September 2, 2025

Public Comment on the DOE: A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate

Introduction

Thank you for the opportunity to comment on the DOE's Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate. We are a group of leading scholars in climate and environmental economics with expertise in econometric methods and economic modeling especially as it applies to the environment and climate. Our collective work includes peer-reviewed research that has been foundational to understanding agricultural economics, climate damages, tipping points, the social cost of carbon, and benefit-cost analysis, including some of which is cited in this report.

As experts in the field, we write to provide comments on the Department of Energy's report *A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate* (July 2025). We focus on:

- Chapter 9: *Climate Change and U.S. Agriculture*
- Chapter 11: *Climate Change, the Economy, and the Social Cost of Carbon*
- Chapter 12: *Global Climate Impacts of U.S. Emissions Policies*

In summary, we conclude:

- This report's review of the relevant economics literature is woefully out of date; the selective referencing of dated research and non-peer reviewed essays misrepresents the state of knowledge; and this assessment fails to consider the past decade of peer-reviewed scholarship documented extensively in EPA (2023).

- The report's discussion of the social cost of carbon (SCC) suggests that this measure is based on a set of arbitrary assumptions, when the current state of knowledge is built on a body of careful empirical research based on the increasing evidence of climate damages.

- The report employs an array of fallacies to give the impression that climate damages are small relative to other trends that are unrelated to the impacts of greenhouse gas emissions on public health and welfare.

- Every ton counts. Employing the standard economic framework for determining if a risk should be addressed through a policy intervention – and the framework guiding Federal regulatory impact analysis for more than four decades – requires a weighing of the benefits and costs of a policy action relative to the appropriate no-new-policy baseline.

The report repeatedly employs strawman scenarios and fallacious reasoning inconsistent with this framework.

- The report grossly misstates the consensus of economists, who do not recommend a “wait and see” approach, but instead overwhelmingly recommend efficient policies to support clean energy innovation and internalize the greenhouse gas externality as documented in the peer-reviewed literature.
- The report misrepresents the net effect of climate change impacts on U.S. agriculture. Climate change will cause significant, negative declines in corn and soybean yields.
- The report focuses on GDP, which does not measure welfare and is an incomplete measure of the impacts of greenhouse gas emissions. In doing so, the report does not appropriately account for non-market climate damages, such as premature mortality from heat stress and climate change-induced wildfire smoke.
- The treatment of uncertainty in this report is inconsistent with standard approaches in decision sciences and the literature on decision-making under uncertainty applied to climate change. Uncertainty is not a facile excuse for inaction, but should inform the strategy for managing the risks of a changing climate.

We elaborate on these and other comments in the following. Each of our comments is numbered, references a specific page number in the published report, and identifies the type of comment.

Comments by Chapter

Chapter 9 - Climate Change and U.S. Agriculture

Chapter 9 of the review cites two papers by Roberts, Schlenker, and Taylor and concludes "In summary, there is abundant evidence going back decades that rising CO_2 levels benefit plants, including agricultural crops, and that CO_2-induced warming will be a net benefit to U.S. agriculture."

The goal of these scholars' research has been to estimate both the negative effects of climate change primarily through an increase in extreme heat (Schlenker and Roberts 2009) and the positive effects of rising CO2 levels on agricultural yields (Schlenker and Taylor 2023) in order to obtain the net effect.

We would like to offer the following comments:

1. **The negative effects of increases in extreme heat outweigh the beneficial effects of CO_2 fertilization.** *Technical Comment* (p. 104-106)
   Due to the accelerated increase in extreme heat from continued warming, the negative impact of additional extreme heat becomes more pronounced over time[1], further highlighting the benefits of limiting future warming.
   Schlenker and Roberts (2009) estimated the effects of changes in temperature and precipitation on U.S. corn, soybean, and cotton yields. We present the predicted changes in Table 1 under "Climate Effects" for the four SRES scenarios used in the Third Assessment Report (AR3), ranging from the more moderate B1 to the fossil-fuel intensive A1FI scenario. The corresponding increases in CO_2 levels are taken from Figure 1 of the IPCC data repository.[2]
   CO_2 fertilization is traditionally estimated using chamber and field experiments. Taylor and Schlenker (2023), a working paper, complements these approaches by using satellite data to estimate CO_2 fertilization under real-world growing conditions by linking CO_2 anomalies as measured by NASA's Orbiting Carbon Observatory (OCO-2) to county-level corn, soybean, and wheat yields. Table 1 uses the central point estimate

[1] Extreme heat is measured by how much and for how long temperatures exceed crop-specific thresholds. For corn, the threshold is 29°C (84°F). Warming temperatures only increase the measure of extreme heat once they surpass this threshold, an occurrence that becomes more frequent with continued warming.

[2] We note that more recent Assessment Reports have switched to RCPs but for consistency we rely on what was used in Schlenker and Roberts (2009).

from this study to calculate the effect on yields in the row labeled "CO_2 fertilization [2023 draft]," as well as to determine the net effect of climate and CO_2 fertilization.

The advantage of Taylor and Schlenker (2023) is that it estimates the effect across the commercially farmed corn, soybean, and wheat growing areas in the U.S., rather than focusing on a few test plots.[3] The main challenge lies in obtaining an accurate measure of exposure and the relative sparseness of satellite data. Taylor and Schlenker recently revised the paper and made two major updates:

a. They find that CO_2 variation in the crop canopy (near ground level) is larger than what is observed by the satellite (which measures the entire air column below it), so they need to rescale the satellite variation accordingly.[4]
b. They are extending the analysis to later years as more satellite data become available (using both OCO-2 and the more recently launched OCO-3).

