EESI INC
Environment Economics & Society Institute, Inc.

January 27, 2014

Office of Information and Regulatory Affairs
Office of Management and Budget (OMB)
725 17th Street NW
Washington, DC 20503
(submitted via regulations.gov)

Subject: OMB-OMB-2013-0007
Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order No. 12866

Dear OMB Staff:

Thank you for providing an opportunity for Environment, Economics and Society Institute (EESI) to comment on the Office of Management and Budget's Technical Update of the Social Cost of Carbon (SCC). EESI is committed to supporting environmental research in the public interest, and has sponsored the attached report.

The SCC is an important regulatory tool and we applaud your efforts to calculate an appropriate dollar amount. While the increase proposed in November 2013 is a step in the right direction, we believe that there are significant flaws with the revised approach, and that a higher value for SCC is warranted. Please consider additional revisions to the SCC that take into account the comments in the attached report.

Sincerely,

Jean Ann Ramey
Executive Director

22 Pearl Street, Cambridge, MA 02139

Comments on the 2013 *Technical Update of the Social Cost of Carbon*

Prepared for the Environment, Economics and Society Institute

January 27, 2014

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1. OVERVIEW: THE NUMBER IS BETTER THAN THE METHODOLOGY

We welcome the invitation from the Office of Management and Budget (OMB) to comment on the November 2013 *Technical Update of the Social Cost of Carbon*. The estimate of the social cost of carbon (SCC) used in federal regulatory analyses is an important and controversial calculation that has received too little public comment and outside review.

Our comments, in summary, argue that the result of the 2013 revision (i.e., a significant increase in the SCC) is a move in the right direction, but is based on a flawed methodology that should be substantially revised. In the following sections we explain that:

- The climate crisis requires a vigorous policy response, including a price on carbon emissions to ensure that these pollutants are correctly valued in regulatory analyses thereby reducing emissions. The price must be high enough to achieve a significant reduction in emissions, and the 2013 updated SCC values are a step in the right direction.
- The choice of the three models used to calculate the SCC has never been justified, except by reference to frequency of citations to them. Many other models are available.
- Two of the models, DICE and PAGE, are too aggregated to represent research on climate impacts in any detail; they offer only their developers' guesses about how to reduce the vast, multi-dimensional array of climate damages to a few summary, monetized impacts. The third model, FUND, attempts a higher level of disaggregation, but produces damage results that are too low to be consistent with current climate science.
- The 2013 changes to the federal SCC are due principally to updates in the PAGE model, including in its treatment of catastrophic events.
- The five scenarios of future emissions used in the SCC analysis are essentially arbitrary choices selected, with little explanation, from other models.
- Anticipated climate damages are severe and will grow steadily worse under a business-as-usual scenario, but it is impossible to put a meaningful price on all of these damages.

We recommend a pragmatic approach to carbon pricing, based on its expected effect on emissions rather than on the futile attempt at a complete, monetized cost-benefit analysis. Like taxes on tobacco and alcohol use, a price on carbon emissions is primarily justified as an incentive to reduce harmful behavior. The 2013 revision of the SCC provides a reasonable initial estimate of a carbon price for policy purposes; more work is needed to refine this estimate by improving on the Administration's methodology. Public scrutiny of the use of the SCC in regulatory impact analysis, and of the underlying methodology—including the choice of models used to calculate the SCC—is essential to setting the right U.S. climate policies to do our part as a nation to avert climate change.

2. THE CLIMATE CRISIS REQUIRES A PRICE ON CARBON EMISSIONS

Climate change is real, and the greenhouse gas emissions that cause it continue to grow every year. If immediate, large-scale actions are not taken to abate these emissions, the resulting economic damages will be severe. Ignoring the problem will not make it go away.[1] A warming world means intensifying droughts, heat waves, and hurricanes; rising sea levels; and worsening ocean acidification. The consensus of the world's scientists, formally and cautiously expressed in the periodic reports of the Intergovernmental Panel on Climate Change (IPCC), leaves no room for doubt; leaked early versions of the IPCC's forthcoming fifth assessment convey even greater certainty and urgency than in past reports.

