OFFICE OF MANAGEMENT AND BUDGET

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Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866	)))))	**Docket No. OMB-2013-0007-0001/OMB_FRDOC_0001-0129** *Via regulations.gov* *February 26, 2014*

Thank you for accepting these comments on the Interagency Working Group's (IWG) Technical Support Document: Social Cost of Carbon (SCC) for Regulatory Impact Analysis Under Executive Order 12866. *See* 78 Fed. Reg. 70,586 (Nov. 26, 2013); 79 Fed. Reg. 4359 (Jan. 27, 2014). We submit these comments on behalf of Sierra Club.

I. Introduction

Global climate change is the defining environmental, political, and economic challenge of our time. As decades of research have shown, the Earth's temperature has increased rapidly since pre-industrial times as a result of human activity and will continue to do so into the foreseeable future without drastic and immediate cuts to atmospheric emissions of heat-trapping greenhouse gases (GHGs). The crises that will result from a continually warming planet are manifold: hotter days and greater air pollution from smog, shrinking snowpack and Arctic ice, decreased water supplies in certain areas, increased flooding in other areas, rising ocean levels that threaten coastal populations, homes, and infrastructure, the spread of air- and water-borne pathogens, toxins, and diseases, habitat loss and increasing rates of extinction among vulnerable species, an increasing number of extreme weather events, threats to livestock and crop productivity, and intensified human conflicts due to dwindling critical resources.[1]

In terms of its overall contribution to global climate change, the most significant GHG by far is carbon dioxide (CO_2), which is released into the atmosphere primarily through fossil fuel combustion for electricity generation, transportation, commercial activity, and residential purposes, but also through oil and gas production, industrial activities, and agriculture.[2] Globally, CO_2 represents over three-quarters of all GHG emissions[3] and approximately 84% of U.S. GHG emissions.[4] After China, the United

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[1] *See generally* Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2007: Synthesis Report* (2007), attached as **Ex. 1**.

[2] *See* Environmental Protection Agency (EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011* (2013) attached as **Ex. 2**, at Table 2-1,

[3] IPCC, **Ex. 1**, *supra*, at 36.

States emits more CO_2 annually than any other nation, contributing approximately 15% of the world's total carbon pollution.[5] Unless U.S. CO_2 emissions are cut drastically and immediately, we will be unable to mitigate the serious harms posed by climate change. Indeed, in 2009, EPA determined after careful review that GHG pollution (and, hence, CO_2 emissions) can be reasonably anticipated to endanger public health and welfare, a finding the D.C. Circuit upheld against legal challenge by state and industry petitioners. *See* 74 Fed. Reg. 66,496 (Dec. 15, 2009); *Coalition for Responsible Regulation, Inc. v. EPA*, 684 F.3d 102, 122—28 (D.C. Cir. 2012).

Accordingly, federal regulation of CO_2 emissions is both legally justified and environmentally urgent. Because cost-benefit analysis has, for several decades, been a significant factor in federal regulatory policy and rulemaking procedures, *see* Exec. Order 12,866 (Sept. 30, 1993), it is crucial that policymakers develop a standardized estimate of the costs that carbon emissions impose on society. Without such an estimate, any cost-benefit analysis of carbon emission regulations would assume that that such emissions impose *no* cost on society, and that *no* benefits would therefore accrue from emissions reductions. In fact, the opposite is true: carbon emissions are the prime driver of climate change, which will have devastating impacts on human society in the absence of serious abatement measures. By that same token, emission reductions will yield significant benefits by helping to stabilize the Earth's temperature and curb the harmful effects climate change. Similarly, carbon emission abatement will help minimize the distinct but interrelated phenomenon of ocean acidification, which threatens to disrupt aquatic ecosystems and intensify global warming impacts.[6]

Simply put, calculating a social cost of carbon (SCC) is a necessary step toward developing regulations that cut CO_2 pollution and mitigate the many threats posed by climate change. Thus, Sierra Club strongly supports the IWG in its effort to formulate a workable SCC. In arriving at the current SCC values, the IWG relied upon rigorous, well-tested modeling systems that reflect the cutting edge of environmental economic theory. Given the complexity of the task at hand, the inherent challenges of monetizing the effects from a global environmental phenomenon such as climate change, and the uncertainty inherent in characterizing events and trends that will occur decades and centuries into the future, the IWG has utilized the best modeling tools currently available, and its efforts pass legal muster from a standpoint of federal regulatory law and policy.

