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Comments on Petition for Correction,: Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (February 2010) and Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (May 2013) submitted to the Office of Management and Budget by America's Natural Gas Alliance, the American Chemistry Council, the American Petroleum Institute, the National Association of Home Builders, the National Association of Manufacturers, the Portland Cement Association, and the U.S. Chamber of Commerce (submitted on September 4, 2013)

Comments submitted by: the Natural Resources Defense Council, Institute for Policy Integrity, Environmental Defense Fund, and Union of Concerned Scientists

The above industry groups recently submitted a petition to the Office of Management and Budget (OMB) and the other agencies involved in the Interagency Working Group on the Social Cost of Carbon (IWG). The petition seeks to prohibit the use of the IWG's 2010 and 2013 social cost of carbon (SCC) estimates by executive branch agencies and requests the withdrawal of the IWG's Technical Support Document.¹ Our organizations respectfully submit these comments to explain why petitioners' arguments are in error. On this basis, we urge OMB to deny the petition.

¹ INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2010), available at <http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf>; INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2013), available at http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

I. Executive Summary

The petitioners' claims fall into three general categories:

- That estimates of the SCC are purportedly too uncertain and imprecise to be used for regulatory analysis. The petitioners contend that alleged uncertainty and imprecision renders the SCC an illegitimate tool for use in regulatory impact analyses. They discuss a number of technical estimation issues with the SCC models used by the IWG, and mistakenly conclude that these limitations preclude IWG's use of them. Petitioners misrepresent both the International Panel on Climate Change (2007) and economists' own assessments of SCC limitations.²
- That the IWG supposedly did not follow appropriate protocols in either its estimation or use of the SCC. The petitioners accuse the IWG of hiding the uncertainties in its analysis; of failing to follow guidelines with respect to discount rates and the choice of a global rather than domestic SCC; of failing to have its analysis peer reviewed; and of denying stakeholders proper notice or opportunity to comment on the IWG's analysis.
- In light of these two claims, that the SCC must be banned from use while it undergoes another public review process. They assert that the IWG's SCC estimates are "arbitrary and capricious," and likely overestimated. While the SCC would be under re-review, the petitioners request that OMB require agencies to assign a value of zero to carbon pollution damages.

Sections II and III of these comments explain why the various claims made in support of the petitioners' arguments are erroneous. Section IV discusses why the SCC is likely to be significantly underestimated, rather than inflated, as the petitioners claim. We conclude in section V.

Before examining these issues in detail, we make two general points with respect to the petitioners' claim that uncertainties involved in estimating the SCC prohibit its use in regulatory analysis, and their assertion that the IWG's SCC estimates were not properly peer reviewed or open for public comment.

First, ***as a matter of law and economics, uncertainty in benefits estimates does not mean they should be excluded from regulatory impact analyses.*** In fact, the courts have explicitly rejected this argument with respect to the SCC, and executive orders dating back as far as the Reagan administration have all issued guidelines specifying explicit consideration of benefits even if the precise size of the benefit is uncertain.

In 2007, the U.S. Court of Appeals for the Ninth Circuit determined that agencies could not assign a zero dollar value to the social costs of the impacts of climate change.³ It determined that *failing* to count SCC benefits would be illegal.

² INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007). <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf>

³ *Center for Biological Diversity v. National Highway Traffic Safety Administration*, 538 F.3d 1172 (9th Cir. 2008).

In this case, the National Highway Traffic Safety Administration (NHTSA) had decided not to count any avoided climate damages in issuing fuel economy standards.⁴ The court concluded: “NHTSA’s reasoning is arbitrary and capricious for several reasons. First while the record shows that there is a **range of values**, the value of carbon emission reductions is certainly **not zero**”(emphases added).⁵ *The court’s decision directly contradicts the petitioners’ argument that uncertainty renders the SCC invalid, as well as their demand that agencies use a value of zero.*

Like the Court of Appeals, executive orders dating back to 1981 have also required agencies to assess benefits and costs even when significant uncertainty exists. Every president since (and including) Ronald Reagan has issued directives requiring that agencies conduct cost benefit analyses of proposed regulations where permitted by statute. Specifically, agencies are directed to “take into account benefits and costs, both quantitative and qualitative...and use the **best available techniques** to quantify anticipated present and future benefits and costs as accurately as possible (emphasis added).”⁶

Second, **while agencies are expected to use rigorous science to inform their regulatory impact analyses, there is no legal requirement for demanding that an agency’s analysis itself undergo academic peer review.** What is required is that agencies undertaking rulemakings provide public notice and an opportunity for public comment on their analyses, and respond to those comments.

The petitioners have had multiple opportunities to comment on the IWG’s analysis and will have additional opportunities to do so in future rulemakings based on the specific factual and legal issues presented. The IWG’s estimates have been referenced in more than 40 rulemakings to date, and agencies have responded to relevant comments submitted thus far.⁷ Indeed, many of the changes the IWG made in its updated methodology were made in *response* to such comments.

⁴ *Center for Biological Diversity v. National Highway Traffic Safety Administration*, 538 F.3d 1172 (9th Cir. 2008) (holding unlawful NHTSA’s fuel economy standards for passenger vehicles when NHTSA ascribed a value of “zero” to the benefits of mitigating carbon dioxide, reasoning that “NHTSA assigned no value to the most significant benefit of more stringent CAFE standards: reduction in carbon emissions.”).

⁵ *Center for Biological Diversity v. National Highway Traffic Safety Administration*, 538 F.3d 1172 (9th Cir. 2008).

⁶ Exec. Order No. 13,563, 3 C.F.R. 215 (2011); Exec. Order No. 12,866, 3 C.F.R. 638 (1994); Exec. Order No. 12,291, 3 C.F.R. 127 (1982).