Repeated surveys of the scientific literature have found overwhelming agreement that human activity, primarily carbon emissions, causes global warming; most recently, a 2013 survey of 20 years of worldwide climate research found 97 percent support for the consensus on "anthropogenic global warming."[2] For a summary of the science and the urgency of action to address climate change, see the review article by an international team of 18 researchers, led by noted climatologist James Hansen.[3] In short, there is no credible support for the dangerously misleading notion that the science is still in doubt, or that there is any serious question about the threat of climate change to our future well-being.

If action to reduce emissions is urgent, how should it be done? A variety of regulatory options, including vehicle fuel economy standards, EPA proposals for power plant regulations, and others, are an important policy tool. Impact analyses for federal regulations are conducted in terms of monetary costs and benefits. For this reason, the benefits of policies that reduce carbon emissions are typically only given weight, as part of a regulation's impact, if these benefits are assigned a value in dollars and cents. Well-known arguments about the efficiency of monetary incentives suggest that a price on carbon emissions applied to internal government analyses is an essential part of a least-cost strategy for abating emissions and mitigating climate change.

If a monetary value should be assigned to carbon emissions, how high should it be? Very low values will induce very small changes in emissions, if any. This has been demonstrated by the Regional Greenhouse Gas Initiative (RGGI) of northeastern states, and by the European Union's Emissions Trading System (EU ETS). In both cases, a cap-and-trade system with a loose cap (barely below unpriced, business-as-usual emissions) has led to a near-zero carbon price—and to little effect on emissions. However the price is calculated, it must be high enough to have a significant effect on emission levels. The 2013 SCC value is much higher than recent RGGI and EU ETS prices; if applied consistently to federal regulatory impact analyses, it can achieve important reductions in U.S. carbon emissions. To have a larger impact on

[1] Frank Ackerman and Elizabeth A. Stanton (2013) *Climate Economics: The State of the Art*. Routledge (New York).
[2] John Cook et al., "Quantifying the consensus on anthropogenic global warming in the scientific literature," *Environmental Research Letters* vol. 8 no. 2 (2013), doi: 10.1088/1748-9326/8/2/024024.
[3] James Hansen et al., "Assessing 'dangerous climate change': Required reduction of carbon emissions to protect young people, future generations and nature," *PLOS ONE* vol. 8 no. 12 (2013), doi:10.1371/journal.pone.0081648.

national emissions and ultimately on climate change itself, it will be essential to broaden the scope of a carbon price to cover most or all sources of emissions.

3. THE CHOICE OF MODELS FOR THE SCC CALCULATION HAS NOT BEEN ADEQUATELY EXPLAINED

Of the many models of climate economics, three were selected for the original SCC calculation in 2010: DICE, PAGE, and FUND. The Interagency Working Group, which produced the 2010 SCC, held no public hearings and did not solicit comments on its methodology or choices.[4] Indeed, the release of the 2010 SCC, without prior announcement, came as a surprise to almost everyone. Regarding the choice of models, the 2010 SCC *Technical Support Document* simply said (p.5):

> We rely on three integrated assessment models (IAMs) commonly used to estimate the SCC: the FUND, DICE, and PAGE models. These models are frequently cited in the peer-reviewed literature and used in the IPCC assessment. Each model is given equal weight in the SCC values developed through this process…

The text goes on to discuss both advantages and disadvantages of these models; there is no suggestion that other models or approaches were considered or compared to the chosen methodology.

The Environmental Protection Agency (EPA) and the Department of Energy (DOE) subsequently held two workshops to discuss the SCC process and calculations. The agendas for the workshops emphasized that they were not soliciting formal comments on the SCC, and could not promise any specific schedule for a revised calculation. Most of the time at the workshops was devoted to presentations given by a list of invited speakers, many of whom were explaining and defending the Working Group's SCC; that is, the workshops were not structured as conventional public hearings on the SCC.[5] A third, invitation-only workshop discussed the appropriate choice of discount rates for climate policy analysis.

