October 21, 2013

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Via Electronic Submission and e-mail

Attn: Docket ID No. EE-2009-BT-STD-0018; RIN 1904-AC00, Energy Conservation Program: Energy Conservation Standards for Metal Halide Lamp Fixtures; Proposed Rule, 78 Fed. Reg. 51,464 (August 20, 2013)

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

Our organizations respectfully submit these comments regarding the Department of Energy's proposed rule to establish revised metal halide lamp fixture energy conservation standards. In particular, we would like to focus our comments on the use of the social cost of carbon (SCC) in the calculation of benefits from this rule, which were included in the regulatory impact analysis (RIA) of the rule. Our comments are summarized in five sections:

1. Introduction - the social cost of carbon is important in estimating benefits of greenhouse gas emission reductions that would accrue from this standard

2. The Interagency Working Group's analytic process was transparent, and every use of the SCC provides opportunity for public comment

3. The IWG modeling framework is based on scientific and economic theory

4. Contrary to industry claims, the SCC should not be zero as a matter of law and economics

5. Current SCC values are likely significant underestimates, and steps should be taken to address this in future updates

6. Concluding remarks

1. Introduction - the social cost of carbon is important in estimating benefits of greenhouse gas emission reductions that would accrue from this standard

The SCC estimates the economic cost of the climate impacts that scientists predict and economists value – specifically the additional economic harm caused by one metric ton of carbon dioxide (CO_2) emissions. SCC calculations are important for evaluating the costs of activities – such as burning fossil fuels to produce energy – that produce greenhouse gas emissions, which in turn have an impact on climate change. The SCC is therefore important for evaluating the benefits of policies that would reduce the amount of those emissions going into the atmosphere. Energy conservation standards, like the metal halide lamp fixture standard at issue in this rulemaking, help reduce the amount of energy used in carrying out a particular activity, which in turn reduces greenhouse gas emissions emitted by the power plants supplying the electricity. In order to properly evaluate energy efficiency standards, it is important to understand the benefits they will provide, including the benefit of reducing carbon pollution and the harm it causes.

Although estimating the economic harm caused by climate change is a complex scientific and economic endeavor, and although benefit-cost analyses inevitably involve uncertainty, evaluating the SCC is critical to enabling a more accurate benefit-cost analyses of regulations that limit greenhouse gases either directly or indirectly. This endeavor is important because benefit-cost analysis is a central tool of regulatory policy in the United States, first institutionalized in a 1981 executive order by President Reagan. The executive order currently in effect provides that agencies:

- "Propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify);"
- "Select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity);"
- In applying these principles, each agency is directed to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. Where appropriate and permitted by law, each agency may consider (and discuss qualitatively) values that are difficult or impossible to quantify, including equity, human dignity, fairness, and distributive impacts..."[1]

[1] Exec. Order No. 13,563, 76 Fed. Reg. 3,821 Federal Regulation (Jan 18, 2011).

Benefit-cost analysis has long been a staple of agency rulemakings, usually conducted as part of the regulatory impact analysis associated with rules. Even though the analysis is generally not able to encompass all of the effects of a policy, and it is challenging to translate impacts on health, mortality, and welfare into dollar values, benefit-cost analysis is an important economic tool to inform decision-makers about the societal benefits of different policy choices that limit pollution. Of course, benefit-cost analysis cannot be the sole criteria for making regulatory decisions, especially in cases where there are overriding public health or safety imperatives.[2] Particularly, in the context of climate change, the precautionary principle indicates a need to lower GHG emissions as rapidly and cost-effectively as possible—rather than make decisions piecemeal using benefit-cost analysis across different rulemakings. And in a few instances not relevant here, legal protections prohibit the consideration of benefit-cost analysis.

Without an SCC estimate, by default regulators would be using a value of zero for the benefits of reducing carbon pollution, implying that carbon pollution has no costs. That is patently not the case, as evidenced by the large body of research outlining the sobering health, environmental, and economic impacts of rising temperatures, extreme weather, intensifying smog, and other climate impacts. And it would be contrary to law for a federal agency to consider societal benefits and costs in its rulemaking but assign no value at all to the considerable benefits of reducing carbon pollution.[3]

2. The Interagency Working Group's analytic process was transparent, and every use of the SCC provides opportunity for public comment

To facilitate the use of the SCC in regulatory proceedings undertaken by different agencies, the United States government assembled the IWG in 2010 to estimate a social cost of carbon that can be utilized across the federal government.[4] This estimate is the measure used for benefits analysis in this proposed energy efficiency rulemaking and other federal rules. The IWG recently released an updated set of SCC estimates, centered at approximately $38 per metric ton of CO_2 for emissions in the year 2015.[5] The 2013 SCC

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[2] President Clinton issued Executive Order 12,866 in 1993, establishing new guidance for benefit-cost analysis and explicitly directing agencies to consider, in addition to costs and benefits for which quantitative estimates are possible, "qualitative measures of costs and benefits that are difficult to quantify, but nevertheless essential to consider." Executive Order 12,866, 3 C.F.R. 638 (1994), *reprinted as amended in* 5 U.S.C. § 601 app. at 86-91 (2006 & Supp. V 2011).

[3] *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." (emphasis added)).

[4] The IWG involved a large number of agencies, including the Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Management and Budget, Office of Science and Technology Policy, and the Department of the Treasury.

[5] 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

estimates are higher than those from 2010, reflecting our growing understanding of the costs that climate impacts will impose on society. For 2020, the earlier central estimate was \$26.3/ton CO_2 in 2007 dollars at a 3 percent discount rate, and the revised central estimate is \$43/ton CO_2.