⁷ The SCC has been used in numerous notice-and-comment rulemakings by various agencies since it was published in 2010, and each of these occasions has provided opportunity for public comment on the SCC. See, e.g., Energy Conservation Program: Energy Conservation Standards for Residential Clothes Washers, 77 Fed. Reg. 32,381 (May 31, 2012); Energy Conservation Program: Energy Conservation Standards for Residential Dishwashers, 77 Fed. Reg. 31,964 (May 30, 2012); Energy Conservation Program: Energy Conservation for Battery Chargers and External Power Supplies, 77 Fed. Reg. 18,478 (Mar. 27, 2012); Energy Conservation Program: Energy Conservation Standards for Standby Mode and Off Mode for Microwave Ovens, 77 Fed. Reg. 8526 (Feb. 14, 2012); Energy Conservation Program: Energy Conservation Standards for Distribution Transformers, 77 Fed. Reg. 7282 (Feb. 10, 2012); Energy Conservation Program for Certain Industrial Equipment: Energy Conservation Standards and Test Procedures for Commercial-Heating, Air-Conditioning, and Water-Heating Equipment, 77 Fed. Reg. 2356 (Jan. 17, 2012); 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 76 Fed. Reg. 74,854 (Dec. 1, 2011); Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews, 76 Fed. Reg. 52,738 (Aug. 23, 2011); Energy Conservation

It is up to each agency to decide whether to rely on the IWG estimates of the SCC in its decisions, to modify those values, or to choose a different means of estimating the cost of carbon pollution, either in the first instance or after receiving comment on the IWG estimate. Affected parties have the opportunity for judicial review at the end of each rulemaking. To our knowledge, no party has raised issues pertaining to the IWG estimates of the SCC in judicial review of any rules.

Finally, it is important to note that in all of those rulemakings (including the microwave efficiency standard which included use of the IWG's updated SCC⁸) benefits greatly exceeded costs even absent any consideration of the SCC. Accordingly, the SCC has not been responsible for any additional legal obligation, restriction, or burden on the petitioners.

In future rulemakings, the petitioners will have ample opportunity to present their arguments and any competing data. Dissatisfied parties will have the right to file lawsuits challenging final rules, and to try to persuade a court that the agency's use of the SCC was arbitrary, capricious, or otherwise unlawful.

The bottom line is that the IWG has properly and lawfully used the best available techniques to quantify the benefits of carbon emission reductions, basing its analysis on the leading peer reviewed science. When agencies use the IWG's estimates of the SCC to calculate the benefits of a rulemaking, they are required to provide an opportunity for comment on the SCC and on the process used to derive that value. That is what the law – and good policy – requires. The petitioners offer no alternative (or better) estimation procedure. They simply ask OMB to contravene the Ninth Circuit's decision by substituting zero for the IWG's best estimate of the costs of carbon pollution.

Given that there is no legal basis for rejecting the current SCC estimates, the following two sections document why the various claims made in support of the petitioners' arguments are incorrect from both the scientific and economic perspectives. We discuss the strength of IWG's uncertainty analysis, and its basis in the methodologies of both fields.

Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps, 76 Fed. Reg. 37,549 (June 27, 2011); Energy Conservation Program: Energy Conservation Standards for Residential Clothes Dryers and Room Air Conditioners, 76 Fed. Reg. 22,324 (Apr. 21, 2011); Energy Conservation Program: Energy Conservation Standards for Fluorescent Lamp Ballasts, 76 Fed. Reg. 20,090 (Apr. 11, 2011); National Emission Standards for Hazardous Air Pollutants: Mercury Emissions from Mercury Cell Chlor-Alkali Plants, 76 Fed. Reg. 13,852 (Mar. 14, 2011); Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, 75 Fed. Reg. 74,152 (Nov. 30, 2010); Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Sewage Sludge Incineration Units, 75 Fed. Reg. 63,260 (Oct. 14, 2010); Energy Conservation Program: Energy Conservation Standards for Residential Refrigerators, Refrigerator-Freezers, and Freezers, 75 Fed. Reg. 59,470 (Sept. 27, 2010); Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone, 75 Fed. Reg. 45,210 (Aug. 2, 2010). The undersigned organizations have provided comment on the SCC during a number of these proceedings.

⁸ In a recent rulemaking establishing energy conservation standards for microwaves, DOE adopted final standards identical to the proposed standards while strengthening the SCC in the final rule to reflect the more rigorous results of the updated IWG. *Compare* 78 Fed. Reg. 36,316 36,317, 36,323 (June 17, 2013) (Final Rule), *with* 77 Fed. Reg. 8526, 8527 (Feb. 14, 2012) (Proposed Rule). The public had ample opportunity to comment on all aspects of the fundamental elements of the SCC and the final rule was unchanged and, manifestly, a logical outgrowth of the proposal.

II. The IWG’s analysis is based upon the leading peer reviewed SCC models which provide a legitimate basis for the IWG’s analysis. *Although quantifying the economic impact of climate impacts involves uncertainty, as the courts have recognized, uncertainty is an accepted, indeed fundamental tenet, of scientific analysis.*

The petitioners contend that because it is difficult to estimate the SCC with near-perfect certainty and precision, any such estimate is not a legitimate tool for regulatory impact analysis. In making this argument, they discuss a number of technical estimation challenges and mistakenly conclude that the limitations of these models make the IWG’s use of them illegitimate. They misrepresent both the science and the assessments by economists of the relevance of uncertainty and approximation to the legitimacy of SCC estimates, and contradict a clear legal determination that uncertainties in the SCC do not make it unfit for regulatory analysis. Below we give the petitioners’ various criticisms and explain why they are incorrect.

- a. The petitioners’ claim that uncertainty makes the models used by the IWG invalid is wrong: science by its very nature is uncertain, and economists have developed a set of tools to deal with uncertainty in climate damages. Economic theory argues for the consideration of the best available information under uncertainty; the models used by the IWG adopt this approach.
- b. The question is not whether there is uncertainty in the analysis of the costs of climate impacts, but rather whether the IWG used proper methods to account for uncertainty. The IWG was impressively comprehensive in its approach, and employed the following best available methods:
 - The IWG conducts a sophisticated statistical procedure called Monte Carlo analysis,⁹ which produces a range of estimates based upon different possible outcomes that climate science research, as well as social science research, indicate are possible. For example, it specified different possible temperature changes in response to greenhouse gas forcing (using a “Roe Baker” distribution¹⁰ estimated by scientists), and a variety of possible future emission and growth scenarios.

⁹ A Monte Carlo simulation will run an integrated assessment model thousands of times, each time randomly picking the value of uncertain parameters. In the case of the SCC, the Working Group ran 10,000 Monte Carlo simulations for each of the three IAMs and five socio-economic scenarios, randomizing the value of climate sensitivity, i.e., the change in average global temperature associated with a doubling of CO₂, and all other uncertain parameters in the IAMs by the original authors. For each randomly drawn set of values, the IAM estimated the associated damages, with the final SCC estimate equaling the average value across all 10,000 runs, five socio-economic scenarios, across all three models. Therefore, each SCC estimate is calculated from 150,000 runs.

