Playing with Fire

Responding to Criticism of the Social Cost of Greenhouse Gases

Working Paper

Institute *for* Policy Integrity

NEW YORK UNIVERSITY SCHOOL OF LAW

June 2021

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This working paper is forthcoming in the Yale Journal on Regulation as The Social Cost of Greenhouse Gases: Legal, Economic, and Institutional Perspective.

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Executive Summary

As the Interagency Working Group on the Social Cost of Greenhouse Gases ("Working Group") prepares to update its social cost estimates, it—and federal agencies that will eventually use the numbers—should be aware of and prepared to respond to misguided criticisms of its methodology that are being made by opponents of climate regulation. This report offers a blueprint for that response.

In early 2021, two state-led coalitions (the "State Parties")—one led by Missouri Attorney General Eric Schmitt, the other by Louisiana Attorney General Jeff Landry—filed suit in federal district court seeking to enjoin agency usage of the Working Group's interim social cost estimates.[1] The complaints in these suits raise some familiar arguments against the Working Group's methodology. First, the State Parties claim it is inappropriate for federal agencies to use a social cost estimate that reflects global climate damages. Second, the State Parties argue that it is inappropriate to exclude a 7% discount rate from the range of social cost estimates. Third, the State Parties claim that there is too much uncertainty and subjectivity to rely on the Working Group's interim social cost estimates, pointing to numerous alleged errors in the valuations.

These criticisms are erroneous. As this report explains, the Working Group developed its social cost estimates based on a rigorous process using the best available science and economics. The Working Group properly took a global view of climate damages, which is both appropriate and necessary for a global pollutant and is in the strategic interest of the United States. The Working Group also applied an appropriate range of discount rates reflecting the intergenerational nature of climate impacts. And the Working Group appropriately accounted for uncertainty and made reasonable methodological choices. While there is some uncertainty in the social cost valuations, this is not a reason to abandon the metric, and evidence overwhelmingly suggests that the Working Group's interim estimates are a lower bound of the true harm of greenhouse gas emissions.

Beyond their methodological objections, the State Parties raise numerous other legal claims that, while equally groundless, are beyond the scope of this report. For instance, the states allege dubious constitutional claims regarding the separation of powers and cooperative federalism, claiming in essence that the executive branch lacks authority to develop interagency climate damage valuations. These arguments disregard the longstanding role of the White House and administrative agencies in using their technical expertise to advance scientific research and identify key regulatory impacts. The State Parties also treat the Working Group's guidance as a final agency action, arguing that it is procedurally deficient for failing to sufficiently respond to comments, consider reliance interests, or anticipate supposedly unlawful coming usages of the social cost values by federal agencies. These arguments fail for numerous reasons, most notably because it is the federal agencies applying the social cost of greenhouse gases—not

[1] Complaint, *Missouri v. Biden*, No. 4:21-cv-00287-AGF (E.D. Mo. filed Mar. 8, 2021) [hereinafter "Mo. Complaint"]; Complaint, *Louisiana v. Biden*, No. 2:21-cv-01074 (W.D. La. filed Apr. 22, 2021 [hereinafter "La. Complaint"]. On May 3, 2021, plaintiffs in the E.D. Missouri case filed a motion for a preliminary injunction, which remains pending as of this writing.

the Working Group itself—that are legally responsible for undertaking notice-and-comment rulemaking and for lawfully applying the valuations in each respective process.[2]

Though these latter claims are premature, they highlight the fact that federal agencies will need to offer considered and detailed responses to objections raised in the notice-and-comment processes for individual regulations or administrative actions that apply the Working Group's social cost valuations. Given its expertise, the Working Group should consider providing such responses now, so that agencies can then incorporate them into future actions. This report offers a blueprint for those responses.

Background: The Working Group's Methodology Is Rigorous, Transparent, and Based on the Best Available Data

Before diving into the State Parties' objections, this report begins with a brief background of the Working Group's process. As this section explains, the Working Group's methodology to develop its interim social cost estimate was rigorous, transparent, and based on the best available science and economics. Attempts to recast the Working Group's process as rushed and opaque are deeply misleading.

Starting in 2009, the Working Group assembled experts from a dozen federal agencies and White House offices to "estimate . . . the monetized damages associated with an incremental increase in carbon emissions in a given year" based on "input assumptions grounded in the existing scientific and economic literatures."[3] The Working Group combined three of the most frequently used models built to predict the economic costs of the physical impacts of each additional ton of carbon.[4] The underlying models themselves were the subject of extensive expertise and peer review: One of the models, DICE, was developed by William Nordhaus, a Yale university economics professor who won a Nobel Prize for developing the model.

The Working Group first issued its social cost of carbon estimates in 2010 and has updated them several times to reflect the latest and best scientific and economic data.[5] These estimates have been subject to public comment both in the context of dozens of agency proceedings as well as a Working Group

[2] Earlier this month, the federal government filed a motion to dismiss the lawsuit in the Eastern District of Missouri that essentially relied on this theory, arguing that the plaintiffs lack standing, that their claims are unripe, and that they fail to state a cause of action. Defendants' Combined Memorandum of Law in Support of Motion to Dismiss and in Opposition to Plaintiffs' Motion for a Preliminary Injunction, *Missouri v. Biden*, 4:21-cv-00287-AGF (filed June 4, 2021).

[3] Working Group, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* at 1 (2010), *available at* https://perma.cc/VTD5-VBL3 [hereinafter "2010 TSD"].

[4] *Id.* at 5. These reduced-form integrated assessment models are DICE (the Dynamic Integrated Model of Climate and the Economy), FUND (the Climate Framework for Uncertainty, Negotiation, and Distribution), and PAGE (Policy Analysis of the Greenhouse Effect).

[5] Working Group, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* at 5–29 (2016), *available at* https://perma.cc/UYX6-2W8M.

comment period in 2013.[6] Following the development of social cost estimates for carbon dioxide, the Working Group applied the same basic methodology in 2016 to develop the social cost of methane and social cost of nitrous oxide.[7] These additional metrics used the same economic models, the same treatment of uncertainty, and the same methodological assumptions that the Working Group applied to the social cost of carbon, and these new estimates underwent rigorous peer-review.[8]

The Working Group's methodology has been repeatedly endorsed by independent reviewers. In 2014, the U.S. Government Accountability Office concluded that the Working Group had followed a "consensus-based" approach, relied on peer-reviewed academic literature, disclosed relevant limitations, and adequately planned to incorporate new information through public comments and updated research.[9] In 2016 and 2017, the National Academies of Sciences, Engineering, and Medicine issued two reports that, while recommending future improvements, supported the continued use of the Working Group's estimates.[10] Leading economists and climate policy experts have also endorsed the Working Group's values as the best available estimates.[11] And the U.S. Court of Appeals for the Seventh Circuit has upheld agency reliance on the Working Group's valuations.[12]

Because the Trump administration disbanded the Working Group in early 2017,[13] the Group was unable to implement suggestions from the National Academies to update the social cost valuations to reflect more recent data. Moreover, without consulting the then-defunct Working Group, several agencies developed so-called "interim" social cost estimates that devalued the social cost of greenhouse gases using a few makeshift methodologies that bucked expert recommendations, citing then-President Trump's executive order.[14] Furthermore, the Trump administration made no attempt to update or improve those valuations by incorporating recent research as recommended by the National Academies.[15] Accordingly, agencies for

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[6] Working Group, *Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide – Interim Estimates Under Executive Order 13,990* at 3 (2021), *available at* https://perma.cc/GZ45-SKP4 [hereinafter "2021 TSD"].