The increase in the SCC estimate is consistent with scientific and economic research on the growing risks and costs of climate change, and is very likely an underestimate of the true cost of our carbon emissions. The increase is also consistent with the costs of climate change that we are already experiencing, such as those associated with sea level rise and rising temperatures. Climate change is making coastal flooding and extreme weather events worse.[6]

In its calculations of the SCC, the IWG relied on the three Integrated Assessment Models (IAMs) with the longest records of peer-reviewed publications that link physical and economic effects: the Dynamic Integrated Model of Climate and the Economy (DICE),[7] the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND),[8] and Policy Analysis of the Greenhouse Effect (PAGE).[9] The government's first SCC estimates, published in 2010, used the then-current versions of the models; the recent update employed revised, peer-reviewed versions of the models but maintained the underlying assumptions of the 2010 IWG analysis. As stated by the 2010 IWG, "the main objective of [the 2010 IWG modeling] process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures."[10]

The analytic work of the IWG has been transparent. The 2010 Technical Support Document (TSD) set out in detail the IWG's decision making process with respect to how it assessed and employed the models.[11] Because the 2013 IWG made no changes to the input

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ORDER 12,8666 (2013), *available at* http://www.whitehouse.gov/sites/default/files/omb/inforeg/social_cost_of_carbon_for_ria_2013_update.pdf

[6] NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, EXPLAINING EXTREME EVENTS OF 2012 FROM A CLIMATE PERSPECTIVE (2013), a*vailable at* http://www.ametsoc.org/2012extremeeventsclimate.pdf.

[7] WILLIAM D. NORDHAUS & JOSEPH BOYER, WARMING THE WORLD (2000).

[8] 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.

[9] 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).

[10] 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 12,8666 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf).

[11] There were several opportunities for the public to comment on the original interagency process. 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

assumptions and procedures for deriving the SCC estimates it developed the 2013 TSD discusses only how the three IAMs, i.e., DICE, FUND, and PAGE, were updated over the three year interim period. The 2013 TSD also establishes that the increase in the SCC estimate from 2010 to 2013 resulted solely from updates to the three underlying IAMs.[12]

DICE, FUND, and PAGE are peer-reviewed models, and they are the state of the art IAMs. Each of these models has been developed over decades of research, and has been subject to rigorous peer review documented in the published literature. It is certainly true that these models do not fully capture the costs of climate impacts to society, but importantly the IWG process provides for updating the SCC estimates every two to three years in order to capture the advances in physical and social sciences that have been incorporated into the models during the intervening period.[13]

To transparently address uncertainty, the IWG conducted sensitivity analysis within their modeling framework over socio-economic and emission scenarios[14] and the two

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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 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.

[12] The 2010 and 2013 IWGs did very little to adjust the three IAMs. The main adjustment by IWG was to DICE to ensure that the IAM has an exogenous growth path that matches FUND and PAGE for the purposes of modeling various socio-economic and emission scenarios.

[13] The IWG stated in their 2010 TSD that "the estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts… Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area." 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 12,8666 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf).

[14] The socio-economic and emissions scenarios were chosen from the Stanford Energy Modeling Forum exercise, EMF-22, and consist of projections for income/consumption, population, and emissions (CO2 and non-CO2). The IWG selected five sets of trajectories, four of which represent business as usual (BAU) trajectories (MiniCAM, MESSAGE, IMAGE, and MERGE models) and a fifth that represents a CO2 emissions pathway with CO2 concentrations stabilizing at 550 ppm. Given the possibility of increases in emissions

parameters over which the SCC estimates are most sensitive: the climate sensitivity parameter[15] and the discount rate.[16] The assumptions for both are clearly stated in the TSD. In addition to their sensitivity analysis, the IWG conducted a Monte Carlo simulation over the climate sensitivity parameter and the other random variables specified within the three IAMs.[17]

3. The IWG modeling framework is based on scientific and economic theory

The IWG modeling framework has many strengths, including documenting and explaining their analysis; their modeling process, including the way they addressed uncertainty, was transparent. In particular, the IWG analysis made several modeling decisions that correspond to economic theory, and with which industry groups incorrectly disagree. These strengths are discussed below. Economic models, and the scientific models they are drawing from, are of course improving continuously. So future updates to the SCC can build on these and go further.

Used consumption discount rates

With respect to the **discount rate**, the IWG conducted sensitivity analysis of the results to three constant discount rates: 2.5%, 3%, and 5%; for each of the discount rates, the TSDs reported the various moments and percentiles of the SCC estimates.[18,19]

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above those expressed by Business As Usual Scenarios, a high- CO_2 emission pathway should also been considered.

[15] Specifying the climate sensitivity parameter as a random variable has a basis in PAGE02, which species a probability distribution function for the parameter. The IWG calibrated the Roe and Baker distribution, a right skewed distribution, to characterize the probability distribution function of this parameter. The 2010 TSD explains the IWG's choice of the Roe and Baker distribution. The right skewed nature of the climate sensitivity parameter's probability distribution function (PDF) is independent of the IWG's choice of the Roe and Baker distribution. Rather, this skewness results from the IPCC's finding that values of the climate sensitivity parameter above 4.5 degree Celsius cannot be excluded. As a result, all of the probability distribution functions fit by the IWG for the climate sensitivity parameter were right skewed (see Figure 2 in the 2010 TSD), including Roe and Baker. 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 12,8666 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf).

[16] With respect to the discount rate, the IWG conducts sensitivity analysis of the results to three discount rates: 2.5%, 3%, and 5% discount rates.

[17] A Monte Carlo simulation will run an integrated assessment model thousands of times, each time randomly picking the value of uncertain parameters from a probability distribution function, i.e. a function that assigns a probability to each possible parameter value. 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, and then across all three models. Therefore, each SCC estimate is calculated using 150,000 runs.

[18] The moments of a distribution (of SCC estimates in this case) are, loosely speaking, the various values that tell you the shape of the distribution: what value is the distribution centered around (mean); how wide is the

Discount rates make it possible to compare values across time but they are based on some critical assumptions: the assumption that a dollar in the future is worth less than a dollar today; that global economy and prosperity grow; and that investments in capital today can contribute to growing prosperity in the future. The choice of discount rate matters greatly because the impacts and costs of our carbon emissions will be borne most heavily by future generations.

The IWG correctly excluded a 7% discount rate, the rate of return on capital, for several reasons. First, 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," (see footnote 30) where individual emissions choices affect public well-being broadly. 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). Second, climate change is expected to affect primarily consumption, not traditional capital investments.[20] OMB guidelines note that in this circumstance, consumption discount rates are appropriate. Third, 7% is considered much too high for reasons of discount rate uncertainty and intergenerational concerns (more discussion below). Accordingly, the IWG replaced the 7% discount rate (the rate of return on capital) with a 5% discount rate (a post-tax risky rate of return on household investments).