¹⁰ According to the 2010 IWG, “Roe and Baker...is [a probability distribution that is] based on a theoretical understanding of the response of the climate system to increased greenhouse gas concentrations.” See Roe and Baker (2007) for further discussion. INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2010), *available at* <http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf>); Gerard H. Roe & Marcia Baker, *Why is climate sensitivity so unpredictable?*, 318 SCIENCE 629 (2007).

- Recognizing that there are different ways of modeling climate science and damages, the IWG uses three different climate economics models: the Dynamic Integrated Model of Climate and the Economy (DICE),¹¹ the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND),¹² and Policy Analysis of the Greenhouse Effect (PAGE).¹³ The use of sensitivity analysis over these integrated assessment models (IAMs) captures three different sets of assumptions about how climate impacts are mathematically translated into economic damages, or the “damage function.” This method addresses uncertainties over the functional form of the damage function.
 - The IWG updated its damage estimates from 2010 to 2013 by using the most recent peer-reviewed versions of the models it used in its analysis. A key scientific precept is that models must be updated as more and better science becomes available—the scientific method requires the continual examination of new evidence and improving the resulting analysis. Recognizing scientific uncertainty and established scientific practice, the IWG has committed to regularly updating its analysis as the underlying science advances. This is a *good* thing, not something illegitimate as the petitioners claim.
- c. The petitioners make several misleading assertions about the state of economic and scientific knowledge. They also misrepresent the IPCC’s assessment of the relevance of uncertainty to the legitimacy of SCC estimates, claiming that the IPCC does not make scientific projections past 2100 (e.g. climate impacts such as temperature rise, sea-level rise, etc.), and that correspondingly its authors do not view the longer-term IAM models as valid. The petitioners claim that little is known about the sensitivity of SCC estimates to various parameters in IAMs; that time horizons are too long; that there is little consensus within the IAM community over key modeling assumptions; and that little is known about the functional form of the damage function. All of these assertions are wrong, as evidenced by the following facts.
- Contrary to the petitioners’ claim, numerous studies analyze changes in various parameters and assumptions underlying IAMs, and their effects on SCC estimates. A number of articles examine the sensitivity of the IAMs to input parameters. For example, Anthoff and Tol (2013) analyze the sensitivity of the social cost of carbon in FUND to the most important parameters in the model;¹⁴ Warren et al. (2006) analyze the damage

¹¹ WILLIAM D. NORDHAUS & JOSEPH BOYER, WARMING THE WORLD (2000).

¹² DAVID ANTHOFF & RICHARD S.J. TOL, THE CLIMATE FRAMEWORK FOR UNCERTAINTY, NEGOTIATION AND DISTRIBUTION (FUND), TECHNICAL DESCRIPTION, VERSION 3.6 (2012), *available at* <http://www.fund-model.org/versions>.

¹³ Chris Hope, *The marginal impact of CO2 from PAGE2002: An integrated assessment model incorporating the IPCC's five reasons for concern*, 6 THE INTEGRATED ASSESSMENT JOURNAL 19 (2006).

¹⁴ According to their analysis, the three most important parameters in terms of their effect on the SCC are the parameters that affect: the curvature of the demand for cooling energy, climate sensitivity, and the curvature

functions of four IAMs, and discuss the relative importance of different sectors; van Vuuren et al. (2011) and Hof et al. (2012) explore the three IAMs' models of the climate system; Ackerman and Stanton (2012) analyze the effect of a recalibrated DICE damage function.¹⁵

- The petitioners claim that the models are illegitimate because they estimate damages past 2100, that the IPCC does not make projections past 2100, and that the IPCC agrees that estimating economic damages past 2100 is inappropriate. None of these claims are true. The methodologically correct way to deal with high levels of uncertainty into the future is not to assume that damages after 2100 are zero (which we know is definitely not true), but to transparently model that uncertainty, which is what the IWG did (see point II-b above and points III-a and III-b below). Furthermore, the IPCC (2007)¹⁶ document actually supports the use of the SCC, and does not discredit the SCC estimates because they include damages after 2100. Instead, the IPCC report indicates that (1) current SCC estimates underestimate future damages, and (2) the wide range of SCC estimates indicate that future damages will be significant and increasing due to rising temperatures and other intensifying harmful climate impacts.¹⁷ And while the IPCC focuses on climate change in the 21st century, it actually does analyze climate change scenarios until 2300 in their long-run climate change analysis sub-section.¹⁸
- To try to discredit the validity of the IWG's analysis, the petitioners highlight uncertainty about the ideal form of the damage function. They

of the agricultural impact function in China. David Anthoff & Richard S. J. Tol. *The uncertainty about the social cost of carbon: A decomposition analysis using fund*. 117 CLIMATIC CHANGE 515 (2013).

¹⁵ Frank Ackerman and Elizabeth E. Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon*. 6 ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL 1864 (2012); David Anthoff & Richard S. J. Tol. *The uncertainty about the social cost of carbon: A decomposition analysis using fund*. 117 CLIMATIC CHANGE. 515 (2013); Andries F. Hof, Chris W. Hope, Jason Lowe, Michael D. Mastrandrea, Malte Meinshausen, Detlef P. van Vuuren, *The benefits of climate change mitigation in integrated assessment models: the role of the carbon cycle and climate component*, 113 CLIMATIC CHANGE 897 (2012); Detlef P. van Vuuren, Jason Lowe, Elke Stehfest, Laila Gohar, Andries F. Hof, Chris Hope, Rachel Warren, Malte Meinshausen, Gian-Kasper Plattner, *How well do integrated assessment models simulate climate change?*. 104 CLIMATIC CHANGE, 255 (2011); Rachael Warren, Chris Hope, Michael Mastrandrea, Richard Tol, Neil Adger, & Irene Lorenzoni, *Spotlighting impacts functions in integrated assessment* (Tyndall Centre on Climate Change, Working Paper No. 91, 2006).

¹⁶ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007), available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf>.