[7] *See* Working Group, *Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide* 2–3 (2016), *available at* https://perma.cc/Z2UK-ZRSX.

[8] *Id.* at 3.

[9] Gov't Accountability Off., *Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates* 12–19 (2014), *available at* https://perma.cc/66GM-BW2S.

[10] Nat'l Acad. Scis., Eng'g & Med., *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide* 3 (2017), *available at* https://perma.cc/TT87-25PU [hereinafter "NAS 2017 Report"]; Nat'l Acad. Scis., Eng'g & Med., *Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update* 1–2 (2016), *available at* https://perma.cc/TJM6-XE65 [hereinafter "NAS 2016 Report"].

[11] *See, e.g.*, Richard Revesz et al., *Best Cost Estimate of Greenhouse Gases*, 357 SCIENCE 655 (2017); Michael Greenstone et al., *Developing a Social Cost of Carbon for U.S. Regulatory Analysis: A Methodology and Interpretation*, 7 REV. ENV'T ECON. & POL'Y 23, 42 (2013); Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014) (co-authored with Nobel Prize winner Kenneth Arrow) (explaining that the Working Group's values, though methodically rigorous and highly useful, are very likely underestimates).

[12] *Zero Zone, Inc. v. U.S. Dept. of Energy*, 832 F.3d 654, 679 (7th Cir. 2016)

[13] Exec. Order 13,783 § 5(b), 82 Fed. Reg. 16,093, 16,095 (Mar. 31, 2017).

[14] *See California v. Bernhardt*, 472 F. Supp. 3d 573, 611-13 (N.D. Cal. 2020) (explaining that Trump administration's methodology "has been soundly rejected by economists as improper and unsupported by science").

[15] Gov't Accountability Off., *Social Cost of Carbon: Identifying a Federal Entity to Address the National Academies' Recommendations Could Strengthen Regulatory Analysis* 24 (2020), *available at* https://perma.cc/9J9S-HZH2 ("The federal

four years under the Trump administration applied social cost values that—though deeply flawed—still nominally relied on the underlying models about which the State Parties now complain.

In early 2021, the Working Group released interim values that are based on the 2016 estimates, adjusted for inflation.[16] Like their predecessors, therefore, these interim numbers are the best available estimates. The Working Group is now planning to update its social cost estimates by January 2022, pursuant to President Biden's Executive Order 13,990.[17] Until those updates are published following the completion of this public comment process, however, agencies should rely on the interim values released by the Working Group in February 2021. This report mainly addresses these interim estimates, rather than anticipated updates, as well as the overall process and methodology of the Working Group to this point.

The Working Group Appropriately Focused on Global Damages

The State Parties argue that the Working Group's interim estimates inappropriately value global climate damages, in violation of standard agency practice.[18] The Institute for Policy Integrity addresses this argument in depth in a separate report.[19] But to summarize the key arguments: the use of global damage valuations reflects U.S. strategic interests, is widely regarded as appropriate for global pollutants like greenhouse gases, and is consistent with federal guidance. In fact, the U.S. Court of Appeals for the Seventh Circuit has recognized that it is reasonable for agencies to determine that because greenhouse gas emissions cause "global effects, . . . those global effects are an appropriate consideration when looking at a national policy."[20] Similarly, the U.S. District Court for the Northern District of California recently held that a global focus is critical for an agency to reliably assess climate impacts.[21]

Considering global damages, as opposed to disregarding all climate effects that occur outside U.S. borders, is desirable for a number of reasons. For one, because of our world's interconnected financial, political, health, security, and environmental systems, climate impacts occurring initially beyond the geographic borders of the United States will cause significant costs that accrue to U.S. citizens and residents.[22] Second, because U.S. climate policy can strategically influence the climate policies of other nations, our actions can trigger reciprocal reductions of foreign emissions, directly benefiting the United States in ways not accounted for in a domestic-only perspective.[23] And third, U.S. citizens have direct interests in climate-

government has no plans to address the National Academies' short- and long-term recommendations for updating the methodologies used by federal agencies to develop their estimates of the social cost of carbon.").

[16] 2021 TSD, *supra* note 6, at 4.

[17] *Id.* at 11.

[18] *See* La. Complaint ¶¶ 53–54.

[19] Jason Schwartz, Inst. for Pol'y Integrity, *Strategically Estimating Climate Pollution Costs in a Global Environment* (Jun. 2021).

[20] *Zero Zone*, 832 F.3d at 679.

[21] *Bernhardt*, 472 F. Supp. 3d at 613 ("[F]ocusing solely on domestic effects has been soundly rejected by economists as improper and unsupported by science.").

[22] *See* Schwartz, *supra* note 19.

[23] *Id.*

related impacts that will occur overseas, including those affecting citizens living abroad or U.S. assets located abroad, and those harming international habitats or species that U.S. citizens value.[24] As an empirical matter, moreover, there are very few region-specific estimates in the literature, and all of them ignore international spillovers and reciprocity and so are incomplete.[25]

For further explanation as to why a global valuation is most appropriate for measuring climate damages, please see the Institute for Policy Integrity report titled "Estimating a Strategic Cost of Climate Pollution in a Global Environment."[26]

The Working Group Selected Discount Rates That Are Legally Sound and Reflect the Nature of the Climate Problem

Contrary to the claim of the State Parties,[27] the Working Group applied an appropriate range of discount rates and was correct to exclude a 7% discount rate from its range of social cost estimates. As above, the Institute for Policy Integrity addresses this argument in depth in a separate report on discounting, but this section highlights a few key points.

A discount rate reflects the fact that, for various reasons, a dollar today is generally considered to be worth more than a dollar tomorrow, and so future costs and benefits are discounted so all effects can be compared in terms of their present value. Given the long time horizons of climate costs, the selection of discount rate has a substantial impact on the ultimate social cost valuation. The higher the discount rate, the more future generations are devalued and, thus, the lower the total damage estimate.