The 2013 revision of the SCC was, again, released without prior announcement or public hearings. There were no changes of any sort in the Working Group's SCC methodology; rather, the values changed because the three chosen models each released new estimates. As the 2013 *Technical Update of the Social Cost of Carbon* put it (p.2):

[4] A preliminary SCC calculation, introduced with little fanfare into draft assessments of some proposed regulations in 2009, drew a few comments in those regulatory proceedings. The final 2010 value adopted a very different methodology from the preliminary calculation, but in a remarkable coincidence arrived at exactly the same central estimate of $21 per ton.

[5] One of us (Frank Ackerman) attended both workshops.

> While acknowledging the continued limitations of the approach taken by the interagency group in 2010, this document provides an update of the SCC estimates based on new versions of each IAM (DICE, PAGE, and FUND). It does not revisit other interagency modeling decisions… Improvements in the way damages are modeled are confined to those that have been incorporated in the latest versions of the models by the developers themselves…

In short, the discussions at the EPA-DOE workshops, the extensive publications on the SCC (including a 2012 special issue of *Economics e-journal* devoted to the topic), and three years of ongoing climate research and economic analysis had no influence on the SCC methodology or resulting values whatsoever—save to the extent that the three chosen modelers have independently decided to incorporate new information.

This is not a reasonable process for setting U.S. government policy. With no public discussion before the fact or formal review after the fact, control of the federal SCC has been handed out, in equal shares, to three specific modelers. The SCC appears to change if and only if these three modelers change their judgments.

Many other integrated assessment models are available. The Energy Modeling Forum (EMF) is an ongoing process, regularly comparing the results of multiple climate-economics models; indeed, the emissions scenarios used by the Interagency Working Group were taken from EMF models. (There was, again, no explanation for the selection of scenarios from some but not others of the EMF models.) In a 2009 review article, two of us and a co-author reviewed 30 different climate economics models that had appeared in the recent peer-reviewed literature, with many different features, structures, and levels of detail.[6] The decision to use solely the DICE, PAGE, and FUND models to estimate the federal SCC requires further justification by the Working Group.

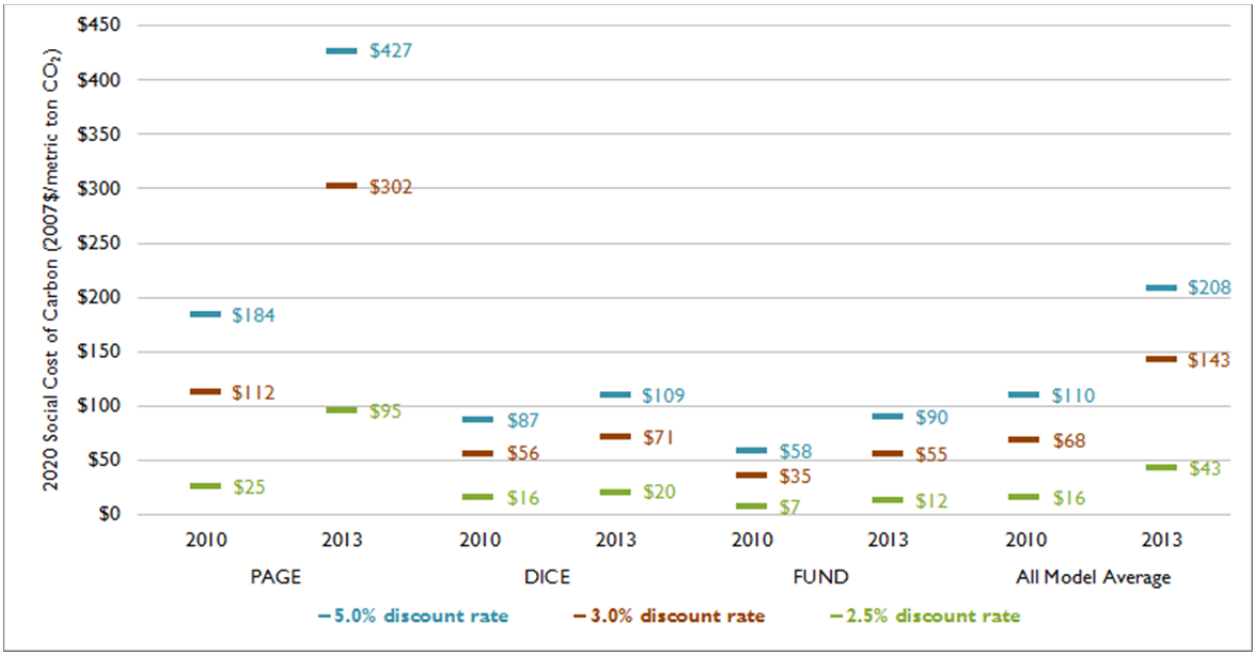
4. DICE, PAGE, AND FUND FAIL TO REPRESENT STATE-OF-THE-ART RESEARCH ON CLIMATE IMPACTS

