity =7.14, and discount rate = 3%,</u> *i.e.*, the 95th percentile pessimistic SCC value.