Adopted as one of its discount rate a value reflecting long term interest rate uncertainty

The IWG chose as one of its constant discount rates 2.5%. This rate served as a proxy for a declining discount rate, taken from an estimate by Newell and Pizer (2003).[21] A consensus

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distribution (the variance); whether the distribution is lopsided (skewness); and whether it is tall and skinny or short and fat (kurtosis).

[19] 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.

[20] "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." Maureen Cropper, *How Should Benefits and Costs Be Discounted in an Intergenerational Context?*, RESOURCES FOR THE FUTURE, http://www.rff.org/Publications/Resources/Pages/183-Benefits-and-Costs-in-Intergenerational-Context.aspx (last visited Oct 20, 2013).

[21] Richard G. Newell and William A. Pizer. 2003. *Discounting the distant future: how much do uncertain rates increase valuations?* 46 JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT, July 2003, at 52.

has emerged among leading climate economists that declining discount rates should be used for climate damages to reflect long term uncertainty in interest rates (Arrow et al, 2013),[22] as recognized in OMB guidelines; the use of declining discount rates is standard practice for the UK and French governments.[23] The uncertainty about future discount rates could stem from a number of reasons particularly salient to climate damages, including uncertainties in future economic growth, consumption and the interest rate reaped by investments. Using a constant discount rate, which makes more sense when applied to individuals (firms and households) within current generations, can lead to substantially undervaluing the well-being of future generations when comparing across generations, given uncertainties related to the future discount rate itself. Therefore a declining discount rate schedule would be preferable. The Newell-Pizer results suggest that the expected benefits from climate change mitigation could be understated by a factor of 2 in analyses that ignore uncertainty in the discount rate.

Used economic tools to address uncertainty

The IWG was rigorous in addressing **uncertainty**. First, it conducted Monte Carlo simulations (see footnote 17) over the IAMs specifying different possible outcomes for climate sensitivity (represented by a Roe and Baker Distribution). It also used five different emissions growth scenarios and three discount rates. Second, the IWGs reported the various moments (see footnote 18) and percentiles (see footnote 19) of the resulting SCC estimates. Third, the IWG put in place an updating process, e.g., the 2013 revision, which updates the models with new information.[24] As such, the IWG used the various tools that economists have developed over time to address the uncertainty inherent in estimating the economic cost of pollution: reporting various measures of uncertainty, using Monte Carlo simulations, and updating estimates as new research becomes available.

Addressed <u>some (but not all)</u> catastrophic damages

Perhaps the most concerning aspect of climate change is the potential for **catastrophic damages**, i.e., low probability-high damage events. These damages come from: uncertainty

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[22] K. Arrow, L. Goulder, R. E. Kopp, M. Livermore, M. Oppenheimer, R. Revesz, T. Sterner, *Counting the Costs of Climate Change*, SCIENCE (forthcoming).

[23] Richard G. Newell and William A. Pizer. 2003. *Discounting the distant future: how much do uncertain rates increase valuations?* 46 JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT, July 2003.

[24] The federal government has committed to continuing to update SCC estimates to account for new information. The IWG stated in its 2010 TSD that "It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area. In the meantime, we will continue to explore the issues raised in this document and consider public comments as part of the ongoing interagency process." 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 12,8666 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf).

in the underlying parameters[25] in IAMs including the climate sensitivity parameter; tipping points - an environmental threshold over which small changes in the environmental state can causes rapid, frequently irreversible changes in ecosystem characteristics; and "black swan" events – which refer to unknown unknowns.[26] While the IAMs take different approaches to explicitly modeling tipping points, which to a great extent is lacking in current versions of FUND and DICE, the IWG improved (but in no way fixed) the representation of uncertain catastrophic damages with the Monte Carlo analysis. Still, black swan events go completely unaddressed in the IWG modeling framework.

The Monte Carlo framework addressed uncertainty by partially addressing catastrophic warming, i.e., the low probability of a high-level of equilibrium warming from a doubling of CO_2 in the atmosphere, using a right-skewed distribution of temperature (as captured in the Roe Baker climate sensitivity parameter) and an increasing, strictly convex damage function;[27] this results in a right skewed distributions of damage and SCC estimates. By using the mean values of these estimates instead of the median, IWG estimates partially captured the effects of small probability, higher damages from high level warming events.[28] To reflect uncertainty in estimates resulting from the right skewed distribution of SCC estimates, the IWG reported the SCC value for the 95th percentile (see footnote 19) from the central 3% discount rate distribution.[29] This is done to reflect the estimation uncertainty in terms of the possibility of higher-than-expected economic impacts from climate change.

Calculated global SCC

The IWG correctly used a global SCC, in order to account for worldwide damages from climate change. There are a variety of reasons that a global SCC is vastly more appropriate for use in federal rulemaking than a purely "domestic" SCC:

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[25] In this case, parameters are the various characteristic that describe the underlying climate and economic systems.

[26] Standard decision theory under uncertainty addresses known unknowns, which are unknowns for which we can specify a probability distribution function. In the cases of unknown unknowns, i.e. black swan events, we cannot specify a probability distribution function. Therefore, standard decision theory does not apply.

[27] An increasing, strictly convex function climate damage function implies a damage function that is strictly increasing in temperature at an increasing rate.

[28] 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 the mean; the median calorie meal would be the meal such that half of all meals had calories below its value, and half above, and the mean calorie meal would be the total number of calories in a month divided by the number of meals eaten. 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 because it 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.

[29] This partially captures catastrophic damages via tipping points through the PAGE model.

- Economic theory strongly prescribes the use of a global rather than domestic SCC. A domestic SCC is not sensible 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"[30] problem, a situation where 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.[31] 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—on 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.

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[30] 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 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.

31 *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").

- 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.

The 2010 TSD has an extensive discussion of global versus domestic SCC estimates, and the 2010 IWG set out a rigorous examination of their use of the global SCC that is consistent with the above discussion. The 2010 IWG came to the conclusion that they should estimate a global SCC due to both the global impacts of climate change and the global action needed to mitigate climate change. The IWG restated these arguments in the 2013 TSD, and refers back explicitly to its discussion in the 2010 TSD.