The three chosen models are not in any self-evident way the best or most reliable in this widely populated field. SCC values for all three models increase from the 2010 to the 2013 Technical Documents (see Figure 1 and Figure 2). Two of the models, DICE and PAGE, are among the simplest and easiest climate-economics models to operate; ease of use would not ordinarily be an argument in favor of their use by experts to set an important government policy.

[6] Elizabeth A. Stanton, Frank Ackerman, and Sivan Kartha, "Inside the integrated assessment models: Four issues in climate economics," *Climate and Development* 1 (2009), doi:10.3763/cdev.2009.0015.

Figure 1. Average 2020 SCC by model for 2010 and 2013 Technical Documents (in 2007$/metric ton)

Figure 2. 95th percentile 2020 SCC by model for 2010 and 2013 Technical Documents (in 2007$/metric ton)



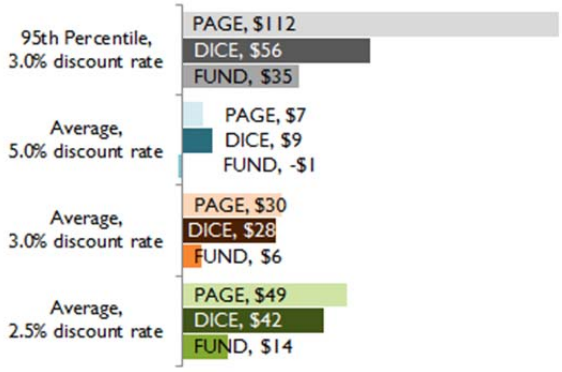
The Working Group uses a modified version of the DICE model that produces results in response to exogenous scenarios of climate and the economy rather than—as is the case in the original DICE—modeling each period's temperature and global GDP based on the emissions and resultant damages determined to be "optimal" in the previous period. DICE is also modified to produce "Monte Carlo" results—or results averaged over a large number of model runs using a variety of parameter values. In the Working Group's DICE runs it is only the climate sensitivity parameter (the relationship between greenhouse gas emissions and temperature) that is varied according to a well-known distribution.

Similarly, PAGE (using its original design) and FUND (as modified for this purpose by its designers) also produce results based on pre-set scenarios of climate and economy, and return results averaged over many runs using various parameter values. PAGE and FUND's Monte Carlo runs explore the distribution of numerous other parameter values in addition to climate sensitivity.

Both DICE and PAGE rely on very simple, formulaic relationships between climate and climate damages. Both models have since 2010 updated their representations of the physical climate cycle and added some nuances—including an explicit accounting of damages from sea-level rise—to the simple functions that determine these models' climate damages. Neither model, however, approaches the level of complexity in estimating damage costs that is represented in the current climate-economics literature.[7] The DICE damage function in particular relies on the outdated notion that monetary climate damages can be well represented as a simple function depending on the square of temperature increases.[8] Another leading economist researching climate change has suggested that a better approximation of current climate science would be a loss of 50 percent of global GDP at a 6°C temperature increase, and a 99 percent loss at a 12°C increase.[9]

The 2013 *Technical Update of the Social Cost of Carbon* describes numerous updates and corrections to the FUND model. FUND includes a more complex damage function with climate impacts disaggregated for multiple sectors but nonetheless continues to produce estimates far lower than either DICE or PAGE at both the average and the 95th percentile climate sensitivity (see Figure 3 and Figure 4).