While the State Parties claim that the Working Group "fails to provide reasoning behind the chosen discount rates" for the interim social cost estimates,[28] that is simply not true. In reality, the Working Group in its most recent Technical Support Document provides extensive discussion of economic evidence supporting its choice of discount rates, detailing voluminous evidence that lower discount rates are appropriate for effects that occur over longer time horizons such as the impacts of climate change.[29] As the Working Group explained, there is broad consensus among economists that use of a consumption-based discount rate of 3% or lower is appropriate for evaluating climate impacts.[30] In fact, the Office of

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[24] *Id. See also* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 COLUM. J. ENV'T L. 203, 241–44 (2017).

[25] 2021 TSD, *supra* note 6, at 15–16.

[26] Schwartz, *supra* note 19; *see also* Howard & Schwartz, *supra* note 24.

[27] La. Complaint ¶ 107.

[28] *Id.*

[29] 2021 TSD, *supra* note 6, at 16–22.

[30] *Id.* at 17 ("[T]he latest data as well as recent discussion in the economics literature indicates that the 3 percent discount rate used by the IWG to develop its range of discount rates is likely an overestimate of the appropriate discount rate"). Of particular note, the Working Group highlights a new framework that demonstrates that the consumption discount rate is the

Management and Budget, Council of Economic Advisers,[31] National Academies of Sciences,[32] and economic literature[33] all conclude that a 7% rate is inappropriate for climate change, and that a discount rate of 3% or lower is warranted.

The Working Group's selection of discount rates is also consistent with federal guidance. Although *Circular A-4* normally calls for agencies to apply default discount rates of 3% and 7%, it requires agency analysts to do more than rigidly apply default assumptions.[34] Analysis must be "based on the best reasonably obtainable scientific, technical, and economic information available,"[35] and agencies must "*[u]se sound and defensible values* or procedures to monetize benefits and costs, and ensure that key analytical assumptions are defensible."[36] Rather than assume a 7% discount rate should be applied automatically to every analysis, like the State Parties do, *Circular A-4* requires agencies to justify the choice of discount rates for each analysis.[37] And as *Circular A-4* further explains, long-term effects counsel for lower discount rates due to their uncertainty and intergenerational nature,[38] and thus the Working Group correctly concluded that "use of *7 percent is not considered appropriate* for intergenerational discounting."[39]

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solely appropriate rate in inter-generational contexts. *Id.* at 19 (citing Qingran Li & William A. Pizer, *Use of the Consumption Discount Rate for Public Policy Over the Distant Future*, 107 J. ENV'T ECON. & MGMT. 102,428 (2021)). Elicitations of experts have also consistently found broad support for lower discount rates when assessing long-term climate damages. *See, e.g.*, Peter Howard & Derek Sylvan, *Expert Consensus on the Economics of Climate Change* 20 (2015), https://policyintegrity.org/publications/detail/expert-climate-consensus (showing overwhelming support for discount rates between 0-3%); Moritz A. Drupp et al., *Discounting Disentangled*, 10 AM. ECON. J. 109, 109 (2018) (finding "consensus among experts" at a 2% discount rate).

[31] Council of Econ. Advisers, *Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate* 12 (2017), *available at* https://perma.cc/HKY9-DSDE.

[32] NAS 2017 Report, *supra* note 10, at 181.

[33] *See, e.g.*, Kenneth J. Arrow et al., *Is There a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation?*, 272 SCIENCE 221, 222 (1996) (explaining that a consumption-based discount rate is appropriate for climate change); Peter Harrison Howard & Derek Sylvan, *Wisdom of the Experts: Using Survey Responses to Address Positive and Normative Uncertainties in Climate-Economic Models*, 162 CLIMATE CHANGE 213 (2020); Martin L Weitzman, *Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate*, 36 J. ENV'T ECON. & MGMT. 201 (1998); Richard G. Newell & William A. Pizer, *Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations?*, 46 J. ENV'T ECON. & MGMT. 52 (2003); Ben Groom et al., *Discounting the Distant Future: How Much Does Model Selection Affect the Certainty Equivalent Rate?*, 22 J. APPL. ECONOMETRICS 641 (2007).

[34] Circular A-4 at 3 ("You cannot conduct a good regulatory analysis according to a formula. Conducting high-quality analysis requires competent professional judgment.").

[35] *Id.* at 17.

[36] *Id.* at 27 (emphasis added).

[37] *Id.* at 3 ("[S]tate in your report what assumptions were used, *such as . . . the discount rates* applied to future benefits and costs," and explain "clearly how you arrived at your estimates[.]").

[38] *Id.* at 35–36.

[39] Working Group, *Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* at 36 (2015), *available at* https://perma.cc/C6X2-KKHP [hereinafter "2015 Response to Comments"] (emphasis added).

For further explanation as to why lower discount rates are appropriate for estimating the social cost values, please see the Institute for Policy Integrity report titled "About Time: Recalibrating the Discount Rate for the Social Cost of Greenhouse Gases."[40]

Not Only Did the Working Group Account for Uncertainty, But Uncertainty Points to Higher Social Cost Estimates

While the State Parties argue that there it too much uncertainty to rely on the Working Group's interim social cost valuations,[41] this argument is incorrect on multiple levels. As a legal matter, the presence of some uncertainty in the social cost valuations should not preclude agencies from using the best numbers available. And as a factual matter, the Working Group rigorously considered uncertainty and accounted for it in numerous ways. If anything, the presence of continued uncertainty suggests that the social cost valuations should be higher than presently valued—not that climate damages should not be valued at all.

Federal courts have repeatedly recognized that agency analysis necessitates making predictive judgments under uncertain conditions, explaining that "[r]egulators by nature work under conditions of serious uncertainty" [42] and "are often called upon to confront difficult administrative problems armed with imperfect data."[43] As the U.S. Court of Appeals for the Ninth Circuit has explained, "the proper response" to the problem of uncertain information is not for the agency to ignore the issue but rather "for the [agency] to do the best it can with the data it has."[44] Courts generally grant broad deference to agencies' analytical methodologies and predictive judgments so long as they are reasonable, and do not require agencies to have complete certainty before acting.[45] The State Parties are thus incorrect to suggest that the presence of some uncertainty in the social cost values merits their abandonment.

The State Parties also overlook the Working Group's rational approach to account for uncertainty. The Working Group's methodology accounted for parametric uncertainty (that is, uncertainty in model inputs), structural uncertainty (that is, uncertainty in model design), and stochastic uncertainty (which refers to predicting future events such as the pace of climate change and economic development). The Working Group considered these various sources of uncertainty "through a combination of a multi-model ensemble, probabilistic analysis, and scenario analysis."[46] As the Working Group explained, the three

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[40] Peter Howard & Jason Schwartz, Inst. for Pol'y Integrity, *About Time: Recalibrating the Discount Rate for the Social Cost of Greenhouse Gases* (2021).