4. Contrary to industry claims, the SCC should not be zero as a matter of law and economics

Several industry groups recently submitted a petition to the Office of Management and Budget (OMB) and the individual agencies involved in the IWG to prohibit the use of the 2010 and 2013 social cost of carbon (SCC) estimates by it and other executive branch agencies and withdraw the supporting documents that describe their calculation.[32] Several U.S. senators also sent a letter to the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the OMB citing some of the same arguments made by the petitioners.

Broadly speaking, the petitioners' claims fall into three general categories:

- <u>That estimates of the SCC are purportedly too uncertain and imprecise to be used for regulatory analysis.</u> 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 the IWG's use of them. Petitioners misrepresent both the view of the Intergovernmental Panel on Climate Change (IPCC) and economists' own assessments of SCC limitations.

- <u>That the IWG supposedly did not follow appropriate protocols in either its estimation or use of the SCC</u>. The petitioners accuse the IWG of hiding the uncertainties in its analysis; of failing to follow requirements 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.

[32] This group consists of the 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.

- In light of these two claims, that the SCC must be banned from use while it undergoes a wholly new 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.

The attached appendix, "Response to Industry Petition to OMB," explains the various claims the petitioners used to support these arguments and why they are wrong.

Before going into these details, two general points need to be made 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. It determined that *failing* to count SCC benefits would be illegal.

In this case, the National Highway Traffic Safety Administration's (NHTSA) had decided not to count any avoided climate damages in issuing fuel economy standards. 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).[33] *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.[34] 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)." [35]

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[33] *Center for Biological Diversity v. National Highway Traffic Safety Administration*, 538 F.3d 1172 (9th Cir. 2008) (emphases added).
[34] Stuart Shapiro, *The Evolution of Cost–Benefit Analysis in US Regulatory Decisionmaking*, *in* HANDBOOK ON THE POLITICS OF REGULATION (David Levi-Faur ed., 2011).
[35] Exec. Order No. 13,563, 76 Fed. Reg. 3,821 Federal Regulation (Jan 18, 2011).

Second***, while agencies are expected to use the best available science to inform their regulatory impact analyses, there is no legal requirement, for demanding that an agency's analysis <u>itself</u> 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. The IWG's estimates have been referenced in more than 40 rulemakings to date, and agencies have responded to relevant comments submitted thus far. Indeed, many of the changes the IWG made in its updated methodology were made in *response* to such comments.

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 benefits greatly exceeded costs absent any consideration of the SCC. Thus, it is almost certain that the standards set in such rules would have been the same even if the SCC had not been considered. Accordingly, to date the SCC has not been responsible for any additional legal obligation, restriction, or burden on the petitioners.

Whatever role the SCC plays in future rulemakings, the petitioners will have ample opportunity to present their arguments and 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 best peer reviewed science. When agencies utilize the IWG's estimates of the SCC to calculate the benefits of a rulemaking, they have taken, and will continue to take, comment on the SCC and 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.

5. Current SCC values are likely significant underestimates, and steps should be taken to address this in future updates[36]

The three IAMs used in IWG model framework are incomplete and make various simplifying assumptions. Most of the resulting biases tend towards an SCC estimate that underestimates the damages of climate change.[37]

The IAMs do not currently capture and evaluate many major impacts of climate change; the components of the IAMs that need to be improved strongly point toward an *under*estimate of the harmful effects of climate change.[38] The models omit important categories of harm, use outdated damage estimates, underestimate climate damages at high temperatures, make simplifications that likely lead to understated damages, inadequately account for catastrophic risks, and include conservative assumptions about discount rates. Each of these factors biases the model downward; collectively they may result in a substantial underestimate.

In particular, the IAMs used to generate the federal SCC values do not capture risks of low-probability but high-impact events, so-called climate "tipping points," such as the melting of the Greenland ice sheet, the release of vast stores of methane trapped under the melting permafrost, or radical changes in the jet stream or ocean currents that could affect major weather patterns like the monsoons. In addition, local variability of climate impacts, which is not reflected in the models, can have a dramatic impact on overall costs. For example, timing of precipitation over the course of the year is very important for the viability of agricultural crops, not just the average annual amount of rainfall in a given year. The global average sea level rise (8 inches since 1880) masks significant local variation (for example, in the United States we have experienced local sea level rise of 10 inches to 46 inches in places along the East and Gulf coasts).

Omitted Damages

Categories of climate effects that are omitted from the leading models include some of the most important risks associated with rising temperatures.[39] One recent IAM suggests that the most severe market losses associated with rising temperatures will result from declining production through falling labor productivity, a factor omitted from the models

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[36] The following section relies heavily on K. Arrow, L. Goulder, R. E. Kopp, M. Livermore, M. Oppenheimer, R. Revesz, T. Sterner, *Counting the Costs of Climate Change*, SCIENCE (forthcoming).
[37] Robert E. Kopp, & Bryan K. Mignone. *The US government's social cost of carbon estimates after their first two years: Pathways for Improvement*, ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL, May 4, 2012, at 1.
[38] Robert E. Kopp, & Bryan K. Mignone.*The US government's social cost of carbon estimates after their first two years: Pathways for Improvement*, ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL, May 4, 2012, at 1.
[39] The EPA is in agreement. The EPA (2010) states that "EPA continues to recognize that the estimates do not include all significant climate changes damages and are therefore underestimates." The EPA (2010) goes on to acknowledge the need to document these omissions, and to recognize that omitting such damages is to set their value equal to zero. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, LIGHT-DUTY VEHICLE GREENHOUSE GAS EMISSION STANDARDS AND CORPORATE AVERAGE FUEL ECONOMY STANDARDS: EPA RESPONSE TO COMMENTS DOCUMENT FOR JOINT RULEMAKING (2010), *available at* http://www.epa.gov/otaq/climate/regulations/420r10012a.pdf.

used in the U.S. government analysis.[40] Climate models have shown the potential for severe disruption in ecosystem services and biodiversity,[41] but these effects are not included in the SCC. Inter-sector damages, like the effect of water quality on health, ecosystems, and agricultural production, are also excluded. Many military and foreign policy leaders are concerned about socially contingent climate change damages, such as political and economic instability, increased social violence, and increased migration; these are also not taken into account.[42]