¹⁷ IPCC (2007) states that "it is very likely that globally aggregated figures [of the SCC] underestimate the damage costs because they cannot include many non-quantifiable impacts. Taken as a whole, the [large] range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time." INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007), available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf>.

¹⁸ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007), available at http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html (see section 10.7).

miss the point: the IWG's choice to analyze three IAMs captures the effect of differing damage functions on the SCC. Furthermore, recent work that was not taken into account in the IWG's analysis indicates that uncertainties over the shape of the damage function suggest higher climate damages than currently captured in the models used by the IWG, not lower, as the petitioners argue.¹⁹

- To try to discredit the validity of the IWG's analysis, the petitioners assert that the models it uses have different climate model assumptions across them (in addition to the different damage functions discussed in the previous point). They again miss the point: the IWG captures the effects of differing model assumptions on the SCC by utilizing multiple models – the modeling of alternatives is a part of good science and uncertainty analysis (see point II-b above).

d. The petitioners misrepresent economists' own assessments of the relevance of uncertainty to the legitimacy of SCC estimates. Petitioners also suggest that two prominent economists, including the developer of the DICE model used by the IWG, believe that the IWG SCC estimates should not be used due to the uncertainty of the damage functions.

- The petitioners claim that work by Pindyck (2013) criticizing IAMs with respect to the accuracy of damage functions casts serious doubt on the IWG analysis.²⁰ Pindyck's central criticism of the IAMs, however, is that they fail to adequately capture very high damages and catastrophic risks, and thus *are likely to underestimate future damages*. The petitioners fail to point this out. Further, Pindyck observes that economists know a considerable amount about climate impacts, and endorses multiple

¹⁹ Examples include Schlenker and Roberts (2008) and Ackerman and Munitz (2012). Schlenker and Roberts (2008) find that U.S. crop yields look more like mesas or cliffs, i.e. crops yields grow slightly with increases in average temperatures before reaching a threshold where they decline rapidly as temperatures continue to rise, versus symmetric hills, i.e. there is an optimal temperature level, and equal movements above or below this temperature have equally negative effects on yield (Hanemann, 2008); these results imply that the IAM damage functions do not sufficiently capture extreme temperature impacts on agriculture. Second, Ackerman and Stanton (2012) update the DICE damage function to follow recommendations made by Weitzman (2012) on how to model climate damages at high temperatures. Specifically, based on recent scientific evidence, the authors assume that humans cannot live at 12 degree higher temperatures (global mean warming), and that 99% of market produced goods are lost at this temperature value. Frank Ackerman & Charles Munitz, *Climate damages in the FUND model: A disaggregated analysis*, 77 *ECOLOGICAL ECONOMICS* 219 (2012); Frank Ackerman and Elizabeth E. Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon*. 6 *ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL* 1864 (2012); W.M. Hanemann, *What is the economic cost of climate change?* (University of California, Berkeley, Working Paper No. 1071, 2008); Martin L. Weitzman, *GHG targets as insurance against catastrophic climate damages*. 14 *JOURNAL OF PUBLIC ECONOMIC THEORY*, 221 (2012); Wolfram Schlenker & Michael J. Roberts, *Nonlinear Temperature Effects indicate Severe Damages to U.S. Crop Yields under Climate Change*, 106 *PROCEEDINGS FROM THE NATIONAL ACADEMY OF SCIENCE*, 15594 (2009).

²⁰ Robert S. Pindyck, *Climate Change Policy: What Do the Models Tell Us?*, 51 *JOURNAL OF ECONOMIC LITERATURE* 860 (2013).

impact studies that estimate specific economic damages.²¹ He also explicitly endorses use of the 2013 IWG SCC estimates as at least a minimum starting value.²²

- The petitioners note that Nordhaus and Sztorc (2013) express reservations about the DICE damage function, and contend this supports the petitioners' claim that imprecise estimates of the damage functions make the SCC illegitimate.²³ This argument mistakes the authors' humility over the level of uncertainty (and the task of estimating climate damages) with an admission of a lack of knowledge (and the impossibility of the task). Nordhaus clearly believes that a reasonable SCC estimate is achievable: he has spent his career developing and improving an IAM to estimate the SCC.
- e. The petitioners claim that the DICE model used by the IWG is an outlier that undermines the IWG's SCC because its damage estimate is at the upper end of a range of estimates presented in the IPCC Fourth Assessment Report (AR4) damage estimates.²⁴ This argument is misplaced: DICE defines the upper end of the AR4 IPCC range of damage estimates. We note the following:
- The AR4 IPCC range consists of four estimates: two estimates from DICE/RICE-1999, which make up the upper end of the IPCC AR4 range, and two estimates from FUND 2.0, which make up the lower end of the IPCC AR4 range.

²¹ Pindyck (2013) states that "I do not want to give the impression that economists know nothing about the impact of climate change. On the contrary, considerable work has been done on specific aspects of that impact, especially with respect to agriculture...the literature is large and growing." Impact studies he refers to include Mendelsohn, Nordhaus, and Shaw (1994), Deschenes and Greenstone (2007), Schlenker and Roberts (2009), Dell, Jones and Olken (2012), and Auffhammer et al. (2013). Maximilian Auffhammer, Solomon M. Hsiang, Wolfram Schlenker, Adam Sobel, *Using Weather Data and Climate Model Output in Economic Analyses of Climate Change*, REVIEW OF ENVIRONMENTAL ECONOMICS AND POLICY, Summer 2013, at 181; Melissa Dell, Benjamin F. Jones, and Benjamin A. Olken, *Temperature Shocks and Economic Growth: Evidence from the Last Half Century*, AMERICAN ECONOMIC JOURNAL: MACROECONOMICS, July 2012, at 66; Olivier Deschenes & Michael Greenstone, *Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the U.S.*, AMERICAN ECONOMIC JOURNAL: APPLIED ECONOMICS, October 2011, at 152; Robert Mendelsohn, William D. Nordhaus, & Daigee Shaw, *The impact of global warming on agriculture: a Ricardian analysis*, THE AMERICAN ECONOMIC REVIEW 753 (1994); Robert S. Pindyck, *Climate Change Policy: What Do the Models Tell Us?*, 51 JOURNAL OF ECONOMIC LITERATURE 860 (2013); Wolfram Schlenker & Michael J. Roberts, *Nonlinear Temperature Effects indicate Severe Damages to U.S. Crop Yields under Climate Change*, 106 PROCEEDINGS FROM THE NATIONAL ACADEMY OF SCIENCE, 15594 (2009).