The row labeled "CO_2 fertilization [current]" derives the CO_2 fertilization effect under these revised numbers which are lower.

2. **The CO_2 fertilization effect is most pronounced for wheat, and more muted for corn and soybeans**. *Technical Comment* (p. 105-108)
Crop responses to CO_2 depend on local environmental conditions and the specific limiting factors they face. However, C3 plants (such as wheat and soybeans) are expected to experience a higher CO_2 fertilization effect than C4 plants (such as corn). In our analysis, we find the largest effect on wheat, followed by soybeans, and then corn. In 2025, the U.S. planted 95.2 million acres of corn, 83.4 million acres of soybeans, and 45.5 million acres of wheat (USDA NASS 2025), meaning the two largest commodity crops—corn and soybeans—are likely to see a weaker CO_2 fertilization response relative to wheat.

3. **Climate change will significantly alter the agricultural economy across different regions of the U.S.** *Technical Comment* (p. 105-108)

[3] Free-air concentration enrichment (FACE), a process involving a series of pipes in fields emitting CO_2, has allowed for larger-scale trials in more realistic crop growing conditions. However, the geographic extent is limited: there are only two long-standing FACE experiments in the US that focus on agriculture: Arizona FACE in Maricopa, AZ, and SOYFACE in Champaign, IL, with only the latter in the Midwestern breadbasket.

[4] An example helps illustrate this point: assume that yields increase by 0.4% in a county, and the satellite measures an average increase in CO_2 of 1 ppm in the air column below it. This results in a CO_2 fertilization effect of 0.4% / 1ppm = 0.4% per ppm. FluxTower data confirm that variations in CO_2 concentrations are greater near the ground than at higher altitudes where there is more mixing and concentrations are more uniform. Continuing the example, suppose that CO_2 increases by 4 ppm within the crop canopy (2 meters above ground for corn), while the average across all heights in the air column increases by only 1 ppm. In this case, the CO_2 fertilization effect would be 0.4% / 4ppm = 0.1% per ppm, which is four times less.

The review focuses on aggregate outcomes for the U.S., but it is important to emphasize that the effects of climate change will vary greatly across different regions. The nonlinear adverse impact of rising temperatures will be felt more acutely in areas that are already warm, while the beneficial effects of CO_2 fertilization are likely to be more uniform nationwide for a given crop. As a result, climate change will shift the comparative advantage in growing agricultural commodities toward cooler (primarily northern) U.S. regions.

4. **The review uses different metrics to assess the effects on agriculture, which are not directly comparable.** *Technical Comment* (p. 105-108)
Specifically, the cited article by Ortiz-Bobea (2019) examines land values and cash rents. It is important to emphasize that the effects on yields can move in the opposite direction of land values and rents. The U.S. is a major producer of corn and soybeans, so any reduction in output tends to increase prices, and vice versa. For decades, U.S. government policy has aimed to decrease output (e.g., through set-aside programs) to support higher prices and increase farmer profits. Similarly, climate change could reduce yields (and thus output), but this reduction may drive up prices and potentially increase profits for producers and in turn land values.
However, it is crucial to note the flip side: consumers pay more for food, and we recently saw significant inflation in agricultural commodity prices. When discussing the effects on agriculture, it is therefore important to distinguish between changes in output, prices, and the impacts on producers versus consumers.

5. **Warming leads to yield declines** *Technical Comment* (p. 106)
Continued warming leads to additional yield declines, highlighting the benefits of mitigation on U.S. agricultural yields. Continued warming under the high emission-A1FI scenario is worse than moderated warming, highlighting the benefits of mitigation efforts for U.S. agricultural yields under all modeling runs. The right column (A1F1) has net changes for yields that are at least 30% lower than what is given in the left column (B1).

6. **Needs a more balanced discussion of different results** *Technical Comment* (p. 106-107)
Methodological differences explain why various studies find different results, and a careful weighing of the advantages and disadvantages of each approach is essential.
The DOE review cites two meta-studies that link changes in yields to changes in climate variables as well as CO_2. These meta-studies include both controlled experiments and statistical analyses.

If a controlled experiment exclusively changes CO_2 levels and examines the resulting effects on yields, linking changes in the latter to changes in the former will correctly identify the CO_2 fertilization effect.

In sharp contrast, statistical studies that associate changes in CO_2 over time with changes in yields are invalid, as both variables trend upward over time and may produce spurious correlations.[5] The DOE review displays Figure 1 from Taylor and Schlenker (2023), which shows yield and CO_2 trends over time. We would like to stress that this graph is intended as motivation and does not depict the analysis used in the paper, which instead utilizes CO_2 anomalies across space. As Taylor and Schlenker emphasize in the introduction of their paper:

> "Establishing a causal link between two trending variables is statistically challenging. CO_2 has risen smoothly in tandem with crop yields as well as other factors such as mechanization and input use. Industrialization, both in agriculture and other sectors, might have independently increased CO_2 levels as well as yields—making it all the more difficult to disentangle CO_2 fertilization from other productivity drivers."

In summary, while more studies on the magnitude of the CO_2 fertilization effect are crucial to estimating the net effect of climate change on agriculture, it is essential to carefully distinguish between different types of studies and to identify which ones provide valid estimates in a given context.