Moreover, while the models do include some agricultural and environmental damages, such as reduced crop yield at lower latitudes for low temperature increases and reduced crop yields in most regions for high temperature increases, they exclude others, such as fires, and increased pest pressures, diseases, and pollution. Most damages due to weather variability, including non-coastal flooding, droughts, wildfires, and heat waves, are also omitted, despite recent high salience events that have called attention to these risks. Perhaps most importantly over the long run, the potential for climate change to impede economic growth because of mechanisms such as the destruction of capital and the diversion of investment from high-productivity-growth sectors to low-productivity-growth adaptive measures is not accounted for. Even small changes in the rate of growth can have massive consequences for well-being over time.[43,44]

In his most recent version of his DICE model, Nordhaus attempted to address these missing categories of risks by increasing his damage estimate by 25%.[45] While this assumption is arguably preferable to completely excluding non-quantified damages, the fact remains that as the models improve and generate a more complete picture of climate risks, their damage estimates are likely to increase well beyond this adjustment.

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[40] Roberto Roson & Dominique Van der Mensbrugghe, *Climate change and economic growth: Impacts and interactions*, 4 INTERNATIONAL JOURNAL OF SUSTAINABLE ECONOMY, 270 (2012).
[41] 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.
[42] U.S. DEPARTMENT OF DEFENSE, QUADRENNIAL DEFENSE REVIEW REPORT, *available at* http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf; Jody Freeman & Andrew T. Guzman, *Sea Walls are Not Enough: Climate Change and US Interests* (UC Berkeley Public Law, Research Paper No. 1357690, 2009); Solomon M. Hsiang, Marshall Burke, and Edward Miguel. *Quantifying the Influence of Climate on Human Conflict*, 341 SCIENCE, 1235367-1 (2013).
[43] Elizabeth J. Moyer, Mark D. Woolley, Michael Glotter, and David A. Weisbach. *Climate Impacts on Economic Growth as Drivers of Uncertainty in the Social Cost of Carbon* (Center for Robust Decision Making on Climate and Energy Policy, Working Paper 13-02, 2013).
[44] Important damages currently missing from the SCC include: non-market damages (ecosystem services, ocean acidification, biodiversity, and omitted health costs), inter-regional damages, inter-sector damages, non-climate events that will act as threat multipliers (e.g. over pumping of ground water), socially contingent damages (political and economic instability, increased migration, increased inter-personal and social violence), omitted factors in agriculture and forestry (fires, increased pest and pathogen pressures, and increased air pollution), effects on inputs (decreased labor productivity and loss of capital), and weather variability (flooding, droughts, and heat waves).
[45] WILLIAM NORDHAUS & PAUL SZTORC, INTRODUCTION AND USER'S MANUAL (2013), *available at* http://www.econ.yale.edu/~nordhaus/homepage/documents/Dicemanualfull.pdf.

Outdated Damages

We now have nearly a decade of rigorous empirical research exploring the impacts of historic temperature changes on social and economic outcomes across various parts of the world and over differing time horizons. For many of the outcomes – such as agricultural yields,[46] human health,[47] civil conflicts,[48] migration,[49] labor productivity,[50] and GDP[51] – that were utilized to calibrate the IAMs' damage functions, recent research has generally revealed that historically the effects of temperature changes have been larger than anticipated. While "questions remain about how this historic evidence maps onto the spatial and temporal impacts of anthropogenic climate change[it] is reasonable to assume that the IAMs used in the IWG process, which were calibrated prior to this research, may be understating the true damage from climate change."[52]

Damages at high temperature levels

The IAMs' damage functions are calibrated using damage estimates for low temperature increases, usually 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.

Often, resulting damage functions imply unrealistically low damages at high temperature levels. For example, according to the DICE-2007 damage function used by the 2010 IWG, 6 and 10 degree Celsius increases imply only 10.2% and 28.3% declines, respectively, in global GDP; these low damage estimates imply insufficient damage estimates and/or overly strong adaptation assumptions. As highlighted by Weitzman (2010)[53], Sherwood and

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[46] 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).
[47] 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.
[48] Solomon M. Hsiang, Marshall Burke, and Edward Miguel. *Quantifying the Influence of Climate on Human Conflict*, 341 SCIENCE, 1235367-1 (2013).
[49] Shuaizhang Feng, Michael Oppenheimer, & Wolfram Schlenker. *Climate Change, Crop Yields, and Internal Migration in the United States* (National Bureau of Economic Research Working Paper, No. 17734, 2012), *available at* http://www.nber.org/papers/w17734.pdf?new_window=1.
[50] Joshua Graff Zivin & Matthew Neidell. *Temperature and the Allocation of Time: Implications for Climate Change* (National Bureau of Economic Research Working Paper, 15717, 2010), *available at* http://www.nber.org/papers/w15717.pdf?new_window=1.
[51] 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.
[52] Arrow, L. Goulder, R. E. Kopp, M. Livermore, M. Oppenheimer, R. Revesz, T. Sterner, *Counting the Costs of Climate Change*, SCIENCE (forthcoming).
[53] Martin L. Weitzman, *GHG targets as insurance against catastrophic climate damages*, 14 JOURNAL OF PUBLIC ECONOMIC THEORY, 221 (2012).

Huberb (2010)[54] recently find that large portions of the earth's surface, where a majority of humans are currently distributed, will be inhospitable at a 11 or 12 degree Celsius increase due to due to hyperthermia in mammals; they see this as an upper limit on the level of adaptation.[55] Using this information, Ackerman and Stanton (2012) assume that humans cannot survive at a 12 degree Celsius increase, and assume that 99% of GDP damages are lost at this temperature value. In other words, updating the damage functions to reflect recent scientific analysis for damages at higher temperatures indicates that damages estimates should increase relative to what is currently in the IAMs. [56]

Oversimplification of modeling assumptions

An additional downward bias in the damage estimates results from various model simplifications. One important one is an implicit assumption of constant relative prices. 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, which 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.[57] 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 declines (e.g. the die off of coral reefs, and losses of biodiversity and ecosystems that sustain life). The current models violate the fundamental economic principle that value arises from scarcity.