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[4] EPA, *Overview of Greenhouse Gases*, available at http://www.epa.gov/climatechange/ghgemissions/gases.html.

[5] See European Commission, Emission Database of Global Atmospheric Research (EDGAR), *CO2 time series 1990-2012 per region/country*, available at http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2012&sort=des9.

[6] *See* National Research Council, *Advancing the Science of Climate Change* (2010), attached as **Ex. 3**, at 55-57.

At the same time, there are various ways in which the IWG can and should improve upon its current SCC estimates so as to better represent the true costs that CO_2 emissions impose on global society. In this regard, we focus on two key topics: the damage function utilized in the modeling programs, and the discount rate the IWG used to calculate the value of future benefits of carbon regulations in terms of today's money. In our estimation, the IWG's current approach to these two matters produces an SCC that rather dramatically underestimates the true cost of carbon, By reevaluating and reformulating the damage function and the discount rates, the IWG will generate a much more accurate SCC for federal regulators to use in their policymaking.

II. Non-Monetizable Costs of Carbon Emissions

At the outset, it is important to note that many of the impacts of climate change are, by their very nature, difficult or impossible to monetize in a meaningful way. For instance, the IPCC cites research indicating that, by the mid 21st century, between 15 and 37% of plant and animal species worldwide may be committed to extinction if temperatures increase 1.6 to 1.8° C above late 20th century levels.[7] While this scenario would surely have dire economic consequences (by drastically disrupting the world's food supply, for example), the non-monetary (and non-monetizable) consequences of a mass extinction of this nature would be truly immense. A quantitative estimate of the social cost of carbon—even one that accounts for biodiversity loss—cannot capture the full extent of these non-monetizable impacts. Similarly, the permanent loss of coastal and island communities due to rising ocean levels would have social, cultural, and ethical ramifications that resonate far beyond a quantifiable dollar figure, as would many other consequences of climate change.

Accordingly, we emphasize that, while it is critical that federal policymakers develop a quantitative estimate of the social cost of carbon, future regulatory decisions must address these non-monetizable costs of CO_2 emissions in addition to those that are more readily quantifiable. Regulations that do not account for the monetary and non-monetary costs alike will not adequately prevent against the many devastating impacts of climate change. Bearing this in mind, we now turn to the SCC itself.

III. The IWG's SCC Estimates Reflect Rigorous, Peer-Reviewed Science and Economics

a. The IWG Utilized the Most Advanced Modeling Platforms Available

To formulate its current estimates for the social cost of carbon (which, for the year 2020, are $12, $43, $64, and $128 per metric ton of CO_2 , depending on the

[7] IPCC, *Climate Change 2007: Impacts, Adaptation, and Vulnerability* (2007) at 243, available at http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter4.pdf.

discount rate used),[8] IWG utilized three cutting-edge integrated assessment models (IAMs): Dynamic Integrated Climate and Economy (DICE), developed by William Nordhaus of Yale University; Policy Analysis of the Greenhouse Effect (PAGE), developed by Chris Hope of the University of Cambridge; and Climate Framework for Uncertainty, Negotiation, and Distribution (FUND), developed by Richard Tol of the University of Sussex.[9] While the three IAMS vary somewhat in terms of approach, each one "combine[s] climate processes, economic growth, and feedbacks between the climate and global economy into a single modeling framework."[10] Specifically, each IAM models three distinct steps: first, translating CO_2 emissions into atmospheric GHG concentrations; second, equating atmospheric GHG concentrations with global temperature changes; and third, computing economic damages based on increased global temperatures.[11] Critically, the IAMs account for feedback effects from climate change, rendering dynamic predictions of global growth rates and economic activity based on emissions and temperature scenarios and vice versa.[12]