[5] A study illustrating the potential pitfalls of correlating two trending variables demonstrates, tongue in cheek, that correlating the declining stork population with decreasing human birth rates "proves" that storks deliver babies. (Matthews 2001)

Table 1: Net Effect of Climate Change on Corn and Soybean Yields to Year 2100[6]

Corn

Scenarios (SRES 2000)	B1 - Low emissions	B2 - Intermediate emissions	A2 - High emissions	A1FI - Highest emissions
Climate Effect - Schlenker and Roberts (2009)	-43%	-51%	-70%	-79%
Change in CO_2	+203ppm	+238ppm	+388ppm	+509ppm
CO_2 fertilization [2023 draft]	+81%	+95%	+155%	+204%
Net effect	+3%	-4%	-23%	-35%
CO_2 fertilization [current]	+18%	+21%	+35%	+46%
Net effect	-33%	-40%	-59%	-69%

Soybeans

Scenarios (SRES 2000)	B1 - Low emissions	B2 - Intermediate emissions	A2 - High emissions	A1FI - Highest emissions
Climate Effect - Schlenker and Roberts (2009)	-35%	-43%	-63%	-73%
Change in CO2	+203ppm	+238ppm	+388ppm	+509ppm
CO_2 fertilization [2023 draft]	+122%	+143%	+233%	+306%
Net effect	+44%	+39%	+24%	+10%
CO_2 fertilization [current]	+20%	+24%	+39%	+51%
Net effect	-22%	-29%	-48%	-59%

Note: The net effect is obtained by multiplying the two scaling factors of the relative impacts. For example, a -43% warming impact (scaling factor of 0.57) combined with a CO_2 fertilization effect of +81% (scaling factor of 1.81) results in a combined scaling factor of 0.57 x 1.81 = 1.03, or a net 3% increase.

[6] Wheat is not estimated because it is not included in Schlenker and Roberts (2009), which focuses on corn, soybeans, and cotton; however, given its larger CO_2 fertilization effect, the net effect is likely to be positive.

Section 11.1 - Climate Change and Economic Growth

1. **Incorrect interpretation of social cost of carbon (SCC)** *Technical Comment* (p. 116) Incorrect statement that "The SCC is not intrinsically informative as to the economic or societal impacts of climate change." By definition, this is exactly what the SCC is: it is the present discounted value of the marginal damages from another ton of CO_2 emitted. This is clearly informative as to the economic and societal impacts of climate change on the margin.

2. **Mischaracterization of role of assumptions in the SCC** *Technical comment* (p. 116) Here and at several later points, the chapter asserts the sensitivity of the SCC to assumptions and that "The evidence for or against the underlying assumptions needs to be established independently" (p.116). There is in fact a vast literature underlying modern estimates of the SCC that is entirely ignored in the report. See the references in EPA (2023). For example, in early versions of the SCC, socioeconomic projections (income and population) were based on judgmental scenarios, or SSPs. In EPA (2023), those were replaced by econometric projections [Müller, Stock and Watson (2022), as summarized in Rennert et al (2022)]. It is fair to say that a primary focus of the modern literature on the SCC (reviewed in EPA (2023)) and its components has in fact been to focus on providing empirical content to replace previous assumptions and on improving previous empirical estimates, and the report ignores and omits this past decade of research.

3. **Mischaracterization of Thomas Schelling's position on climate change.** *Reference and technical comment* (p. 116-117)
The report has an extended quote from a paper by Schelling in 1992, which mischaracterizes his full views of climate change. Over the 1990s until the end of his life in 2016, he became increasingly focused on the problem, and he wrote and spoke extensively on climate change, viewing it and nuclear war as two of the greatest threats facing humanity. Schelling was deeply concerned that "Above all, we know that "developing" countries will experience the greatest impacts from climate change." [Schelling (2009), p. 13]. He viewed uncertainty not as a reason to do nothing or delay: "Neither of the two extreme principles—do nothing until we are absolutely sure it's safe; do nothing until we are absolutely sure the alternative is dangerous—makes economic sense, or any other kind." [Schelling 2007, p. 4]. To the contrary, he argued instead that uncertainty is in fact a reason to act and to take an insurance-based approach:

> In some public discourse, and in sentiments emanating from the Bush Administration, it appears to be accepted that uncertainty regarding global warming is a legitimate basis for postponement of any action until more is known. The action to be postponed is usually identified as "costly." (Little attention is paid to actions that have been identified as of little or no serious cost.) It is interesting that this idea that costly actions are unwarranted if the dangers are uncertain is almost unique to climate. In other areas of policy, such as terrorism, nuclear proliferation, inflation, or vaccination, some "insurance" principle seems to prevail: if there is a sufficient likelihood of sufficient damage we take some measured anticipatory action.
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> Schelling (2007, p. 4)

4. **Incorrect emphasis on the scale of climate change as opposed to the sign** *Technical Comment* (p. 117)
There is much discussion in this review about the effects of climate change being small relative to other factors, but that is not an appropriate standard for determining whether a policy intervention could increase social welfare. The appropriate standard is well-established in Executive Order 12866 and OMB Circular A-4: the weighing of the benefits of policy intervention against its costs. Specifically, E.O. 12866 states that:

> "[f]ederal agencies should promulgate only such regulations as are required by law, are necessary to interpret the law, or are made necessary by compelling public need, such as material failures of private markets to protect or improve the health and safety of the public, the environment, or the well-being of the American people. In deciding whether and how to regulate, agencies should assess all costs and benefits of available regulatory alternatives, including the alternative of not regulating" (section 1(a)). And,
> "Each agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs" (Section 1(b)(6)).

These principles guiding policy intervention are reflected in the 2003 OMB Circular A-4, which focuses on the practice of "organizing the evidence on the key effects, good and bad, of the various alternatives that should be considered in developing regulations. The motivation is to (1) learn if the benefits or an action are likely to justify the costs or (2) discover which of various possible alternatives would be the most cost-effective" (Section A). These principles represent an uncontroversial and long-held perspective in economics that the welfare effect of a policy intervention should reflect a weighing of the marginal costs and the marginal benefits of that intervention. These principles and guidance have been used across many presidential administrations and were reinforced recently under Executive Order 14219.