Another simplifying assumption is ignoring the rate of temperature increases. Only one of the three models, FUND, accounts for this. Yet, there is a strong consensus that rapid climate change is more costly than slow climate change. With slow change, ecosystems and societies may be able to adapt up to a point, for example by abandoning coastal settlements, altering planting patterns, and anticipating climate change in infrastructure decisions. On the other hand, if climate change is rapid, these adaptation strategies become more difficult, and more costly. If climate changes are too extreme, it will probably be impossible for humans to adapt to them regardless of the time scale.

Failure to sufficiently account for catastrophic damages: tipping points, black swan events, and fat tails

Currently, IAMs are failing to account for catastrophic damages resulting from tipping points, "fat tail" distributions, and "black swan" events. Tipping points are an

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[54] Steven C. Sherwood & Matthew Huber, *An adaptability limit to climate change due to heat stress*, 107 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, 9552 (2010).
[55] At a seven degree Celsius increase, some portions of the planet start becoming inhospitable due to hyperthermia.
[56] Frank Ackerman & Elizabeth Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon* (Economics Discussion Paper, No. 2011-40, 2011).
[57] Thomas Sterner & U. Martin Persson, *An Even Sterner Review: Introducing Relative Prices into the Discounting Debate*, 2 REVIEW OF ENVIRONMENTAL ECONOMICS AND POLICY, 61 (2008).

environmental threshold over which small changes in the environmental state can cause rapid, frequently irreversible changes in ecosystem characteristics. A "fat-tailed" distribution refers to a distribution with 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. 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.

The probability level and severity of potential extreme climate change events, such as the rapid melting of ice sheets or runaway methane emissions from melting permafrost (and an acceleration of warming), examples of tipping point events, are poorly understood. These risks, which would impose almost unimaginable hardship on human societies should they occur, provide one of the most convincing and forceful reasons to aggressively reduce greenhouse gas emissions.[58]

Each of the IAMs addresses tipping points differently. The FUND model ignores them altogether. The DICE model has shifted from modeling willingness to pay to avoid a catastrophe to a meta-analysis of other estimates, some of which do not include catastrophic damages via tipping points.[59] Unlike the other two models, the newest version of PAGE[60] explicitly models catastrophic damages via tipping points, but assumes only a single, general event (i.e. not a specific damage, like melted ice sheets) that has a probability of occurring in each time period.

Also, the risks and uncertainties involved in climate change may be fat-tailed. As a result, it would be rational for a risk averse actor to be considerably more cautious than if he were risk neutral and faced normally distributed risks—an effect that would lead to a higher SCC. The potential for inappropriate use of thin tailed distributions may bias damage estimates downwards.

Black swan events are all together ignored by the IAMs and IWG. At the current moment, there is no specific strategy on how to address them. The best the IWG can do is be transparent about their existence.

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. This rate is one of the most important inputs in models of climate damages, with plausible assumptions easily leading to differences of an order of magnitude in the SCC. As discussed above, there is a consensus among climate economists that a declining discount rate should be used to account for uncertainty about future

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[58] Timothy M. Lenton & Juan-Carlos Ciscar. *Integrating tipping points into climate impact assessments*. 117 CLIMATIC CHANGE, 585 (2013).
[59] Compare DICE-1999 and DICE-2007 with DICE-2010 and DICE-2013 (meta-analysis based on estimates in Table 1 of Tol (2009)). Richard S.J. Tol, *The economic effects of climate change*, THE JOURNAL OF ECONOMIC PERSPECTIVES, Spring 2009, at 29.
[60] PAGE09

discount rates.[61] Such discount rates are now the official policy of the United Kingdom and France. The IWG has one discount rate that attempts to take uncertainty into account (a constant 2.5%), but none of the three main economic models are designed to be run with declining discount rates.

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.[62]

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).[63]

Failure to include a risk premium and account for risk aversion

In addition to option value, the IAMs fail to include a risk premium. This is the amount of money society would require (were it given the option) to accept the uncertainty over the magnitude of damages from climate change. While this risk premium is not accounted for by current IAMs, it will be positive due to current assumed shape of the social welfare function in these models.[64] Like its response to option value, the EPA (2010) agreed that a risk premium should be included, but concluded then that "further research in this area is needed to develop a reasonable approach to account for catastrophic risks in regulatory analyses."

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[61] Arrow, K., M L. Cropper, C Gollier, B Groom, G M. Heal, R G. Newell, W D. Nordhaus, R S. Pindyck, W A. Pizer, P Portney, T Sterner, R Tol and M,L. Weitzman ,Determining Benefits and Costs for Future Generations, *SCIENCE* July 26 2013.

[62] 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.

[63] 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).

[64] IAMs currently assume a utility function that is increasing at a decreasing rate in per capita consumption.

The IWG decided in early 2010 to continue "investigating" the issue of risk aversion in lieu of including a risk premium in the SCC. The IWG did note that Anthoff, Tol, and Yohe found that risk aversion is at least as important as the discount rate (see earlier discussion) - a topic that the IWG discussed in great detail.[65] However, without citing studies with different results, it still concluded that further investigation was necessary before including a risk premium in the SCC.[66,67]

The IWG discussion failed to mention the work of Heal and Kristrom,[68] Heal,[69] Hennlock,[70] Tol,[71] Yohe and Tol,[72] or additional work by Weitzman,[73] among many others that suggest the use of significant risk premiums. In short, the current failure to include a risk premium in the SCC is inconsistent with the literature. Although scholars use different methods for calculating risk premiums and arrive at different results, disagreement over the size of these values does not suggest that they should be zero.[74] The degree of risk society faces is