[41] La. Complaint ¶ 74.

[42] *Pub. Citizen v. Fed. Motor Carrier Safety Admin.*, 374 F.3d 1209, 1221 (D.C. Cir. 2004).

[43] *Mont. Wilderness Ass'n v. McAllister*, 666 F.3d 549, 559 (9th Cir. 2011).

[44] *Id.*

[45] *See Wis. Pub. Power, Inc. v. FERC,* 493 F.3d 239, 260 (D.C. Cir. 2007) ("It is well established that an agency's predictive judgments about areas that are within the agency's field of discretion and expertise are entitled to particularly deferential review, as long as they are reasonable.") (internal quotation marks omitted).

[46] 2021 TSD, *supra* note 6, at 26.

reduced-form integrated assessment models ("IAMs") used account for uncertainty themselves by spanning a range of economic and ecological outcomes.[47] Additionally, the use of three separate models—all developed by different experts—accounts for uncertainty by integrating a diversity of viewpoints and structural and analytical considerations.[48] The Working Group further integrated a range of different uncertain parameters such as baseline emissions, population, and economic growth.[49]

The Working Group ran the IAMs 150,000 times per greenhouse gas and discount rate, took random draws of different uncertain parameters to develop a probability distribution of social cost values, used a Monte Carlo simulation to make thousands of random draws from the probability distribution, and then averaged across those results to develop the estimates that agencies apply.[50] In addition to reporting the average valuations, the Working Group also published the results of each model run and summarized results for each scenario.[51] Thus, contrary to the suggestion of the State Parties,[52] the Working Group analyzed uncertainty methodically and transparently, and its rigorous methodology easily satisfies the deferential standard of judicial review.

Moreover, experts broadly agree that the presence of uncertainty in the social cost valuations counsels for more stringent climate regulation, not less.[53] This is due to various factors including risk aversion, the informational value of delaying greenhouse gas emissions, insurance value, and the possibility of irreversible climate tipping points that cause catastrophic damage.[54] In fact, uncertainty is a factor justifying a lowering the discount rate, particularly in intergenerational settings.[55] Furthermore, current

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[47] *See id.*

[48] *See id.*

[49] *See* 2010 TSD, *supra* note 3, at 15–17.

[50] 2021 TSD, *supra* note 6, at 26–27.

[51] *Id.* at 27.

[52] *E.g.*, La. Complaint ¶ 74.

[53] *See, e.g.*, Alexander Golub et al., *Uncertainty in Integrated Assessment Models of Climate Change: Alternative Analytical Approaches*, 19 ENV'T MODELING & ASSESSMENT 99, 107 (2014) ("The most important general policy implication from the literature is that despite a wide variety of analytical approaches addressing different types of climate change uncertainty, none of those studies supports the argument that no action against climate change should be taken until uncertainty is resolved. On the contrary, uncertainty despite its resolution in the future is often found to favor a stricter policy."). *See also* Robert S. Pindyck, Comments to Ms. Catherine Cook, Bureau of Land Management, on Proposed Rule and Regulatory Impact Analysis on Delay and Suspension of Certain Requirements for Waste Prevention and Resource Conservation at 3 (Nov. 6, 2017), *available at* https://perma.cc/8MY5-58P5. ("[M]y expert opinion about the uncertainty associated with Integrated Assessment Models (IAMs) was used to justify setting the [social cost of methane] to zero until this uncertainty is resolved. That conclusion does not logically follow and I have rejected it in the past, and I reiterate my rejection of that view again here. While at this time we do not know the Social Cost of Carbon (SCC) or the Social Cost of Methane with precision, we do know that the correct values are well above zero. . . Because of my concerns about the IAMs used by the . . . Interagency Working Group to compute the [social cost of carbon] and [social cost of methane], I have undertaken two lines of research that do not rely on IAMs … [They lead] me to believe that the [social cost of carbon] is larger than the value estimated by the U.S. Government.").

[54] Policy Integrity and other groups have filed comments in numerous regulatory proceedings highlighting the various forms of uncertainty that increase the social cost of greenhouse gases and have provided numerous references. *See, e.g.*, Env't Def. Fund et al., *Improper Valuation of Climate Effects in the Proposed Revised Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS*, Technical App'x: Uncertainty (Dec. 14, 2020), https://policyintegrity.org/documents/Joint_SCC_comments_EPA_revised_CSAPR_Ozone_NAAQS_2020.12.14.pdf.

[55] *See* Howard & Schwartz, *supra* note 40.

omission of key features of the climate problem such as catastrophic damages and certain cross-regional spillover effects further suggests that the true social cost values are likely higher than the Working Group's best estimates.[56] According to the Working Group, "these limitations suggest that the [social cost of greenhouse gases] estimates are likely conservative."[57] In short, the State Parties' claim that there is too much uncertainty to use the social cost estimates is false, and, if anything, the presence of uncertainty is a reason to view the Working Group's estimates as a lower bound.

The Working Group Did Not Ignore Important Positive Impacts of Climate Change

The State Parties claim that the Working Group's interim social cost values "refuse to consider the potential benefits of a warming climate" and thus overstate the costs of climate pollution.[58] For instance, the State Parties allege that the Working Group's interim social cost of greenhouse gases "fails to fairly account for agricultural benefits caused by increased carbon dioxide concentrations."[59] The State Parties further claim that the Working Group's interim values "ignore[] decreased . . . wintertime mortality" resulting from warming temperatures.[60] And finally, the State Parties claim that the Working Group's interim valuations disregard the positive economic effects of energy production such as economic development.[61] These arguments are all incorrect.

Starting with agricultural benefits, the models that the Working Group relies on to develop its interim social cost estimates do account for the potential agricultural benefits of carbon dioxide fertilization from a warming planet.[62] Evidence suggests that, if anything, these models overvalue agricultural benefits from a warming planet—and thus undervalue the social cost of greenhouse gases.[63] One paper, for instance,

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[56] *Id.*

[57] Working Group, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis* 21 (2016), *available at* https://perma.cc/R7NC-XH6S [hereinafter "2016 TSD"].

[58] La. Complaint ¶ 103; *accord id.* ¶ 144 (claiming that Working Group's values "ignore important aspects of the problem including the positive externalities of energy production").

[59] Plaintiffs' Memorandum in Support of Motion for Preliminary Injunction at 24, *Missouri v. Biden*, 4:21-cv-00287-AGF (filed May 3, 2021) [hereinafter "Mo. Motion for Preliminary Injunction"].