A related key element of weighing benefits and costs addresses the identification of an appropriate baseline – often referred to as a "no action" or no-new-policy baseline (Section A of OMB Circular A-4). The references to various associations over the course of the 20th century on p. 117 – warming of 1.3C as incomes and lifespans grew since 1900 – reflect a failure to specify an appropriate, alternative baseline: the counterfactual in the absence of warming. Moreover, this discussion reflects errors in reasoning that arise from assuming that associations serve as validation evidence. Correlation does not imply causation.

5. **Mischaracterization of policy recommendations of climate economists** *Technical Comment and reference* (p. 117-118)
    a. The characterization of mainstream climate economics' recommendations on climate policy is false and unsupported by the evidence. Climate economists, beginning with Nordhaus' work in the 1980s and 1990s (e.g. Nordhaus 1992) have consistently recommended pricing of carbon emissions at the social cost of carbon, based on basic economic principles regarding the correction of market failures dating back to Pigou (1932). The world is now, and has always been, far short of this recommended level of ambition. For instance, currently only 40% of global emissions are covered by a carbon price, and that price is only $20 per ton CO_2, far lower than current (or previous) estimates of the social cost of carbon (OECD, 2024).
    b. In 2019, 45 prominent U.S. economists including almost all former chairs of the Council of Economic Advisers, three former heads of the Federal Reserve and multiple Nobel laureates, signed a letter advocating for U.S. carbon pricing to address climate change (Akerlof et al. 2019). The number of economist signatories to that letter now stands at 3,649 (here) and this is thought to be the largest public statement of economists in history.
    c. The quote from Storm (2017) is taken grossly out of context and misconstrues Storm's (2017) meaning. The quote in the report (p. 118) ends with the sentence, "Most climate economists thus recommend humanity to just wait-and-see." Here is the full quote including the subsequent sentence:

> …Most climate economists thus recommend humanity to just wait-and-see. Their idea is that it makes sense to set the initial carbon price at a low level and then ratchet it upwards (Nordhaus 2007, 2008, 2010; Tol 2013; Golosov et al. 2014; Gerlagh and Liski 2013).
>
> Storm (2017, pp. 1307-1308)

What Storm means by "wait-and-see" is in fact setting an initially small carbon price that increases over time.

d. Storm (2017) was written a decade ago and was not written by a climate economist. As the references above show, its review is based on dated papers and omits the past decade of very active research. Instead, DOE should reference Drupp et al. (2024) for an accurate characterization of what most climate economists recommend. In their paper, Drupp et al. surveyed more than 400 economists and found that the recommended global carbon price should start, on average, at about \$50/tCO_2 in 2020, increase to \$92/tCO_2 by 2030, and increase thereafter. In the absence of a global climate policy, the approximately 90 U.S. economists surveyed by Drupp et al. recommended a unilateral carbon price of about \$40/tCO_2 in 2020, increasing to about \$80/tCO_2 in 2030 (see Figure 4 of Drupp et al. 2024). DOE should remove the inaccurate statement from Storm (2017) that characterizes the mainstream climate economics position as a "wait and see" approach since the actual position of this community has always been, and remains, that the external costs of CO_2 should be reflected in the market price of fossil fuels.

6. **Outdated discussion of DICE model** *Technical Comment* (p. 118-119)
The discussion in this section focuses on a single, 10 year old, version of the DICE model (i.e. DICE 2016R2). EPA (2023) does not use results from the DICE or FUND models. The DOE report's discussion of DICE ignores both the more recent version of the DICE model (DICE-2023) as well as a substantial scientific literature exploring other extensions and improvements within the DICE framework. The discussion should be revised to refer to findings and policy recommendations in the current version of DICE (i.e. DICE-2023, Barrage and Nordhaus 2024). This update implements a number of important revisions to the DICE framework, including a critical update to modernize the climate module.

Dietz et al. (2021) show that the climate model in earlier versions of DICE has a warming response to an emissions pulse that is incompatible with evidence from the ensemble of General Circulations Models (GCM), with substantial implications for resulting economic analysis and policy recommendations. The DICE-2023 version implements an important correction to update the climate model to a more complex and accurate emulator of the GCM ensemble. In addition, damages have been also updated not based on “assumptions” but on a new, independent literature synthesis on climate change damages conducted by Barrage and Nordhaus, that slightly revised estimated losses upwards. Contrary to the DOE statements in this section, the optimal policy pathway differs substantially from the no-new-policy pathway, reducing emissions by approximately 50% by 2070 and reducing 2100 temperatures by a full degree (from 3.5 degrees to 2.5 degrees warming).

7. **Misrepresentation of Newell et al.** *Technical Comment* (p. 119)
   The DOE review misstates the findings of Newell et al. (2021). Newell et al. (2021) estimates model uncertainty. They find that growth models generate the large degree of uncertainty that the DOE review cites. However, models relating temperature to GDP *levels* – that is, a proportional shift in the *level* of GDP, not a shift in the long-run *growth rate* of GDP – yield climate impact estimates that are far more certain. The main finding of the Newell et al. (2021) paper is to understand the different levels of uncertainty associated with these different models, which they note that modern calculations of the U.S. social cost of carbon do. The DOE review should correct its characterization of Newell et al (2021) and revise its summary to reflect this understanding of model uncertainty.