Figure 3. 2020 SCC by model for 2010 Technical Documents (in 2007$/metric ton)

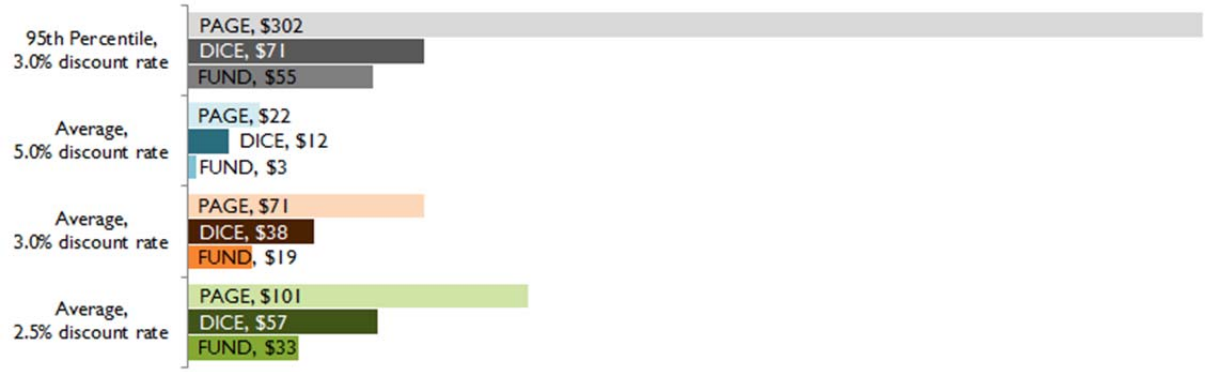


[7] See, for example, Reilly et al. (2013) "Valuing climate impacts in integrated assessment models: the MIT IGSM." *Climatic Change* 117: 561-573.

[8] Frank Ackerman and Elizabeth A. Stanton (2012) "Climate Risks and Carbon Prices: Revising the Social Cost of Carbon." *Economics: The Open-Access, Open-Assessment E-Journal*, Vol. 6, 2012-10. http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10

[9] Martin L. Weitzman (2010) "Targets as Insurance Against Catastrophic Climate Damages." National Bureau of Economic Research Working Paper No.16136, June 2010. http://www.nber.org/papers/w16136.

Figure 4. 2020 SCC by model for 2013 Technical Documents (in 2007$/metric ton)



FUND's developers make the assumption that there are important climate benefits from higher temperatures, including reduced space heating costs and increased agricultural productivity in some regions.[10] In fact, the optimum temperature for agriculture in FUND 3.7 is an increase in every region; for 12 of 16 world regions, including South Asia, FUND's central estimate is that higher temperature levels increase productivity in agriculture until temperatures have increased by more than 2°C.[11] Although the latest (2013) article from FUND's developers refers to ongoing research on climate impacts on agriculture, the most recently published documentation for FUND cites no sources published since 1996 in describing the calibration of its agriculture estimates.[12]

In about 5 percent of runs at the 2.5- and 3.0-percent discount rates and 25 percent of runs at the 5 percent discount rates FUND finds that the SCC is negative—that is, that additional greenhouse gas emissions are beneficial to the world economy. The FUND damage function produces average SCCs that are approximately one half the value of those projected by DICE and one third those of PAGE (in 2020 at the 2.5- and 3.0-percent discount rates).

EPA's web page on the SCC contains an appropriately sober, if somewhat understated, assessment:[13]

[10] David Anthoff and Richard S. J. Tol (2013) "The uncertainty about the social cost of carbon: A decomposition analysis using FUND." *Climatic Change* 117: 515-530.