[60] La. Complaint ¶ 103.

[61] *Id.*

[62] *See* Peter Howard, *Omitted Damages: What's Missing from the Social Cost of Carbon* 6 (2014), *available at* https://policyintegrity.org/files/publications/Omitted_Damages_Whats_Missing_From_the_Social_Cost_of_Carbon.pdf [hereinafter "Omitted Damages"]. *See also* Inst. for Pol'y Integrity, *A Lower Bound: Why the Social Cost of Carbon Does Not Capture Critical Climate Damages and What That Means for Policymakers* 5 (2019), *available at* https://policyintegrity.org/files/publications/Lower_Bound_Issue_Brief.pdf; *Climate Impacts Reflected in the SCC Estimates*, Cost of Carbon Project, https://costofcarbon.org/scc-climate-impacts.

[63] *See, e.g.*, Frances C. Moore et al., *Economic Impacts of Climate Change on Agriculture: A Comparison of Process-Based and Statistical Yield Models*, 12 ENV'T RSCH. LETTERS. 65,008, 65,008 ("[W]e find little evidence for differences in the yield

concludes that the applied estimates of net agricultural impacts produced an undervaluation of the social cost of carbon by more than 50%, explaining that "new damage functions reveal far more adverse agricultural impacts than currently represented" in the IAMs used by the Working Group.[64] And a comprehensive investigation of the impacts of climate change on agriculture has rejected the hypothesis "that agricultural damages over the next century will be minimal and indeed that a few degrees Celsius of global warming would be beneficial for world agriculture," concluding that climate change "would have at least a modest negative impact on global agriculture in the aggregate."[65]

The State Parties' other arguments are equally misguided. For example, the State Parties misleadingly point out that one of the models, DICE, includes increased heat-related morality but does not account for reductions in mortality during historically colder months (i.e., "wintertime").[66] However, consideration of the many damages omitted from the IAMs (particulate matter from wildfires, deaths from flooding, Lyme and other tick-based diseases), including certain mortality effects, consistently point toward a higher social cost value.[67] One recent study, in fact, concludes that the IAMs, on net, undervalue mortality increases from climate change.[68] DICE also omits diarrheal disease, which, as another paper explains, is the most costly health impact from climate change (according to another IAM) and thus has a far larger impact, in the opposite direction, than the omission of possible reductions in wintertime mortality.[69]

Moreover, while the State Parties also tout the supposed economic benefits of fossil fuel production such as economic productivity,[70] those effects are attributable to energy production in general and are not unique to fossil fuels.[71] In fact, controls on fossil fuels will hasten a transition to a greener electrical grid, and so have limited net economic impacts.[72] Insofar as an action does have some negative economic

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response to warming. The magnitude of CO_2 fertilization is instead a much larger source of uncertainty. Based on this set of impact results, we find a very limited potential for on-farm adaptation to reduce yield impacts.").

[64] Frances C. Moore et al., *New Science of Climate Change Impacts on Agriculture Implies Higher Social Cost of Carbon*, 8 NATURE COMMC'NS 1607, 1607 (2017).

[65] William R. Cline, *Global Warming and Agriculture: Impact Estimates by Country* 1–2 (2007).

[66] La. Complaint ¶ 103.

[67] *See, e.g., Omitted Damages*, *supra* note 59, at 4-5. *See also* 2016 TSD, *supra* note 57, at 21.

[68] *See* Tamma A. Carleton et al., *Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits (Nat'l Bureau of Econ. Research, Working Paper No. 27,599)* 4–5 (July 2020), *available at* https://perma.cc/82AT-SFBC (finding that new empirical estimates suggest that the increase in morality risk from climate change is valued at approximately 3.2% of global GDP in 2100, and concluding that "[t]hese empirically grounded estimates of the costs of climate-induced mortality risks substantially exceed available estimates from leading IAMs.").

[69] Kevin Cromar et al., *Public Health Benefits of Climate Mitigation in Social Cost of Carbon Estimates* (forthcoming in BioHealth, 2021) (explaining that 74% of health impacts in FUND model are attributable to increased diarrheal mortality, which DICE omits).

[70] *E.g.* La. Complaint ¶ 103.

[71] Renewable energy, like fossil fuels, generates revenue, supports jobs, and vitalizes local economies. *See, e.g.*, Katie Siegner et al., Rocky Mtn. Inst., *Seeds of Opportunity: How Rural America Is Reaping Economic Development Benefits from the Growth of Renewables* 6–16 (2021), *available at* https://perma.cc/DWH9-D4L7.

[72] Environmental regulation typically has limited impacts on total employment or other macroeconomic indicators, but rather shifts production from one sector to another. *See* Inst. for Pol'y Integrity, *Does Environmental Regulation Kill or Create Jobs* (2017), *available at* https://policyintegrity.org/files/media/Jobs_and_Regulation_Factsheet.pdf. Meanwhile, the sharp decline in the cost renewable energy is already expected to crowd out the demand for gas-fuel electricity in the coming years and decades. *See* Charles Teplin et al., ROCKY MTN. INST., *The Growing Market for Clean Energy Portfolios* 8 fig. ES-2 (2019),

impacts such as compliance costs or job losses, moreover, those impacts should not be included in any calculation of climate damages, but rather considered separately by regulators on the costs side of the ledger in individual determinations. Thus, this supposed omission is not an omission at all.

In addition to being factually suspect, the State Parties' legal premise here is also incorrect, as the mere omission of some effects does not counsel for abandoning the social cost valuations. The Working Group has acknowledged that its social cost of greenhouse gases valuations do not capture all impacts of climate change (either positive or negative), and independent experts broadly agree that the interim estimates likely undervalue true climate damages because they omit far more negative effects than positive ones.[73] For instance, the Working Group has explained that several of the underlying economic models omit certain major damage categories such as catastrophic damages and certain cross-regional spillover effects.[74] These effects can be massive: One paper, for instance, finds that the inclusion of tipping points doubles[75] or triples[76] the social cost estimates, with another paper explaining that the Working Group's existing values "may be significantly underestimating the needs for controlling climate change."[77] The current consensus of experts puts damages for a 3°C increase at roughly 5% to 10% of gross domestic product,[78] which is substantially higher than the damages estimated by the IAMs.[79] As the U.S. Court of Appeals for the Ninth Circuit has explained, the presence of some omitted damages does not provide a legal basis to ignore established methodologies to monetize climate damages, since while "there is a range of [plausible] values, the value of carbon emissions reduction is certainly not zero."[80]

The Working Group Did Not Overstate the Pace of Climate Change

In its lawsuit in Missouri, the State Parties' argues that the Working Group's Equilibrium Climate Sensitivity ("ECS") distribution—that is, the amount of warming that is expected to result from a doubling of the atmospheric carbon dioxide concentration—is "out of date" and fails to account for recent

available at https://perma.cc/P5YJ-WARJ (showing precipitous decline in cost of clean energy to being cheaper than fossil fuels).