8. **Erroneously connects climate change impacts of GDP to abatement policies** *Technical Comment* (p. 119-120, p. 125)
   a. In this section the review makes an error in connecting evidence regarding climate change impacts on GDP to abatement policy, for instance by claiming that modest effects on economic growth imply a cap on global warming would be “worse than doing nothing”. The appropriate evaluation metric for the benefits of reducing emissions is the total welfare impact of greenhouse gas emissions. This includes both market impacts (i.e. those that might be captured in GDP) and non-market impacts (i.e. things that affect welfare but are not included in GDP accounting). Evidence suggests a large proportion of total impacts in the U.S. are non-market in nature, most notably via increases in mortality risk for the over-65 population (Carleton et al. 2022; Hsiang et al. 2017). The evidence reviewed in this section, and the impact curves shown in Figure 11.2, do not include these non-market impacts and are thus uninformative regarding net benefits of alternative abatement options such as meeting the Paris target. DOE should remove any discussion of the net-benefits of abatement from this section and explicitly discuss the limitations of exclusively market-based measures in inferring total climate damages.
   b. The discussion of costs of abatement policies here and on p. 120 and p. 125 relies on a combination of assertions made without citations and estimates derived from out of date models. There has been, however, a vast number of studies of

abatement policy costs. A somewhat dated review is Gillingham and Stock (2018), which assesses the cost per ton of various abatement policies and finds many that fall below then-current estimates of the SCC. More recently there has been empirical work on macroeconomic impacts of economy-wide abatement policies, for example Metcalf and Stock (2023) find very small effects of a modest ($40/ton) carbon tax on GDP and employment in European countries that adopted a carbon tax (with the controls being those that did not).

9. **Negative effects of CO_2 being too small to justify aggressive abatement policy is not supported by the literature** *Technical Comment* (p. 120)
    a. The premise that a benefit is small, so should be rounded to zero, is illogical and should be rejected. In a grocery store, if the price of a bag of candy on sale is small, say $2, that does not mean the customer should walk out without paying. In the case of climate policy, even if the damage is small, then these damages should be priced, such as through a carbon tax.
    b. The statement that the negative effects of CO_2 are too small to justify aggressive abatement policy is not supported by the literature summarized in this section. The question of optimal abatement policy depends both on the costs of abatement as well as the costs of climate change. If the costs of abatement are small then even modest climate damages would justify large emissions reductions. Assessing optimal climate policy requires weighing both the costs and benefits of actions on climate change. The current version of DICE model (DICE-2023) finds optimal climate policy should entail large (~50%) reductions in global emissions relative to a business as usual case by 2070 (Barrage and Nordhaus 2024). Other implementations of the DICE framework accounting for different damages, mitigation costs, or discount rates find that Paris Agreement targets, particularly the 2 degree target, could be justified on a cost-benefit basis and these implementations still do not include all possible categories of damages or examine the full distribution of possible outcomes (e.g. Moore et al. 2015; Hansel et al. 2020).

Section 11.2 - Models of the Social Cost of Carbon

1. **Misunderstanding of estimates** *Technical Comment* (p. 121)
    a. DOE asserts that the SCC should not be used because there are assumptions that underpin its calculation. Any estimate of any cost or benefit has assumptions. Manski et al. (2021) write, "Whatever the field of science may be, the logic of empirical inference is summarized by the following relationship: assumptions + data → conclusions. Data alone does not suffice to draw useful conclusions." The DOE should withdraw this dismissal of SCC.
    b. That said, much of what is characterized as assumptions is in fact firmly grounded in a large body of empirical research over the past decade, which the report does not cite. See the references in EPA (2023) and comment number 2 above on Section 11.1.
    c. The future mortality risk component of the SCC is not "perceived" as claimed on p. 121; in the recent literature, it is grounded in causal inference estimates of the historical relationship between temperature and mortality, accounting for adaptation, which is then applied to future states of the world based on GCM outputs (e.g., Carleton et al. 2022).

2. **Misrepresentation of literature on valuing mortality risk reductions** *Technical Comment* (p. 121)
   Dating back at least to Rosen (1974), economists have characterized goods as having multiple attributes, and the market price for each good represents the value associated with its attributes. This insight has informed an extensive empirical literature that explores how individuals reveal how much income they would be willing to give up for a marginal reduction in mortality risk by studying behavior in labor markets, new vehicle markets, residential property markets, etc. In these markets, individuals reveal their preferences over income and mortality risk by selecting from a set of options, each one of which is characterized, in part, by its associated mortality risk (Viscusi and Aldy 2003; Viscusi 2018). To claim that "there is no market in which people can directly attach a price to that risk" is misleading given this literature. Moreover, claiming that it is inferred from real estate or insurance likewise reflects a lack of familiarity or understanding with this academic literature.

3. **Misleading discussion of Roe and Bauman 2013** *Technical Comment* (p. 121)
   The discussion of Roe and Baumann (2013) is accurate but misleading without additional context of current SCC calculations. Current estimates of the SCC (i.e., Barrage and Nordhaus, 2024; Rennert et al.2022; EPA 2023) all make important updates to the carbon cycle and climate modules that account for co-variance between equilibrium climate

sensitivity and the time scale of the climate response. This is done by updating older simpler climate models with the FAIR emulator of the GCM ensemble, which includes both variance and co-variance in climate system parameters. This is why discussion of older IAMs (e.g. Section 11.1.1) and the implication that updates in more recent models arise solely from damage function revisions is also misleading.

4. **Out of date studies** *Technical Comment* (Secs 11.2.1-11.2.3)
The review repeatedly mentions the FUND model, published in 1997, but it is long out of date. To be clear, EPA (2023) did not "introduce new ones for its recent work." The agency drew from extensive, recent peer-reviewed literature that differ in fundamental ways in which they characterize the damages of an incremental ton of carbon dioxide emissions when compared to FUND and the 2016 edition of DICE that is the focus of the discussion in this chapter.