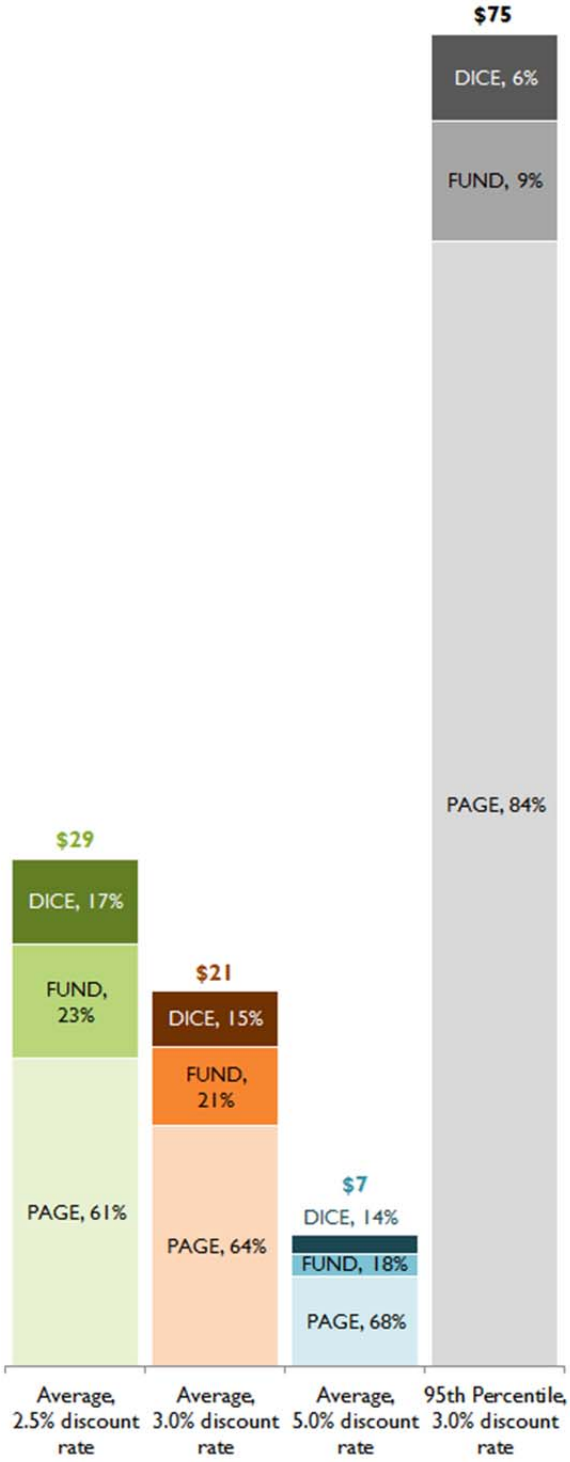
[11] Calculated from the FUND 3.7 documentation, equation A.3, and corresponding data in the FUND 3.7 data tables, both available at http://www.fund-model.org/versions, accessed January 24, 2014.

[12] The article is Anthoff and Tol (2013), cited in a previous note. The problems of outdated and implausible data in FUND's analysis of agriculture are discussed in more detail in Frank Ackerman and Charles Munitz (2012), "Climate damages in the FUND model: A disaggregated assessment," *Ecological Economics*, 77:219-224. (The risks of division by zero in FUND 3.5, discussed in that article, have been eliminated in FUND 3.7, but the data sources for agricultural inputs remain unchanged.)

[13] http://www.epa.gov/climatechange/EPAactivities/economics/scc.html, accessed January 17, 2014.

> … given current modeling and data limitations, [the SCC] does not include all important damages. As noted by the IPCC Fourth Assessment Report, it is "very likely that [SCC] underestimates" the damages. The models used to develop SCC estimates, known as integrated assessment models, do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research.

Figure 5. 2020 SCC for 2013 Technical Update (in 2007$/metric ton) with share of 3-model average by model



5. INCREASE TO THE SCC LARGELY DUE TO HIGHER VALUE OF CATASTROPHIC DAMAGES IN THE PAGE MODEL

Changes made to the PAGE model account for two-thirds of the increase from the 2010 to 2013 versions of the average 2020 SCC (61 to 68 percent depending on discount rate) and five-sixths of the increase of the 95th percentile 2020 SCC.