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[65] 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 12,8666, at 31 (2010).
(citing David Anthoff, Richard S. J. Tol, & Gary W. Yohe, *Risk Aversion, Time Preference, and the Social Cost of Carbon*, 4 ENVTL. RESEARCH LETTERS 1, 1 (2009) ("[T]he assumed rate of risk aversion is at least as important as the assumed rate of time preference in determining the social cost of carbon.")).
[66] EPA-HQ-OAR-2010-0799-9480-A1, p. 6
[67] EPA-HQ-OAR-2010-0799-9480-A1, p. 7
[68] Geoffrey Heal & Bengt Kristrom, *Uncertainty and Climate Change*, 22 ENVTL. RESOURCE ECON. 3 (2003) (analogizing climate change to insurance markets).
[69] Geoffrey Heal, *The Economics of Climate Change: A Post-Stern Perspective*, 96 CLIMATE CHANGE 275 (2009) (identifying the effects of uncertainty and risk aversion and suggesting that society will pay to avoid climate change risks).
[70] Magnus Hennlock, *Robust Control in Global Warming Management: An Analytical Dynamic Integrated Assessment* (University of Gothenberg, Working Papers in Economics No. 354, 2009) (finding that the preference for avoiding uncertainty entails a higher SCC due to the need for an ambiguity premium).
[71] Richard S. J. Tol, *The Social Cost of Carbon: Trends, Outliers, and* Catastrophes 2 ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL (2008).
[72] See Gary W. Yohe & Richard S. J. Tol, *The Stern Review and the Economics of Climate Change: An Editorial Essay*, 89 CLIMATE CHANGE 231, 237 (2008).
[73] Martin L. Weitzman, *Additive Damages, Fat-Tailed Climate Dynamics, and Uncertain Discounting*, 3 2 ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL 1 (2009); and Martin L. Weitzman, *GHG Targets as Insurance Against Catastrophic Climate Damages* (NBER, Working Paper No. 16136, 2010).
[74] See, e.g., Gary Yohe, *Toward an Integrated Framework Derived from a Risk-Management Approach to Climate Change*, 95 CLIMATE CHANGE 325, 329 (2009) (suggesting the need to account for risk and uncertainty in climate change policy); Gary W. Yohe & Richard S. J. Tol, *The Stern Review and the Economics of Climate Change: An Editorial Essay*, 89 CLIMATE CHANGE 231, 237 (2008) (arguing that the optimal carbon tax must be augmented by a non-zero risk premium); Geoffrey Heal & Bengt Kristrom, *Uncertainty and Climate Change*, 22 ENVTL. RESOURCE ECON. 3 (2003); Geoffrey Heal, *The Economics of Climate Change: A Post-Stern Perspective*, 96 CLIMATE CHANGE 275 (2009); Magnus Hennlock, *Robust Control in Global Warming Management: An Analytical Dynamic Integrated Assessment* (University of Gothenberg, Working Papers in Economics No. 354, 2009); Antony Millner, Simon Dietz, & Geoffrey Heal, *Ambiguity and Climate Policy* (Center for Climate Change Economics and Policy, Working Paper No. 28, 2010) (finding that aversion to uncertainty in some cases leads to very large "ambiguity" premiums); Michael D. Gerst, Richard B. Howarth & Mark E. Borsuk, *Accounting for the Risk of Extreme Outcomes in an Integrated Assessment of Climate Change*, 38 ENERGY POL'Y 4540 (2010) (showing that ignoring uncertainty underestimates climate damages); and Robert E. Kopp et al., The Influence of the Specification of Climate Change Damages on the Social Cost of Carbon (ECONOMICS: THE OPEN-ACCESS,

a subject of contention, but most economists believe that there is some non-negligible risk premium that must be accounted for in the SCC.[75]

More important than the precise value is the realization that positive risk aversion warrants incorporating a positive risk premium into the SCC.[76] There are two different pathways for risk aversion to be important for calculating the value of greenhouse gas abatement. In the first, mitigation steps taken today can be understood as an investment that is part of a larger portfolio of investments made by society. Under this framework, risk aversion can lead to a higher or lower social cost of carbon, depending on whether the value of greenhouse gas emissions in the future are correlated with the overall growth rate of the economy. To the extent that many of the effects of climate change will involve non-market impacts—the decimation of coral reefs, for example, or widespread extinction of terrestrial species—they may be substantially unrelated to the returns in the economy as a whole. If a substantial share of the damages from climate change is expected to be uncorrelated to returns in the economy as a whole, the discount rate should move toward the risk-free rate, ie. a discount rate with no risk premium.[77]

For policymakers today, there is also a great deal of uncertainty about the relationship between the greenhouse gas emissions and climate outcomes. Resolution of that uncertainty is structurally similar to the realization of a risk that is uncorrelated with market returns, and can be thought of as serving the same function within an investment portfolio.[78]

In addition, the relationship between reductions in greenhouse gas emissions and economic growth reflects causation as well as correlation. Severe climate change could

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OPEN-ASSESSMENT E-JOURNAL, Discussion Paper No. 2011-22, 2011) (finding that uncertainty and risk aversion can significantly increase the SCC). Much of this literature review is based on Carolyn Kousky, Robert E. Kopp & Roger Cooke, *Risk Premia and the Social Cost of Carbon: A Review* 5 (ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL, Discussion Paper No. 2011-19, 2011). See also Ctr. for Biological Diversity v. NHTSA, 538 F.3d 1172, 1200 (9th Cir. 2008).

[75] See, e.g., David Anthoff, Richard S. J. Tol, & Gary W. Yohe, *Risk Aversion, Time Preference, and the Social Cost of Carbon*, 4 ENVTL. RESEARCH LETTERS 1, 5 (2009) (finding SCC estimates over $5,000 per ton of carbon dioxide for some parameter values); Antony Millner, Simon Dietz, & Geoffrey Heal, *Ambiguity and Climate Policy* (Center for Climate Change Economics and Policy, Working Paper No. 28, 2010); Carolyn Kousky, Robert E. Kopp & Roger Cooke, *Risk Premia and the Social Cost of Carbon: A Review* 14 (ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL, Discussion Paper No. 2011-19, 2011) (concluding after surveying the literature on risk and uncertainty premiums that these premiums could be "quite large").

[76] See generally Gary Yohe, *Toward an Integrated Framework Derived from a Risk-Management Approach to Climate Change*, 95 CLIMATE CHANGE 325, 329 (2009); Gary W. Yohe & Richard S. J. Tol, *The Stern Review and the Economics of Climate Change: An Editorial Essay*, 89 95 CLIMATE CHANGE 231, 237 (2008) ("While reasonable people disagree how much of a risk premium should be placed on top of the Pigou tax, it should be clear that no reasonable person would argue that this premium should be zero."); Carolyn Kousky, Robert E. Kopp & Roger Cooke, *Risk Premia and the Social Cost of Carbon*: A Review 5 (ECONOMICS: THE OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL, Discussion Paper No. 2011-19, 2011). See also Klaus Keller, Gary Yohe, & Michael Schlesinger, *Managing the Risks of Climate Thresholds: Uncertainties and Information Needs*, 91 CLIMATE CHANGE 5 (2008) (discussing the proper portfolio of mitigation policies).