[73] Howard, *supra* note 62, at 44 ("The inclusion of all omitted damages, including these more significant omitted damages, is likely to result in an increase in the [social cost of carbon].").

[74] 2010 TSD, *supra* note 3, at 26, 32.

[75] Derek Lemoine & Christian P. Traeger, *Economics of Tipping the Climate Dominoes*. 6 NATURE CLIMATE CHANGE 514, 514 (2016).

[76] Yongyang Cai et al., *Environmental Tipping Points Significantly Affect the Cost-Benefit Assessment of Climate Policies*, 112 PROCS. NAT'L ACADS. SCIS. 4606, 4606 (2015).

[77] *Id.*

[78] *See, e.g.*, Peter Howard & Derek Sylvan, Inst. for Pol'y Integrity, *Gauging Economic Consensus on Climate Change* 25 (2021) (reporting mean estimate of 8.5% GPD loss and median estimate of 5% loss, based on elicitation of over 700 climate-policy experts).

[79] 2010 TSD, *supra* note 3, at 9 fig.1A (showing range of GDP loss below 5% for 3°C temperature increase).

[80] *Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1,172, 1,200 (9th Cir. 2008).

evidence showing that sensitivity to be lower than previously believed.[81] This argument relies on cherry-picked data and ignores the scientific consensus.

As support for their claim, the State Parties cite a single paper—Lewis & Curry (2015)—which estimates a median ECS of 1.64 °C with an uncertainty range (5–95%) of 1.05–4.05 °C.[82] But that paper is an outlier. The most recent consensus estimate from the Intergovernmental Panel on Climate Change ("IPCC") projects an ECS range of 1.5–4.5 °C.[83] This is far higher than the range from Lewis & Curry (2015). In fact, the median value of 1.64 °C from Lewis & Curry (2015) falls at the very bottom of the consensus IPCC range. The states elevate the findings of a single outlier paper over consensus estimates from the broader scientific community to cast doubt on the Working Group's methodology. In evaluating the ECS, the Working Group assessed estimates from a wide range of experts and selected median values—not extreme outlier estimates like the one the State Parties champion.[84] In fact, the Working Group acknowledged that some ECS estimate ranges go as high as 10 °C, making its selected ECS distribution substantially lower than these high-end estimates.[85]

The State Parties are additionally incorrect to suggest that this one outlier estimate from Lewis & Curry (2015) reflects a growing trend toward lower ECS values. "Through the decades, the range of ECS values has stayed remarkably consistent—somewhere around 1.5 to 4.5 degrees Celsius."[86] For this reason, the National Academies of Sciences in 2016, after the publication of Lewis & Curry (2015), "recommend[ed] against a near-term change in the distributional form of the ECS" when confronted with the very question of whether to endorse an immediate update, explaining that revisions on this front incorporating the latest science "should have a minimal impact on estimates of the [social cost of greenhouse gases]."[87] On the whole, in fact, recent evidence that is informing the IPCC's next synthesis report tends to indicate that the ECS is higher than previously estimated, not lower.[88] And since its publication, Lewis & Curry (2015) has

[81] Mo. Motion for Preliminary Injunction, *supra* note 59, at 23–24.

[82] *Id.* at 24 (citing Nicholas Lewis & Judith A. Curry, *The Implications for Climate Sensitivity of AR5 Forcing and Heat Uptake Estimates*, 45 CLIMATE DYNAMICS 1009 (2015)).

[83] IPCC, *AR5 Synthesis Report* 62 (2014). The IPCC did not provide a central or median estimate in this report.

[84] 2010 TSD, *supra* note 3, at 12–15.

[85] *Id.* at 14 fig.2.

[86] *Increased Warming in Latest Generation of Climate Models Likely Caused by Clouds*, ScienceDaily (June 24, 2020), https://perma.cc/63PB-XCPC.

[87] NAS 2016 Report, *supra* note 10 at 34, 46.

[88] ScienceDaily, *supra* note 86. It should also be noted that several feedback effects are current excluded in the calculation of the ECS. For example, the versions of the assessment models used by the Working Group do not directly model methane emissions from the melting of the permafrost, despite its exclusion from current ECS calculations. Dmitry Yumashev et al., *Climate Policy Implications of Nonlinear Decline of Arctic Land Permafrost and Other Cryosphere Elements*, 10 NATURE COMMC'NS 1,900, 1,900 (2019). Also, several of the assessment models used by the Working Group do not model ocean uptake. Masakazu Yoshimori et al., *A Review of Progress Towards Understanding the Transient Global Mean Surface Temperature Response to Radiative Perturbation*, 3 PROGRESS IN EARTH & PLANETARY SCI. 1, 1 (2016). This further points to current ECS estimates underestimating the amount of warming, not overestimating it.

been criticized by other climate scientists for methodological deficiencies that cause it to underestimate the ECS.[89] Thus, the State Parties' criticism falls flat.

The Working Group Used an Appropriate Emissions Baseline

The State Parties argue that the Working Group's interim valuations are a vast overestimate because they apply "badly out of date" emissions scenarios that exaggerate the baseline level of greenhouse gas emissions in the atmosphere.[90] It is true that using a higher baseline level of emissions raises the social cost estimates because the harm from an additional unit of emissions rises with the baseline emissions level. However, the Working Group used a reasonable emissions baseline that reflects different possible mitigation scenarios and so does not inappropriately increase the social cost of greenhouse gases.

The State Parties' criticism here has no substance once the relevant terminology is understood. While the State Parties faults the Working Group for relying on supposedly "business-as-usual" emission scenarios that assume no mitigation, in reality the scenarios that the Working Group applied—though referred to as "business-as-usual" by the Working Group—apply "various assumptions about how the future will evolve without prejudging what is likely to occur" and thus "span a wide range [of possible scenarios], from the more optimistic (e.g. abundant low-cost, low-carbon energy) to more pessimistic (e.g. constraints on the availability of nuclear and renewables)."[91] Thus, while the State Parties suggests that "business-as-usual" refers to a world without emission reductions,[92] this is not how the Working Group applied the term.