The PAGE dollar-value contribution to all four official SCC values more than doubled due in no small part to its revised treatment of damages from "discontinuous" or "nonlinear extreme" (that is, catastrophic) events. As the 2013 *Technical Update of the Social Cost of Carbon* explains, in the version of PAGE used for the 2010 *Technical Document* damages from catastrophic events were included as their expected value (the value of the damages multiplied by the likelihood that these damages would occur)—

the same method used in the DICE model. In the updated PAGE model, the full range of catastrophic damage costs is explored in the Monte Carlo analysis. This change together with a less optimistic view of the potential for adaptation measures to prevent climate damages and a more explicit treatment of the damages from sea-level rise result in a dramatic increase in the PAGE SCC estimates.[14]

Recent research suggests that there is a chance that one or more catastrophic "tipping points" will be exceeded, even with significant mitigation efforts, and that at least one such threshold may be passed in this century. Lenton and Ciscar (2013) critique the treatment of catastrophic damages in DICE, PAGE, and FUND, and suggest that for more realistic results IAMs should incorporate estimates of damages from multiple tipping points at the climatic thresholds indicated by the most recent scientific literature.[15]

6. USE OF SCENARIOS FROM OTHER MODELS YIELDS AN INTERNALLY INCONSISTENT MODELING APPARATUS

The Working Group applies DICE, PAGE, and FUND to five possible scenarios of the future climate taken from other climate-economics models. The choice of these scenarios is left unexplained both in the 2010 and 2013 Technical Documents. Four of the scenarios approximate "business-as-usual" futures in which greenhouse gas emissions continue to grow unabated; the fifth scenario is a "550 ppm" scenario of moderate emissions abatement.[16]

The original DICE and FUND models—prior to modifications made by the Working Group—are welfare optimization models that choose each period's level of abatement effort (and, therefore, its emissions) to maximize a measure of global income. These emission levels endogenously determine each future period's temperatures, climate damages, and GDP. In the Working Group's analysis, all three IAMs are run as "scenario models," in which emissions and damages are determined not by the mitigation actions taken but instead by an exogenously determined climate scenario.[17] Results for the five-climate scenarios are averaged across each of the three models; these average model results are shown in the figures above.

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[14] See also Chris Hope (2013) "Critical issues for the calculation of the social cost of CO_2: why the estimates from PAGE09 are higher than those from PAGE2002." *Climatic Change* 117: 531-543.

[15] Timothy M. Lenton and Juan-Carlos Ciscar (2013) "Integrating tipping points into climate impact assessments." *Climatic Change* 117: 585-597.

[16] Frank Ackerman and Elizabeth A. Stanton (2012) "Climate Risks and Carbon Prices: Revising the Social Cost of Carbon." *Economics: The Open-Access, Open-Assessment E-Journal*, Vol. 6, 2012-10. http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10

[17] Elizabeth A. Stanton, Frank Ackerman, and Sivan Kartha, "Inside the integrated assessment models: Four issues in climate economics," *Climate and Development* 1 (2009), doi:10.3763/cdev.2009.0015.

The social cost of carbon—the damages expected to occur from an additional ton of CO_2 emitted into the atmosphere in a given year—depends on the severity of future damages, and therefore on current and future emissions. Damages in near-term years will impact on the ability of the economy to produce emissions in the longer term, and emissions and damages in the near term also impact on the scale of the economy that will be available to be damaged in the longer term. The interconnections among causes and effects in different time periods are limitless.

The economic modeling tool commonly used to sort out these multiple, iterative, endogenous effects is optimization: the native form of the DICE and FUND models. The Working Group's choice to forgo optimization and instead shoe-horn exogenous emission scenarios from unrelated IAMs into its selected models requires explanation. So too does the entirely unexplained choice of four business-as-usual scenarios and a moderate mitigation scenario for this purpose. Since the results from the same model differ widely by scenario, the choice of scenarios is another important, largely unexamined determinant of the reported average SCC value.