[77] EPA-HQ-OAR-2010-0799-9480-A1, p. 7

[78] EPA-HQ-OAR-2010-0799-9480-A1, pp. 7-8

bear negatively and directly on overall economic productivity. For example, sea level rise could threaten large parts of the coastal United States, especially low-lying areas like Florida. In effect, such a causal relationship will be a source of negative correlation between the benefits of mitigation and broader market returns. In climate scenarios with greater temperature change, total damages from climate change will be higher, but total economic activity will be lower (ceteris paribus)—marginal damages and therefore marginal benefits of mitigation will be high (due to convexity of damages – see footnote 27) while the returns to the broader economy will tend to be low (the productivity effect).[79]

The second pathway for risk aversion to affect the SCC concerns how investment in climate change mitigation reduces the variance of expected outcomes for the economy as a whole. The distribution of possible climate outcomes is a function of emissions, such that each ton of emissions can amplify the variance of aggregate economic damages and thereby further increase systematic risk. This means that, in addition to increasing the likelihood of catastrophic outcomes, each additional unit of emissions also increases the uncertainty about which outcome will occur. Thus, a full risk premium in the climate change context values the ability of emissions abatement to reduce the variance of outcomes.[80]

Despite these justifications, the IWG noted that government is usually risk neutral and questioned whether the climate change context merits different treatment. In fact, the nature of the climate problem requires government to be risk averse. For most social problems, the government is large enough that it can self-insure against disaster and act without aversion to risk. But because climate change is qualitatively different than other social problems involving risk, the agencies should treat it differently. The IWG noted the suggestion in the Office of Management and Budget's Circular A-4 that government agencies should "generally" assume the perspective of a risk neutral actor. But it also observed that society should not always be risk neutral, that Circular A-4 "allows for a different assumption on risk preference in regulatory analysis if it is adequately justified,"[81] and that agencies should deviate from the risk neutral perspective when necessary.[82] The global nature of climate change catastrophes requires such a deviation. Circular A-4 endorses the use of expected values without a risk premium—here, the average damages of all possible climate outcomes—only when society is risk neutral. However, society will not be neutral when risks cannot be offset by other investments. Compensating for the loss of habitability on Earth is impossible; the ability of the planet to sustain human life is irreplaceable. The magnitude of the damages associated with the risk of catastrophic climate change overwhelms the ability of society to match these damages with gains from

[79] EPA-HQ-OAR-2010-0799-9480-A1, p. 8
[80] EPA-HQ-OAR-2010-0799-9480-A1, p. 8
[81] See 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 12,8666, at 31 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf).
[82] See id. at 30 (citing OFFICE OF MGMT. & BUDGET, EXECUTIVE OFFICE OF THE PRESIDENT, CIRCULAR A-4, 42 (2003)).

other investments.[83] This suggests that risk aversion is necessary for society to account for the uniquely problematic nature of climate change.[84]

The IWG attempted to account for risk aversion by including a 95th percentile SCC estimate at a 3% discount rate.[85] The decision to include consideration of risk aversion in one of four estimated SCC values misses the point. Risk and uncertainty are systematic in the climate change context. Consequently, all SCC estimates should include risk premiums to account for these factors. Furthermore, it is not clear whether the selection of the 95th percentile SCC estimate was chosen based on a reasoned connection to the risks under consideration, or out of simple convenience.[86]

6. Concluding remarks

As a supplement to this submission, we will be adding to the docket concrete recommendations for improving the SCC, in light of the problems we have identified, and will be submitting them separately.

Briefly, while the current SCC estimates are biased downwards due to the reasons discussed in the previous section and more can (and will) be done to improve the science and economics underlying IAMs (as will be discussed in our supplementary material to be submitted later), it is critical that agencies proceed with using the best available SCC estimate in rulemaking processes. The costs of climate change are all too real already for communities across America. To ignore these costs and costs to future generations would be detrimental to the health and well-being of Americans and contrary to law and Presidential directives to agencies to evaluate the cost of pollution to society when considering standards to abate that pollution. In the context of agency rulemakings, the SCC is the best available means to factor those costs into the benefits-cost analysis of our pollution mitigation choices. The use of the best available SCC estimates should be balanced by putting in place an update process, as occurred in 2013, to update SCC estimates for new economic and scientific consensus. This approach is in line with the stated intentions of the IWG, which stated in the 2010 TSD that the IWG is committed to "updating these estimates as the science and economic understanding of climate change . . . improves." A discussion of the specifics on how and when an update should take place will be included in our supplementary material.

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[83] See Martin Weitzman, *On Modeling and Interpreting the Economics of Catastrophic Climate Change*, 91 REV. ECON. & STAT., 1, 11 (2009).
[84] EPA-HQ-OAR-2010-0799-9480-A1, p. 8
[85] See 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 12,8666, at 30 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.pdf).
[86] EPA-HQ-OAR-2010-0799-9480-A1, pp. 8-9

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October 21, 2013

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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.

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[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 12,8666 (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 12,8666 (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.

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[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 <u>itself</u> 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.

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[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 SCC[8]) 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. <u>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</u>. Economic theory argues for the consideration of the best available information under uncertainty; the models used by the IWG adopt this approach.

b. <u>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:</u>
    - 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" distribution[10] estimated by scientists), and a variety of possible future emission and growth scenarios.

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[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 12,8666 (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. <u>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</u>, 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 <u>underestimate</u> 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 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

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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. <u>The petitioners misrepresent economists' own assessments of the relevance of uncertainty to the legitimacy of SCC estimates.</u> 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 <u>underestimate</u> 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. <u>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.</u> 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.

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[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.

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[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 12,8666 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.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 12,8666 (2010), *available at* http://www.epa.gov/otaq/climate/regulations/scc-tsd.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. <u>The petitioners make several unsupportable assertions regarding the appropriateness of the IWG's use of central rather than median estimates</u>. 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]

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[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. <u>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.</u>

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.

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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]

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[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.