In fact, the emissions scenarios that the Working Group applied are in line with—and in fact potentially understate—the baseline level of emissions under a range of mitigation scenarios, providing another reason that the Working Group's interim valuations likely underestimate the true social cost of greenhouse gases. While the Working Group assumed a baseline emissions range of 13–118 gigatons of carbon dioxide emitted per year by 2100,[93] recent projections from the Climate Action Tracker indicate that baseline emissions will reach between 14–175 gigatons of carbon dioxide by 2100 under a range of

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[89] *See, e.g.*, Kate Marvel et al., *Internal Variability and Disequilibrium Confound Estimates of Climate Sensitivity From Observations*, 45 GEOPHYSICAL RSCH. LETTERS 1595, 1595 (2018) ("[A] range of recent work … suggests that such estimates [including Lewis & Curry (2015)] may underestimate equilibrium warming."); Yoshimori et al., *supra* note 88, at 11 (citing Lewis & Curry (2015) for the critique that "[b]ecause the observed data represent the transient stage of the response under increasing green-house gas forcing, this deviation is a concern for the observation-based estimate of the ECS"); Timothy Andrews et al., *Accounting for Changing Temperature Patterns Increases Historical Estimates of Climate Sensitivity*, 45 GEOPHYSICAL RSCH. LETTERS 8490, 8491 (2018) (explaining that Lewis and Curry disregard "the impact from non-CO_2 forcings and unforced climate variability that could have had a significant impact on the pattern of historical temperature change").

[90] Mo. Motion for Preliminary Injunction, *supra* note 59, at 25 (internal quotation marks omitted).

[91] 2010 TSD, *supra* note 3, at 16–17.

[92] *See* Mo. Motion for Preliminary Injunction, *supra* note 59, at 25.

[93] 2010 TSD, *supra* note 3, at 16 tbl.2.

scenarios reflecting different levels of mitigation.[94] Thus, the baselines used by the Working Group potentially understate baseline emissions and therefore undervalue the social cost values. In fact, several of the Working Group's supposedly "business-as-usual" scenarios are actually more consistent with baseline estimates reflecting policy projections.[95] In contrast, the low-end emissions scenario that the State Parties tout—i.e. the one that assumes 13 gigatons of carbon dioxide emissions in 2100—is plausible but reflects an optimistic trajectory based on current projections.[96]

Moreover, while the State Parties argue that the Working Group should have relied less on supposedly business-as-usual scenarios and more on scenarios consistent with widespread mitigatory action, this choice does not especially affect the social cost valuations. In comparison to the Working Group's interim central social cost of carbon estimate in 2020 of $51 per ton, the average social cost of carbon under the Working Group's supposed business-as-usual emissions scenarios is $53 per ton and $41 per ton under the emissions scenario that is consistent with sustained and widespread mitigatory action.[97] While relying less on the Working Group's supposed business-as-usual scenarios would therefore modestly decrease the interim social cost valuations in a vacuum, more holistic updates to the metrics as recommended by the National Academies of Sciences would very likely increase the social cost valuations overall due to the omitted damages discussed above and recent evidence regarding long-term discount rates.[98] Thus, even assuming the State Parties' factual predicate, their argument makes a mountain out of a molehill. But again, the State Parties' factual premise is dubious because recent evidence suggests that the Working Group may well have undervalued baseline emissions in developing its interim estimates.

The Working Group Relied on Reasonable Damage Functions

While the State Parties argue that the damage functions for translating climate impacts caused by an additional unit of emissions into economic losses[99] are flawed and arbitrary, this argument too falls flat. In reality, the damage functions are based on reasonable assumptions made by experts based on the current science on climate change.[100] Moreover, the Working Group's methodology for its interim estimates,

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[94] Climate Action Tracker, *Global Emissions Time Series* (Dec. 1, 2020), *available at* https://perma.cc/B4X2-RAWA.

[95] *Compare id.* (projecting 35-48 gigatons of emissions in 2100 under "current policy projections" scenarios and 83-175 gigatons under business-as-usual scenario) *with* 2010 TSD, *supra* note 3, at 16 tbl.2 (incorporating supposedly business-as-usual scenarios of 42.7 and 60.1 gigatons in 2100).

[96] *See* Climate Action Tracker, *supra* note 94 (projecting 2100 emissions as high as 175 gigatons).

[97] *See* Peter Howard et al., *Option Value and the Social Cost of Carbon: What Are We Waiting For? (Inst. for Pol'y Integrity Working Paper No. 2020/1)* 16 tbl.1 (2020), *available at* https://policyintegrity.org/files/publications/Working_paper_06.22.20.pdf.

[98] *See* 2021 TSD, *supra* note 6, at 4 (Working Group acknowledging that its current social cost valuations "likely underestimate societal damages from [greenhouse gas] emissions").

[99] *See id.* at 4 (explaining that damage functions are "the core parts of the IAMs that map global mean temperature changes and other physical impacts of climate change into economic (both market and nonmarket) damages…").

[100] 2015 Response to Comments, *supra* note 39, at 8 ("While the development of the DICE, FUND and PAGE models necessarily involved assumptions and judgments on the part of the modelers, the damage functions are not simply arbitrary representations of the modelers' opinions about climate damages.").

including in selecting which models to use, was rigorous and transparent. The damage functions have also withstood scientific scrutiny, and criticism of the damage functions by a notable economist referenced by the State Parties[101] has been taken out of context.

The damage functions used by the creators of the IAMs are not arbitrary, but in fact are based on sound science and economics. For example, the Working Group explains the logic underlying DICE's damage function, noting that the curve's quadratic shape "capture[s] the more rapid increase in damages expected to occur under more extreme climate change."[102] And there is ample additional documentation explaining the economic and scientific decisions behind DICE's calibration. Nobel Prize winner William D. Nordhaus, the creator of DICE, calibrated early versions of that model's damage function using an enumerative method. The enumerative calibration method, which has been described as "bottom-up approach," was at the time the chosen methodology for IAM modelers.[103] In their book, *Warming the World: Economic Models of Global Warming*, Nordhaus and Joseph Boyer discuss extensively how the DICE-1999 model was calibrated and why.[104] Later, Nordhaus similarly documented his calibration decisions in the model's accompanying documentation.[105]

Changes to the damage functions are also well-documented and grounded in the best available science and economics. More recently, Nordhaus updated the calibration approach such that it reflects not only his own expert opinion on the correct functional form (shape) of the damage function, but also the expertise of other climate economists. Specifically, beginning with DICE-2013R, Nordhaus recalibrated the model using a meta-analysis approach.[106] For the 2013 update, Nordhaus also considered whether the updated damage function for DICE was consistent with those of the other IAMs (which it is).[107] The 2016 version of DICE was also calibrated using a meta-analysis, and in a 2017 discussion paper, Nordhaus noted that "the DICE model has been through many iterations, incorporating more recent economic and scientific findings and updated economic and environmental data."[108] In short, though the damage functions used by the reduced-form IAMs are evolving, they have always been grounded in the best available information, and can be revised as part of the Working Group's upcoming updates.