5. **IAM structure** *Technical Comment* (p. 122)
The review makes several errors while discussing IAMs.
    a. It erroneously claims that IAMs use exponential functions to model CO_2/warming and net harm. Most IAMs use polynomial or linear functions.
    b. The DOE claims "IAMs generate SCC estimates that increase as the pre-existing concentration of CO_2 increases. Consequently, the value of damages later in the century will be higher." Based on the GIVE model, the first sentence is incorrect. In other models SCC values also rise over time because of economic growth.
    c. The statement that "IAMs assume CO_2 and warming cause net harms" is inaccurate. The parameterization of damage functions is not an assumption, rather in all cases parameterization is based on a review of underlying scientific and empirical evidence. In modern SCC estimates (e.g., these supporting EPA 2023) the functional form does not restrict the impacts of warming to be net-negative. Rather, depending on sector and region, the effects of anthropogenic warming can be either positive or negative, with the net effect determined by the underlying evidence base.

6. **Misrepresentation of Dayaratna et al. (2023)** *Technical Comment* (p. 122)
Dayaratna et al. 2023 do make the point that using very low ECS values can dramatically lower the SCC, which is a useful sensitivity analysis. However, low values are not empirically supported. DOE should remove this citation that argues for a much lower ECS than the literature supports.

7. **Inaccurate Representation of the Role of Agricultural Damages in the EPA 2023 SCC Update** *Technical Comment* (p. 122)

The discussion of the role of agricultural damages in the EPA 2023 SCC update is unsupported for several reasons. Firstly, McKitrick (2025) inaccurately characterizes the analysis in Moore et al. (2017). Moore et al. (2017) accurately report using 1010 observations from the underlying Challinor et al. (2014) dataset, accounting for some missing CO_2 observations. Therefore, any differences in findings between McKitrick (2025) and Moore et al. (2017) is unlikely to be due to differences in CO_2 fertilization data. Moreover, uncertainty bounds between McKitrick (2025) and Moore et al. (2017) are strongly overlapping for most warming levels and crops (see Figure 9.2 in the DOE report) meaning yield responses cannot be confidently distinguished, with the exception of soybeans, which constitute a smaller fraction of global production than wheat, rice, or maize. Second, the implications of the yield-temperature responses estimated in McKitrick (2025) for the social cost of carbon cannot be inferred from data provided in that paper. SCC damage functions capture welfare changes, not yield changes, and depend on regional-specific yield changes (not reported in McKitrick 2025) and a country's trade position in agricultural commodities, which requires use of a global trade model (not done in McKitrick 2025). Given non-linear interactions between yield and welfare changes, baseline projections of economic growth, and overall SCC estimates, the overall implication of the McKitrick (2025) analysis for SCC estimates is far from clear. Finally, EPA's revision to agricultural damages did not just rely on Moore et al. (2017) but also Hultgren et al. (2025). While the latter finds smaller impacts than the former, both find net-negative global impacts of climate change on agriculture. This stands in stark contrast to the treatment of agricultural damages in the previous generation of SCC estimates, which, based on the FUND model, showed substantial net-benefits of anthropogenic warming and CO_2 changes. Therefore, multiple lines of evidence, not just Moore et al. (2017), supported an upward revision of agricultural climate change damages in the overall SCC calculation.

8. **Misrepresentation of Dietz et al. (2021)** *Technical Comment* (p. 123, 125)
    a. Dietz et al. (2021) is selectively quoted to give an overall misleading impression of its findings. While it is true that their central estimate of the contribution of tipping points to the SCC is +25%, this is a measure of the central tendency of a distribution of outcomes that includes roughly a 10% chance of climate tipping points more than doubling the SCC, and roughly a 2% chance of them more than tripling the SCC. A +25% is hardly "modest" as the DOE review characterizes it; using the 2023 EPA SCC, it would amount to an additional \$50/tCO_2.
    b. Moreover, Dietz et al. (2021) emphasize that their estimates were "probable underestimates given that some tipping points… have not been covered in the literature so far". The DOE review fails to mention this, instead suggesting that Dietz et al. (2021) overestimate the effect of tipping points on the SCC because some tipping points are "very unlikely" by the IPCC's definition. Some tipping

points are indeed very unlikely, but that does not mean the expected cost of such tipping points is small. It is incorrect to confuse probability with consequence/impact of an event. Just because the risk of one's house burning down is very low does not mean it should be completely ignored. On the contrary, it is wise to try to prevent it and further insure against it, because the consequences are so severe. The DOE should update its interpretation of Dietz et al. (2021) to reflect an accurate understanding of the cost of tipping points.

9. **Incorrect interpretation and use of SCC** *Technical Comment* (p. 123)
   The second paragraph on p. 123 makes several errors interpreting and using the SCC.
   a. The paragraph deflates the SCC by the marginal cost of public funds (MCPF). The MCPF is the cost of raising a dollar's worth of tax revenue, due to the fact that most taxes cause market distortions. But the SCC is not a tax, it's the cost that is already being imposed by carbon pollution. Carbon pollution has no MCPF. In fact, if the SCC were used to assess a $75/ton carbon tax the economic value of the carbon tax revenues would be worth more than $75, not less. The DOE gets the sign wrong in this calculation and should correct this in the review.
   b. The end of the paragraph notes that "A pre-tax price of $3.00 per gallon would imply the marginal social benefit of the fuel is nearly seven times the marginal social cost." This is a partial and confused comparison because it juxtaposes the full benefits of the gasoline ($3) to just one part of the costs of the gasoline ($0.44). It omits the private costs of providing the gasoline, also $3. The calculation also ignores the other non-climate external costs of gasoline, such as local air pollution. The full cost of burning a gallon of gasoline exceeds the full benefits, even using the paragraph's erroneously small SCC.
   c. The comparison of the external social costs to the private benefits makes an additional error, which is it attributes those private benefits to gasoline. The private benefits received by the consumer, however, is not the gasoline, rather, the gasoline is a factor in production of transportation services. The consumer directly consumes those transportation services, not the gasoline. Those transportation services could be provided by other means, such as an electric vehicle, which does not use gasoline as a factor of production in providing transportation services.