²² Specifically, Pindyck (2013) states that "My criticism of IAMs [and the resulting SCC] should not be taken to imply that because we know so little, nothing should be done...[using IWG's SCC] would help to establish that there is a social cost of carbon, and that [it] must be internalized in the prices that consumers and firms pay...most economists already understand this... Given the limited available information, the Interagency Working Group did the best it could."

²³ WILLIAM NORDHAUS & PAUL SZTORC, INTRODUCTION AND USER'S MANUAL (2013), available at <http://www.econ.yale.edu/~nordhaus/homepage/documents/Dicemanualfull.pdf>.

²⁴ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007), available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf>.

- Under the petitioners' mistaken logic, they could have just as easily argued that the FUND model used by the IWG was an outlier on the low end, biasing the IWG's SCC downward.
- f. The petitioners claim that PAGE's upper end SCC values, relative to FUND and DICE, make it an outlier model that was inappropriately used by the IWG to inflate its SCC estimate. They make this point in a roundabout way, by noting that the spread between the mean and median SCC values in PAGE is larger than it is in either DICE or FUND (see footnote 31 under point III-f for a discussion of mean versus median values in the IAMs). The petitioners' argument is both wrong and irrelevant:
- The IWG chose PAGE for one of its input models because, along with DICE and FUND, it is one of the most widely used, cited, and peer reviewed IAMs. The fact that it has higher estimates than the other two models is no more a cause of concern than the fact that the FUND model has *lower* estimates than the other two models -- models are supposed to vary to capture uncertainties; that is the point of using several, as discussed in point II-b.
 - More important is the *reason* for PAGE's larger spread and SCC values: the model includes a broader range of catastrophic risk damages than either DICE or FUND. Correspondingly, its estimates are appropriately higher, and arguably better.
 - Notably, the most recent IPCC assessment report, [AR5](#), [provides a range](#) of SCC estimates with upper end values significantly *higher* than PAGE; in this sense, the IWG was conservative in its chosen models. FUND produces the lowest estimates in the literature, but PAGE is not the highest.²⁵

III. The Interagency Working Group followed appropriate protocols in both its estimation and use of the SCC

The petitioners accuse the IWG of hiding the uncertainties in its analysis; of failing to explain its sources of data, the assumptions it employed, and the analytic methods it applied; of neglecting standards for rigorous peer review; of denying stakeholders proper notice and opportunity to comment on the IWG's analysis; and of violating guidelines with respect to discount rates and the choice of a global rather than domestic SCC. Below, we show why petitioners' arguments are wrong.

- a. The petitioners falsely claim the IWG hides the uncertainty of its analysis. In fact, the exact opposite is true. The IWG is exacting in its presentation of the uncertainty inherent in analyzing the economic consequences of expected future climate impacts:

²⁵ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE. CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007), available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf>.

- The 2010 and 2013 Technical Support Documents (TSD)²⁶ provide an extensive distribution of results from the IAMs, from the 1st to the 99th percentiles, as well as other statistical measures that describe uncertainty.²⁷
 - They provide these results for each of the three models, over 5 different socioeconomic projections.
 - The documentation explicitly discusses uncertainty over a variety of factors; indeed, the word "uncertain" appears over 40 times in the 2010 TSD.
 - The 2010 TSD provides various figures and tables to display the uncertainty across IAMs and the various input assumptions. For example, Figures 1A and 1B examine how damages vary with temperature changes, Figure 2 with climate sensitivity, and Table 3, by model, discount rate, and socioeconomic trajectory.
- b. The petitioners claim the IWG failed to fully explain its sources of data, assumptions, and analytic methods.²⁸ This is simply not true. In the 2010 TSD, the IWG provides an extensive discussion of its methodology (see pp 4-26, 29-33). Perhaps the petitioners read only the 2013 TSD update, which discusses only changes in the models it used as input to its analysis. As none of this analysis was changed, the 2013 TSD refers readers to the 2010 TSD for the data assumptions and methodological details.
- c. The petitioners assert that the 60% increase in IWG's SCC estimates from 2010 to 2013 was arbitrary and evidence of flawed IWG methodology when in fact the IWG's methodology was not changed at all. As explained above, the IWG simply used the updated versions of the IAMs on which it relied, consistent with best scientific practices. We note the following:
- The update reflected recent advances in climate and social sciences incorporated into the IWG's three input models (DICE, FUND, PAGE). All aspects of the update were based on scientific studies that had been externally peer reviewed, and there were no methodological changes by the IWG between 2010 and 2013.

²⁶ INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2010), available at <http://www.epa.gov/otaq/climate/regulations/scc-tds.pdf>.

²⁷ A percentile is a statistical measure of the value (the SCC value in this case) at which a specified percentage of (SCC) observation falls below. The 1st percentile indicates the SCC value above which (the other) 99% of observed SCC values fall. The 99th percentile indicates the SCC value below which 99% of all other observed SCC values fall.

²⁸ INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2010), available at <http://www.epa.gov/otaq/climate/regulations/scc-tds.pdf>.

- Importantly, relevant to petitioners' claim that there has been insufficient opportunity to comment on the SCC, the update was *in response to comments* on previous rulemakings using the SCC urging that the IWG adhere to its promise in the original 2010 TSD to update its analysis as models are revised to incorporate more science.
- d. By conflating peer review of the IWG analysis with peer review of the inputs used by the IWG, the petitioners disingenuously suggest that the IWG's SCC lacks proper academic rigor. The IWG used heavily peer reviewed academic inputs and methods, and there is no legal requirement that an agency's analysis itself be subject to academic peer review. But, of course, the analysis can and will be reviewed in rulemakings, through the notice-and-comment procedures.

The petitioners argue that the “modeling system,” which they define as “the models with inputs ... used for the SCC estimates and the subsequent analyses,” was not peer reviewed. By “modeling system,” they refer to the three peer reviewed IAMs (DICE, FUND, and PAGE) and the IWG's analysis using these. By conflating these elements, they misleadingly characterize the SCC estimate process as failing to incorporate peer review.