7. CARBON PRICES SHOULD BE BASED ON COST-EFFECTIVENESS IN EMISSION REDUCTION, NOT COST-BENEFIT ANALYSIS

As emissions continue to increase, climate damages, both current and those expected in the future, will grow worse. Many of these damages defy accurate monetization, either because they are out of the range of our current experience or because some of what will be destroyed is not bought and sold in markets (human lives and livelihoods, vulnerable ecosystems, the continued existence of particular species). At their extreme, expected climate losses, while not readily translated into dollars and cents, reach a level that is simply unacceptable.

In circumstances where the risks of climate damages are well-known (even if not easily monetized) and too dire to accept, the appropriate economic tool for policy analysis is cost-effectiveness analysis, rather than the cost-benefit analysis advocated by OMB. When using cost-effectiveness analysis, a physical limit is set (in the case of climate change this would be a maximum permissible temperature increase or an inflexible cap on emissions). Given this constraint, economic analysis is used to determine which policy solutions are the most cost effective or least expensive methods to achieve the limit. Calculation of the cost-effective policy option requires a complex and important economic analysis, but it is a better formulated and more feasible analytical problem that avoids the methodological dilemmas of cost-benefit calculations.

In the event that OMB continues to require cost-benefit analysis for regulatory impact assessments, two changes to the current methodology would each, independently, result in emission reductions more consistent with the level of urgency identified by climate scientists. First, while the published SCC schedule includes average values for the 2.5-, 3.0-, and 5.0-percent discount rates and 95th-percentile

values for the 3.0-percent discount rate, in practice, the average results for the 3.0-percent discount rates are referred to as the "central value" and are given precedence in regulatory decisions. No justification for this practice is given in the 2010 and 2013 Technical Documents. A requirement that the benefits of regulation exceed its costs using the 2.5 percent discount rate or the 95th percentile results (or, indeed, both) would result in regulatory "options" with deeper emission reductions being judged economic by OMB. (For a presentation of the arguments for using a still lower discount rate in climate analysis, see the Stern Review.[18])

Second, the practice of using cost-benefit analysis to determine which regulatory options are preferable may require a price on carbon, but it does not require that price be set based on an SCC or other damage estimate. Use instead of the expected market cost of reducing emissions (the marginal abatement cost or mitigation cost) would result in prices better suited to representing the economy-wide costs of mitigation, and would not suffer from the problems of incomplete estimation that plague environmental benefits assessment in general and SCC estimates in particular. The EMF model comparison project, from which the current SCC emission scenarios are borrowed, consists primarily of climate-economics models using a bottom-up or cost-effectiveness methodology to determine a carbon price. Drawing on the latest EMF model comparison for a range of carbon prices to apply in regulatory impact analyses would have the added benefit of avoiding the issue of a mismatch between models and climate scenarios used in the SCC methodology.

The updated SCC values presented in the November 2013 *Technical Update of the Social Cost of Carbon* are higher than in the previous version—a step in the right direction. This increase in the expected cost of damages from climate change reflects the individual judgments of three climate-economics modeling teams who have found that the most recent climate science warrants a higher valuation of future climate impacts. We concur with the direction in which that assessment is moving, while differing with its methods and specific features of its calculations. The basic standards for public scrutiny cannot be met by the practice of setting the U.S. SCC on the basis of the individual judgments of three modeling groups. Instead, there should be a more open process, incorporating a broader range of expert knowledge and recent research, in which regulatory authorities carry out their responsibility to justify the technical choices that affect public policy.

[18] Nicholas Stern (2006) *The Economics of Climate Change: The Stern Review*. Cambridge University Press (Cambridge, UK). See also Frank Ackerman and Elizabeth A. Stanton (2012) "Climate Risks and Carbon Prices: Revising the Social Cost of Carbon." *Economics: The Open-Access, Open-Assessment E-Journal*, Vol. 6, 2012-10. http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10; and Frank Ackerman and Elizabeth A. Stanton (2013) *Climate Economics: The State of the Art*. Routledge (New York).