10. **Confusing discussion of tipping points** *Technical Comment* (p. 123)
    The DOE review offers a confusing discussion of what climate tipping points are. It would have been clearer to first provide an authoritative, widely used definition of climate tipping points (e.g., from IPCC AR6, or Lenton et al., 2008) and use that to derive a list of relevant phenomena. The class of phenomena is broad and includes positive carbon-cycle and temperature feedbacks, ice sheet disintegration, changes in

large-scale circulation, and biome/ecosystem collapses. The review eventually does this, but only after confusing matters by digressing into bifurcations in non-linear dynamical systems.

11. **Misunderstanding of tail risks** *Technical Comment* (p. 124)
    The review suggests that in the face of possible climate tipping points, society should not spend money on greenhouse gas (GHG) abatement, because tipping points are very hard to predict and model. This would clearly run counter to rational decision-making under uncertainty. While predicting and modelling tipping points is very challenging, there is widespread agreement that tipping points increase uncertainty about the future impacts of climate change, almost entirely in the direction of downside risk, with the particular possibility of catastrophic outcomes. GHG abatement can reduce this uncertainty, since crossing tipping points becomes more likely at higher emissions/temperature levels. The economic case for GHG abatement today is therefore increased. As a measure of this value, the SCC should be increased. The DOE should reflect this fundamental understanding of decision-making under uncertainty in its discussion of tipping points and the SCC.

12. **Ignores literature on decision-making under uncertainty and climate change** *Technical Comment* (p. 125).
    Section 11.2.5 quotes a consultancy blog post that it is "'time to kill' [the SCC] due to uncertainties." This is fundamentally confused about decision-making under uncertainty.
    a. Different models of uncertainty and loss yield different solutions for optimal policy under uncertainty. Even in the most benign circumstances, however, such as quadratic loss, the optimal policy under uncertainty at most scales back from the optimal policy without uncertainty, but does not set the optimal policy to zero as would be implied by "killing" the SCC (Brainard 1967).
    b. In the case of climate, however, the situation is less benign, for two reasons. First, there is substantial "tail risk", that is, the possibility of potentially extreme outcomes. Second, those extreme outcomes, should they occur, could induce steep damages for mankind (and the natural world), beyond what would be characterized as quadratic loss. If so the conservative approach to uncertainty is reversed. A mathematical formulation of this concern is Weitzman's "dismal theorem" (2009, 2014); also see Pindyck (2012). Generally, the logic of these decision-theoretic approaches is that, because there is the risk of significantly bad outcomes in the future, it is optimal to pay something today (i.e. invest in costly abatement policy) to reduce the chances of those very bad outcomes transpiring.
    c. There are other decision-theoretic frameworks that yield similar precautionary approaches to climate policy, in which uncertainty calls for more rather than less aggressive policy. One such approach is when there is uncertainty not just about

model parameters, but about what the right model actually is. In this case, the theory of robust control typically yields more rather than less aggressive policy recommendations. In the case of climate change see for example Barnett et al. (2022).

12. **Erroneous claim that regulations fail a cost-benefit test** *Reference and Technical Comment* (p. 125)
Section 11.2.5 claims, without providing any citations or references, that "many emissions regulations (such as electric vehicle mandates, renewable energy mandates, energy efficiency regulations and bans on certain types of home appliances) cost far more per tonne of abatement than any mainstream SCC estimate, which is sufficient to establish that they fail a cost-benefit test." This report should specifically cite the regulations and associated regulatory impact analyses to justify this claim. In doing so, the report should identify the cost per tonne estimates as published in the regulatory impact analyses for each of the suggested rules in the parenthetical and explicitly state the "any mainstream SCC estimate" the authors use for this comparison. More importantly, the report should strike the erroneous claim that a regulation with a cost per tonne of abatement exceeding the social cost of carbon is "sufficient to establish that they fail a cost-benefit test." As noted above in the discussion of OMB Circular A-4, the appropriate comparison is the full set of benefits and the full set of costs of a policy intervention relative to a no-new-policy baseline. A renewable energy mandate, for example, could reduce both carbon dioxide emissions and particulate matter emissions. In this context, whether the mandate "passes" a cost-benefit test depends on the consideration of all categories of benefits (including reduced premature mortality risk and reduced morbidity risk caused by particulate matter pollution exposure), not simply the social cost of carbon. See the comments on Chapter 12 below for more detail, as well as the standard framework for considering the full set of benefits of regulatory actions in both the economics literature (Aldy et al. 2021) and regulatory practice (OMB Circular A-4).

Chapter 12 - Global Climate Impacts of U.S. Emissions Policies

This section is based on two scientific aspects of climate change, but then makes errors, ignores realities, and draws incorrect inferences and conclusions.

First, climate change is characterized by the global commons nature of greenhouse gas emissions, where actions in one country affect all others. Second, climate change is a function of the stock of accumulated GHGs in the atmosphere, and CO_2 has a half-life in the atmosphere exceeding 100 years. Hence, the costs of a policy are up front, whereas the benefits of the policy are spread over time.