The Working Group thoughtfully selected the IAMs and has continuously followed the science. To begin, the Working Group selected the three "most widely cited models in the economic literature that link

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[101] La. Complaint ¶ 68.

[102] 2010 TSD, *supra* note 3, at 6.

[103] Peter H. Howard & Thomas Sterner, *Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates*, 68 ENV'T & RSCH. ECON. 197, 201 (2017). *See also* Omitted Damages, *supra* note 59, at 11-13 (describing how the DICE model was calibrated).

[104] WILLIAM D. NORDHAUS & JOSEPH BOYER, WARMING THE WORLD: ECONOMIC MODELS OF GLOBAL WARMING 101 (2000), *available at* https://perma.cc/5MRC-S8LX.

[105] William Nordhaus, *Accompanying Notes and Documentation on Development of DICE-2007 Model: Notes on DICE-2007.delta.v8* (July 2007), *available at* https://perma.cc/Q2BS-PEA5.

[106] *See* William Nordhaus & Paul Sztorc, *DICE 2013: Introduction & User's Manual* 11 (Oct. 2013), *available at* https://perma.cc/427S-DXT6 (noting that the damage function is based off of Richard S. J. Tol, *The Economic Effects of Climate Change*, 23 J. ECON. PERSPECTIVES 29 (2009)).

[107] *Id.*

[108] William D. Nordhaus, *Evolution of Modeling of the Economics of Global Warming: Changes in the DICE Model, 1992-2017 (Cowles Foundation Discussion Paper no. 2084)* 2 (Mar. 2017), *available at* https://perma.cc/HW64-NS9D.

physical impacts to economic damages."[109] Moreover, the Working Group has explained that "the damage functions are not simply arbitrary representations of the modelers' opinions about climate damages."[110] Instead, the damage functions "are based on a review by the modelers of the currently available literature on the effects of climate change on society."[111] The Working Group further explained how the modelers have been transparent about the conclusions they draw from the literature.[112] Evidence of this can be seen, for example, in DICE's user manual.[113]

While the National Academies of Sciences report recommended some updates to the Working Group's damage functions, it did not suggest that these functions systematically overvalue the social cost values or supply a reason to abandon the metric. For example, the National Academies recommend that the Working Group apply region- and/or sector-specific damage functions in its next update.[114] The National Academies noted, however, that the damage functions used by the Working Group are constrained by the available literature and so as the state of knowledge on climate change advances, so can the accuracy of the damage functions.[115] This reflects the Working Group's own strategy.[116] As there have been a number of advances in the literature since 2016, when the Working Group last updated its social cost estimates, the recently reconvened Working Group will have more material to draw from as it completes its updates.[117]

In addition to general concerns about the damage functions, the State Parties specifically refer to comments from the U.S. Chamber of Commerce, citing a paper by Massachusetts Institute of Technology economics professor Robert S. Pindyck to support their claim that the damage functions are arbitrary.[118] While Professor Pindyck has questioned the shape of the models' damage functions,[119] he has also acknowledged that the damage functions reflect "common beliefs" about the effects of two or three degrees of warming. And, in reference to this paper, Pindyck emphatically states that uncertainty about

[109] 2015 Response to Comments, *supra* note 39, at 7; 2010 TSD, *supra* note 3, at 5 ("These models are frequently cited in the peer-reviewed literature and used in the IPCC assessment.… These models are useful because they combine climate processes, economic growth, and feedbacks between the climate and the global economy into a single modeling framework.").
[110] 2015 Response to Comments, *supra* note 39, at 8.
[111] *Id.*
[112] *Id.*
[113] *E.g.*, Nordhaus & Sztorc, *supra* note 106.
[114] NAS 2017 Report, *supra* note 10, at 50–51.
[115] *Id.* at 139.
[116] 2015 Response to Comments, *supra* note 39, at 8 ("Moving forward, the IWG will continue to follow and evaluate the latest peer reviewed literature applying IAMs.").
[117] The Working Group has indicated as much ("…in the time since the versions of the IAMs used in this TSD were published, there has been an explosion of research on climate impacts and damages.… Several efforts are underway to draw on recent literature for improving damage functions and to generate new damage estimates."). 2021 TSD, *supra* note 6, at 32-33.
[118] La. Complaint ¶ 68.
[119] Robert Pindyck, *Climate Change Policy: What do the Models Tell Us? (Nat'l Bureau of Econ. Research, Working Paper No. 19244)* 16 (2013), *available at* https://perma.cc/G25M-MA7W.

the social cost estimates, including the damage functions, "does not imply that [their] value should be set to zero until the uncertainty is resolved."[120]

As is the case with the State Parties' complaints, Pindyck's work on social cost metric has often been misinterpreted. In fact, Pindyck himself has submitted comments to federal agencies warning them not to falsely cite to the specific working paper in question because it had been widely misused by opponents of climate regulation.[121] He actually advocates for an even higher social cost value than that produced by the Working Group. He says: "My criticism of IAMs should not be taken to imply that because we know so little, nothing should be done about climate change right now, and instead we should wait until we learn more. Quite the contrary."[122] He goes on to explain that being proactive will benefit society in the long term.[123]

As noted above, Pindyck's work actually supports the idea that the uncertainty underlying the social cost of greenhouse gases does not supply a reason to abandon the Working Group's estimates. In fact, in 2019, Pindyck's own best estimate of the average social cost of carbon dioxide was between $80 to $100, with plausible values going up to $200, which is significantly higher than the Working Group's central estimate of $51.[124] The State Parties cite Pindyck when criticizing the social cost of greenhouse gas estimates, but fail to mention that his work actually supports a robust accounting of climate damage externalities in decisionmaking.

Conclusion

The pending lawsuits challenging the Working Group's interim estimates of the social cost of greenhouse gases are meritless. Time after time, these lawsuits mischaracterize the Working Group's approach, disregard the science and economics underlying climate change, and elevate outlier theories over scientific consensus. This report discusses the Working Group's methodology and rebuts the State Parties' objections regarding global damage valuations, discount rates, the treatment of uncertainty, positive externalities, equilibrium climate sensitivities, emission baselines, and damage functions. As the Working Group revises its social cost estimates, it should carefully consider all public comments and provide detailed responses that agencies can incorporate into future actions, so that agencies are well prepared to rebut these same kind of arguments in the future.

[120] Pindyck, supra note 53, at 3.
[121] *See, e.g., id.*
[122] Pindyck, *supra* note 119, at 16.
[123] *Id.* ("One can think of a [greenhouse gas] abatement policy as a form of insurance: society would be paying for a guarantee that a low-probability catastrophe will not occur (or is less likely).").
[124] Robert S. Pindyck, *The Social Cost of Carbon Revisited*, 94 J. ENV'T ECON. & MGMT. 140, 140, 154–55 (2019).