On these points, we note the following:

- All of the agencies' inputs were peer reviewed, *including the analytical methods it applied to those inputs* (e.g., Monte Carlo analysis, and the Roe-Baker distribution to address climate sensitivity). The Monte Carlo analysis itself is a powerful statistical technique used for decades in social science, and indeed has been extensively applied to the SCC models and published in the literature. Further, contrary to petitioners' claim that there has been insufficient peer review, the use of Monte Carlo analysis was *in response to comments* on the interim SCC in the proposed small engine efficiency rulemaking—the first rulemaking for which the IWG's SCC was used. The purpose of the methodology is to better capture catastrophic risk, and was incorporated in response to requests for improvements along these lines.
- The IWG was not required to submit the peer reviewed science it used for a second round of academic peer review, and as a matter of standard academic practice, this approach would make no sense. Once articles have been peer reviewed and accepted for publication in academic journals, they do not get re-peer reviewed before a government agency relies on them.
- While agencies are expected to use rigorous science to inform their regulatory impact analyses, there is no legal requirement that an agency's analysis itself undergo academic peer review. What *is* required is that agencies undertaking rulemakings provide public notice and an opportunity for public comment on their analyses, and respond to those comments. As stated above, the petitioners and the public had ample

opportunity to comment on the IWG's analysis; indeed over 40 rulemakings have used the IWG's estimates (see footnote 7).

- Although the IWG analysis need not undergo peer review, it is worth noting that the 2010 IWG methods have been extensively discussed in numerous academic journals. According to Google Scholar, 67 documents mention "Interagency Working Group on the Social Cost of Carbon", 210 documents mention "Technical Support Document" and "social cost of carbon", 282 documents mention "Interagency Working Group" and "Social Cost of Carbon", and 625 documents mention "Working Group" and "Social Cost of Carbon." Separately, the peer reviewed SCC models, which the IWG used in its analysis, have been fully documented in the economics literature, and peer reviewed at the various steps in their twenty-year development.
- e. The petitioners wrongly claim OMB Circular A-4 guidelines require the IWG use a 7% discount rate. This is incorrect. OMB guidelines do not create legally binding requirements for regulatory impact analyses. Indeed, the guidelines contain only recommendations and do not purport to create requirements. The IWG explained its criteria for its choices regarding discount rates, based upon economic theory and practice widely accepted in the economics literature. Moreover, the IWG discount rates are based upon factors discussed in the guidelines that should be considered when primarily consumption is affected and when there are intergenerational impacts (pp. 33-36, OMB Circular A-4):
- The IWG correctly excludes the 7% discount rate (the rate of return on capital) because climate change is expected to negatively affect future generations' consumption which returns to capital do not capture.²⁹
 - The IWG is correct to include the 2.5% discount rate. There is consensus among climate economists that a declining discount rate should be used to account for long term interest rate uncertainty (Arrow et al. 2013); 2.5% is a downward adjusted rate of return to partially account for this.
 - With respect to high discount rates, there is also the issue of intergenerational equity. Consistent with the economics literature and recognized in OMB guidelines, discount rates as low as 1% are considered appropriate for intergenerational damages. The choice of discount rate

²⁹ There are two rationales for discounting future benefits—one based on consumption and the other on investment. The consumption rate of discount reflects the rate at which society is willing to trade consumption in the future for consumption today. Basically, we discount the consumption of future generations because we assume future generations will be wealthier than we are and that the utility people receive from consumption declines as their level of consumption increases...The investment approach says that, as long as the rate of return to investment is positive, we need to invest less than a dollar today to obtain a dollar of benefits in the future. Under the investment approach, the discount rate is the rate of return on investment. If there were no distortions or inefficiencies in markets, the consumption rate of discount would equal the rate of return on investment. There are, however, many reasons why the two may differ. As a result, using a consumption rather than investment approach will often lead to very different discount rates (<http://www.rff.org/Publications/Resources/Pages/183-Benefits-and-Costs-in-Intergenerational-Context.aspx>).

matters greatly because the impacts and costs of our carbon emissions will be borne most heavily by future generations, and high discount rates often make damages to these future individuals irrelevant to current policy decisions. When used over very long periods of time, high discount rates yield absurd results due to the compounding effects of discounting: at a rate of 3%, \$1 million 300 years hence is around \$140 today, and at 5% less than 50 cents. Some might even consider 1% too high: \$1 million 300 years hence would be valued at \$50,000 today.³⁰

- With respect to the use of private rates of return, typical financial decisions, such as how much to save in a bank account or invest in stocks, focus on private decisions and utilize private rates of return. However, here we are concerned with social discount rates because climate change is a “public bad,” where individual emissions choices affect public well-being broadly (see footnote 32). Rather than evaluating an optimal outcome from the narrow perspective of investors alone, economic theory would require that we make the optimal choices based on societal preferences (and discount rates).

f. The petitioners make several unsupportable assertions regarding the appropriateness of the IWG’s use of central rather than median estimates. We make the following points:

- The petitioners incorrectly claim that the use of the mean SCC value is illegitimate because it exceeds the median value due to the skew of the underlying SCC distribution (i.e., very high damages that skew the distribution to the right). They miss the point: the use of the mean estimate, in addition to reporting the 95th and 99th percentiles of the SCC, is necessary to capture the effects of low probability, high damage events that are particularly concerning.³¹

³⁰ Dallas Burtraw & Thomas Sterner, *Climate Change Abatement: Not, Stern “Enough*, RESOURCES FOR THE FUTURE, Apr. 4, 2009,

http://www.rff.org/Publications/WPC/Pages/09_04_06_Climate_Change_Abatement.aspx.

³¹ The point here is that we miss the big picture if we ignore the tails, or upper most values in the case of the right skewed SCC, and as a result come to the wrong conclusions. An every-day analogy might be if an individual who is trying to watch his or her weight by going on a diet focused on their median calorie intake per meal in a given month instead of an average. (The median calorie meal would be the meal such that half of all meals had calories below its value, and half above). Dieters often deviate from their plan by occasionally having normal or excessive-calorie meals. If they focused on their median calorie intake, they’d never count the high calorie deviations and would undermine their efforts to lose weight. Indeed, they could even gain weight. Rather than the median, the mean would be the correct metric to use (the total number of calories in a month divided by the number of meals eaten) would capture these infrequent, high calorie breaks with the diet. Unlike in the median, going out to a meal of burgers, fries, a shake, and dessert would affect the average number of calories consumed when using the mean. Another analogy is airplane safety regulation: safety is protected by guarding against the low-probability but highly dangerous events. With climate change we do not have the luxury of knowing how damaging the extremes could be; all we know is that there is a very real possibility they could be devastating.