This means that climate change is a very difficult political problem, but neither aspect means that climate change should be ignored.

We would like to offer the following comments:

1. **Omittance of the scale of U.S. emissions** *Technical Comment* (p. 129)
   In terms of scale, the DOE report fails to note that the U.S., since 2006, is the world's second largest annual emitter of GHGs (before 2006, it was number one). But more importantly, the U.S. is the number one contributor to the stock of anthropogenic GHGs in the atmosphere, which is what drives climate change impacts.

2. **Incorrect timeline of climate policy** *Technical* (p. 129)
   The DOE review mistakenly asserts that "any effect [of a climate policy] will emerge only with long delays." This is completely incorrect. The reality is that the effects emerge *immediately* and continue for a very long time due to the long residence time of CO_2 in the atmosphere. Methane with a relatively short (~10 year) residence time in the atmosphere imposes near-term impacts. In addition, correlated pollutants, such as the emissions of particular matter, have immediate impacts.

3. **Omittances of the spillovers of U.S. climate policy** *Technical Comment* (p. 129)
   When estimating the impacts of a U.S. climate policy, it is essential to include not just the U.S. emission reductions, but the effects of U.S. policies and actions on the policies and actions of other countries. U.S. policy action can leverage policy action by other countries. Moreover, U.S. mitigation policies can enable technological innovation and commercialization that lower the costs of and encourage the adoption of more ambitious policies and actions in other countries. Hence, the review understates the overall global emissions reductions due to a U.S. climate policy.

4. **No mention of correlated pollutants** *Technical Comment* (p. 129)
   In the U.S., climate policies (in the electricity sector) mean less reliance on coal, and that brings crucial reductions in correlated pollutants, such as fine particulate matter (PM2.5),

which imposes significant premature mortality risks. The share of domestic monetized benefits in the Obama RIA for the Clean Power Plan from PM2.5 reductions was calculated to be 94%. The other 6% were associated directly with climate change. The DOE review ignores correlated pollutants, which also arise in the transportation, industrial, and residential sectors.

5. **Flawed cost benefit analysis** *Technical Comment* (p. 129 -130)
The DOE review claims that "even if global emissions were to stop tomorrow, it would take decades or centuries to see a meaningful reduction in global CO_2 concentration and hence human influences on the climate." This statement and the subsequent discussion is characterized by multiple errors that should be addressed:
    a. Every ton counts. The appropriate framework for assessing the impact of reducing a unit of emissions is to weigh the marginal benefits and the marginal costs of the action that delivers that unit of reduction relative to a counterfactual, no-new-policy baseline. Emission reduction policies that slow the growth in atmospheric greenhouse gas concentrations and slow the growth of warming will deliver significant economic benefits. For example, the recent application of the DICE model shows that policies motivated by a conventional benefit-cost analysis framework would result in CO_2 concentrations slowly growing over the rest of this century, but at a significantly slower rate than the no-new-policy baseline, and of course this is only one application of the model, which does not include all possible categories of damages or the full distribution of possible outcomes. This slow growth in concentrations reflects significant emission reductions from the counterfactual baseline (Barrage and Nordhaus 2024, Figure 1). In the DICE model, doing so would result in about $120 trillion greater present value of consumption globally than under the no-new-policy counterfactual (Barrage and Nordhaus 2024). Moreover, limiting warming to less than 2 degrees C relative to pre-industrial levels in the updated DICE model would yield about $107 trillion more in present value consumption than the no-new-policy baseline.
    b. The review's statement narrowly focuses on CO_2. It should also address methane, the second most common anthropogenic greenhouse gas. "Stopping anthropogenic methane emissions tomorrow" would deliver significant near-term benefits – given the relatively short residence time of atmospheric methane – and slow the rate of change in climate change impacts.
    c. There is an extensive peer-reviewed economics literature – largely ignored in this report – that provide the rigorous evidence necessary to answer the question posed at the top of p. 130: "What would be the climate impact of such regulation?" The appropriate approach to addressing this question is not, however, to make an irrelevant, vague, and uncited claim about the precision of warming trends over 1979-2023. The appropriate approach requires the identification of a no-new-

policy baseline, estimation of the change in emissions compared with that baseline, and then evaluation with the most recent, peer-reviewed evidence of how that change in emissions translates into specific outcomes that affect public health and welfare. In short, applying the standard analytic framework under Circular A-4 and consistent with E.O. 12866 (as discussed in comment number 4 under Chapter 11.1 above) illustrates the significant impacts of carbon dioxide emissions from U.S. cars and light trucks. With annual emissions of about 1.05 billion metric tons of carbon dioxide (as stated on p. 130), and the peer-reviewed social cost of carbon of $190/tCO_2$, this sector imposes nearly $200 billion in annual damages. Given the multi-year time horizon of regulatory and other policy proposals addressing vehicles that operate for decades, reducing emissions from light-duty vehicles could reduce climate change damages in the trillions of dollars. Mitigating even a modest fraction of these emissions and associated damages would satisfy the standard for being "a significant regulatory action" under E.O. 12866 (section 3(f)). Avoiding these impacts should be weighed against the cost of regulation in standard cost-benefit analysis.

Conclusion

We respectfully recommend that DOE:

- Revise its inaccurate characterization of the economics literature;
- Present a balanced discussion of decision making under uncertainty;
- Correct misstatements about key economics concepts and ideas;
- Affirm the social cost of carbon as the essential tool for climate policy evaluation.
- Frame the evaluation of impacts consistent with standard benefit-cost analysis principles.

By addressing these issues, DOE can ensure that its review accurately reflects the state of knowledge in environmental and climate economics and strengthens the evidence base for policymaking.

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