- The skew of SCC estimates is the result of two economically correct research-based assumptions that the petitioners ignore (1) as average global temperatures rise, damages increase at an increasing rate; and (2) the climate sensitivity parameter is asymmetrically distributed, consistent with IPCC analysis. A Monte Carlo simulation (see Section II-b) over a right skewed distribution of temperature, and damage functions that increase at an increasing rate as temperatures increase, will produce right skewed distributions of damage and SCC estimates, as they should.
 - To attempt to discredit the validity of the IWG’s analysis, the petitioners incorrectly argue that the range of SCC estimates across the three models is unacceptably wide. This range of estimates is the result of the IWG properly modeling uncertainty by using three different IAMs and the right-skewed distribution (per the previous point), as discussed in Section II-b. Furthermore, the IWG averaging of SCC estimates across the three IAMs has the effect of reducing the impact of the most right-skewed model, PAGE. Indeed, the high damage estimate of PAGE and the low estimate of FUND are canceled out to some degree, and the resulting SCC is only slightly above the DICE estimate.
 - The petitioners incorrectly argue that the high variance caused by the right tailed distributions of the damage functions invalidate the SCC. However, this is not a meaningful statement, as variance by itself is not a test of statistical significance.
- g. The petitioners argue that the IWG process is invalid because the IWG ignored the domestic SCC, and focused on the global SCC. There is no legal requirement that the IWG use the domestic SCC, and the IWG chose the global SCC because it is the methodologically the correct value and incorporates the domestic SCC.

There are a variety of reasons that a global SCC is vastly more appropriate for use in federal rulemaking than a purely “domestic” SCC:

- Economic theory strongly prescribes the use of a global rather than domestic SCC. A domestic SCC is inadequate because it only partially solves the problem: were all countries to use domestic SCC values to set internal controls, there would be sub-optimal protection of climate stability. This is because carbon pollution doesn’t stay within one country’s borders. If one country only takes into account the effect of its emissions on its own citizens and no one else, and every other country does the same, society would be ignoring most of the problem—guaranteeing that efficient emissions controls will not be achieved. Economists refer to this as a “public goods”³² problem, a situation where

³² A public good is one that is “non-rivalrous” and “non-excludable.” Non-rival refers to the idea that one person’s consumption of the good does not take away from another person’s consumption of it (we are not “competing” for who gets it, as we all get it in equal measure). Non-excludable refers to the fact that we can’t stop other people from enjoying it. A normal market good is exactly the opposite: only one person can consume the item (at the expense of another not consuming it), and the seller is able to prevent anyone other than the purchaser from consuming the product. The non-rivalrous and non-excludability aspects of a public

everyone acting only in their narrow self-interest leaves everyone worse off. Other people call it the Golden Rule.

- Basic moral principles of comity and justice prescribe a global SCC. GHG emissions cause significant harm to other countries—the prevention of cross-border harm is a basic principle of international environmental law.³³ For the United States to knowingly set pollution levels in light of only domestic harm, while recognizing that its pollution is directly imposing environmental risk—including catastrophic risks—to other countries, would be a violation of basic norms of comity between countries and corrective justice. The United States would be knowingly causing foreseeable harm to other countries, without compensation, and without any just cause. Given that the nations most at risk from climate change are often the poorest countries in the world, such a policy would also violate basic and widely shared intuitions about egalitarian justice.
- It would not be in US interests to assume that the climate damages it imposes on other countries will not have negative spillover effects on the United States. When millions of people are displaced by drought or storms, Americans shoulder greater costs for humanitarian assistance. Climate impacts can force millions of people to cross borders in search of safety. And our military recognizes that climate-driven water scarcity can trigger social unrest and war in places like the Middle East and Africa.
- Another reason why a domestic SCC is not in U.S. interests is the fact that the United States is engaged in an international process to control GHG emissions. The required role of the United States as a leader in achieving a global treaty to reduce the impacts of climate change is clear. Use of a domestic SCC could undercut the negotiating posture of the United States by signaling a refusal to recognize that GHG emissions generated in the United States can cause important harms well beyond its borders. In this instance, U.S. leadership itself might determine whether society will overcome the “public goods” problem.

good result in an economically inefficient under-provision of it; in this situation, compensating the supplier of the good is extremely difficult, if not impossible—so the good will either be under-provided or not provided at all. Climate mitigation confronts exactly this problem. The enjoyment of climate stability by one person does not interfere with the enjoyment of climate stability by another person. And once climate stability is provided, there is no way to “exclude” anyone from enjoying its benefits. Under these conditions, we can expect, and in fact have seen, under-provision of this good. From an economic perspective, there is too little investment in climate stability.

³³ See PHILIPPE SANDS, *PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW* 241 (2nd ed. 2003) (noting that “the responsibility not to cause damage to the environment of other states or of areas beyond national jurisdiction has been accepted as an obligation by all states[;] . . . there can be no questions but that [this principle] reflects a rule of customary international law”).

IV. The SCC is likely to be significantly underestimated, not overestimated.

The petitioners are incorrect to argue that the IWG's SCC might be biased upwards. The IAMs are conservative along several dimensions that make them likely to significantly underestimate the SCC:

- a. Outdated Damages. Currently, IAMs (including the three used in the IWG's updated SCC) calibrate their damage functions based on damage estimates that are outdated. In many cases, IAMs use estimates that are one to two decades old. Since then updated estimates are available, and the effects are, in general, larger than these older estimates.
- b. Omitted Damages. IAMs currently omit a wide array of important climate damages: non-market damages (ecosystem services, ocean acidification, biodiversity, and some health costs); inter-regional damages (e.g., migration); inter-sector damages (e.g., the effect of water quality and availability on agriculture and health), non-climate events that will act as threat multipliers (e.g., over-pumping of ground water as drought accelerates), socially contingent damages (political and economic instability, increased migration, increased inter-personal and social violence), negative impacts on agriculture and forestry (fires, increased pest and pathogen pressures, and increased air pollution levels), effects on basic economic inputs to production (i.e. decreased labor productivity and loss of capital, due in part weather variability and extreme events, such as flooding, droughts, and heat waves).
- c. Lack of "calibration" at high temperatures. The IAMs are estimated using damage estimates derived from climate impacts at low temperature increases; typically damage estimates are for a 2.5 or 3 degree Celsius *average* global increase. Damages at low levels are then extrapolated to higher average global temperatures, which often underestimate damages at these higher temperatures. Furthermore, temperature extremes can diverge significantly from averages (high or low) over different geographical regions and temporal scales; these extremes are also not captured.
- d. Oversimplification of modeling assumptions. IAMs tend to have various modeling simplifications that bias the SCC downward, such as constant relative prices and the rate of temperature changes. Constant relative prices assume that there is no rise in the value of agriculture and environmental goods relative to other goods as climate change worsens. But this would undoubtedly occur due to increased scarcity of food and environmental goods. Essentially, the models do not estimate agricultural losses at higher market prices than those today despite decreasing food supplies caused by climate extremes. The concept also applies to ecosystems: the models all assume continued economic growth that will make us much wealthier over time, without taking into account the increasing relative value of ecosystems as they experience disruption (e.g. the die off of coral reefs, and losses of biodiversity and ecosystems that sustain life).

With respect to temperature changes, this rate is critically important in determining the level of climate damages as it determines the amount of time societies will have to adapt. Only FUND takes into account this factor.

- e. Failure to account for some catastrophic damages. Currently, IAMs are failing to account for catastrophic events via tipping points,³⁴ fat tails,³⁵ and “black swan” events.³⁶
- f. Flawed use of a constant discount rate. A controversial assumption in the IWG analysis is the use of a constant discount rate to value harms in the far future. The IGW uses constant rates, but there is a consensus among climate economists that a declining discount rate should be used to account for uncertainty about future discount rates. Such discount rates are now the official policy of the United Kingdom and France. The use of all available estimates of declining discount rates, and the elimination of its constant 3% and 5% rates, would substantially increase the IWG’s social cost of carbon estimate.

Further, consistent with the economics literature and recognized in OMB guidelines, discount rates as low as 1% are considered appropriate for intergenerational damages. When used over very long periods of time, high discount rates yield absurd results due to the compounding effects of discounting: at a rate of 3%, \$1 million 300 years hence is around \$140 today, and at 5% less than 50 cents. Some might even consider 1% too high: \$1 million 300 years hence would be valued at \$50,000 today.

- g. Ignoring Option value. The damage estimates ignore option value, i.e., what society is willing to pay for the value of future information it will learn by delaying an irreversible decision in the current time period. In layman’s terms, the existence of an option value arises when not developing a resource (or avoiding depleting one) could result in higher returns to society than if the resource is developed (or not depleted). Option values arise due to three characteristics that characterize the climate problem: irreversibility, uncertainty, and the ability to delay emissions (i.e. depletion of the atmosphere) (Dixit and Pindyck, 1994; Arrow and Fisher, 1974).³⁷

³⁴ Tipping points are thresholds over which small changes in the state can cause rapid, frequently irreversible changes in system characteristics. For example, an ice sheet in a warming world could reach a tipping point that would lead to its complete disintegration as the melting cycle became self-amplifying.

³⁵ A “fat-tailed” distribution refers to a distribution having a long extended “tail” at the upper end, as opposed to a normal bell curve. Very high damages with a low but real chance of occurring are represented in these tails. See the discussion under point I-f on skewed distributions.

³⁶ Black swan events are unknown unknowns, and refer to tipping points that we are currently unaware of and parameters for which we do not know their probability distribution function.

³⁷ Kenneth J. Arrow & Anthony C. Fisher, *Environmental Preservation, Uncertainty, and Irreversibility*, 88 QUARTERLY JOURNAL OF ECONOMICS, 312 (1974); AVINASH K. DIXIT & ROBERT S. PINDYCK, INVESTMENT UNDER UNCERTAINTY (1994).

- h. Failure to include a risk premium and account for risk aversion. Current IAMs ignore the positive amount of money society would be willing to pay to reduce the uncertainty over the magnitude of damages from climate change and lower the chances of catastrophic outcomes.

Each of these factors biases the SCC downward; collectively they may result in a substantial underestimate of the SCC.

V. Summary and conclusion

In sum, the IWG's SCC is not undermined by scientific uncertainties underlying its analysis: uncertainty is a fundamental tenet of scientific analysis, and economists and other social scientists have developed a set of tools designed to address it. The IWG fully used these tools according to best scientific practice. The petitioners misrepresented both the IPCC and economists' views of the relevancy of uncertainty to the legitimacy of using the SCC. Both support the use of the IWG's SCC despite the uncertainty inherent in translating expected climate impacts into a monetary value, and both the IPCC and leading economists have indicated that the SCC is likely to be underestimated rather than overestimated.

Further, as a matter of law and economics, uncertainty in benefits estimates does not mean they should be excluded from regulatory impact analyses. In fact, the courts have explicitly rejected this argument with respect to the SCC, and executive orders dating back as far as the Reagan administration have all issued guidelines directing explicit consideration of benefits even if the precise size of the benefit is uncertain. The courts have ruled that agencies *must* use an SCC to estimate climate benefits from emission reductions—that a value of zero is not permissible.

With respect to process and transparency issues, the IWG clearly laid out its sources of data, the assumptions it employed, and the analytic methods it applied, and the methods it used to address uncertainties. These are fully documented in the 2010 Technical Support Document. The IWG process incorporated rigorous peer reviewed models, research, and methods and provided stakeholders with ample notice and opportunity to comment as the SCC estimate was developed and every time the SCC was used in a proposed rule. As such, petitioners have had multiple opportunities to comment on the IWG's analysis and will have additional opportunities to do so in future rulemakings. Finally, the IWG fully explained the discount rates it selected and its use of a global rather than domestic SCC—there are no legal requirements concerning either of these choices, and the IWG explained its decisions.

In sum, the IWG has properly and lawfully used the leading models and well-established statistical methodologies to estimate the damages of climate impacts and therefore the benefits of reducing carbon emissions, and followed proper public commenting protocols.

Sincerely,

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* No part of this document purports to present New York University School of Law's views, if any.