Climate change and its economic consequences are enormously complicated global phenomena. Hence, any researcher seeking to model these processes must grapple with a large degree of uncertainty, and cannot avoid simplifying some of their complexities in order to develop a useful modeling framework. However, DICE, PAGE, and FUND incorporate decades of peer-reviewed scientific research, and have been—and are continually being—updated to account for the latest advances in the field and the input from experts in the environmental and economic communities. The 2013 updates to the SCC estimates relied upon the most recent versions of each IAM, which appeared in 2009 (PAGE), 2010 (DICE), and 2012 (FUND).[13] Among other technical updates, each model now accounts (for the first time) for damages that will result from rising sea levels, which is the primary reason for the updated SCC values' increase over the the 2010 estimates.[14] Cumulatively, these models represent the best tools currently available for determining an appropriate social cost of carbon.

b. The IWG Correctly Selected and Calibrated the Roe-Baker Distribution for Equilibrium Climate Sensitivity

The IWG also relied upon appropriate input parameters when utilizing the IAMs. One of the critical input parameters for determining damages from climate change is

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[8] IWG, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (2013), **attached as Ex. 4**, at 3.
[9] IWG, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (2010), **attached as Ex. 5**, at 5 n.2.
[10] *Id.* at 5.
[11] *Id.*
[12] *Id.*
[13] IWG, **Ex. 4**, *supra*, at 5, Table 1.
[14] *Id.*

the equilibrium climate sensitivity (ECS) value. This figure represents the long-term global temperature increase that will result from a doubling of atmospheric carbon concentrations relative to pre-industrial levels.[15] To account for the uncertainties in this parameter, climate modelers utilize a sensitivity distribution, a mathematical formula that maps out range of probabilistic ECS values. Out of four possible sensitivity distribution options (Roe-Baker, log-normal, gamma, and Weibull), the IWG properly selected the same one used by the IPCC in its Fourth Assessment Report (AR4): the Roe-Baker distribution.

As the IWG noted in its 2010 technical support document for the SCC, Roe-Baker has two primary advantages over the other distribution functions. First, it is the only distribution that is "based on a theoretical understanding of the response of the climate system to increased greenhouse gas concentrations. . . . In contrast, the other three distributions are mathematical functions that are arbitrarily chosen based on simplicity, convenience, and general shape."[16] Second, compared the other distributions, Roe-Baker better incorporates the IPCC's judgment that scenarios cannot be excluded in which the global temperature increases by more than 4.5° C over the next century.[17] In other words, it is a "fat-tailed" distribution that ably accounts for the possibility of low-probability, high-impact events.

Following the IPCC's recommendations, the IWG calibrated the Roe-Baker distribution in three ways. First, it set the median ECS value equal to 3°C "to reflect the judgment of 'a most likely value of about 3 °C.'"[18] Second, the distribution provides for a two-thirds probability that the ECS lies between 2 and 4.5 °C.[19] Finally, the model's lower and upper bounds are 0°C and 10°C; in other words, it presumes a 100% probability that the ECS will fall between those two values.[20] The IWG's calibrations, in addition to its selection of the Roe-Baker distribution, reflect the authoritative judgment of the IPCC. Hence, with regard to the critical ECS input parameter, the IWG's SCC values track the best science and economic theory currently available.

c. The IWG Adopted Rigorous Emissions Modeling Scenarios

Another critical input for calculating an accurate SCC is the socio-economic/emissions parameter. This variable describes the predicted path of global carbon emissions over the next century, primarily as a function of economic growth rates and population levels. As the IWG aptly notes, "[s]ocio-economic pathways are closely tied to climate damages because, all else equal, more and wealthier people tend

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[15] IWG, **Ex. 5**, *supra*, at 12.
[16] *Id.* at 13-14.
[17] *Id.* at 14.
[18] *Id.* at 13.
[19] *Id.*
[20] *Id.*

to emit more greenhouse gases and also have a higher (absolute) willingness to pay to avoid climate disruptions."[21] This parameter thus predicts how global CO_2 emissions can be expected to progress over the next century.

Out of a host of options for this parameter, the IWG selected Stanford Energy Modeling Forum's EMF-22 exercise. The EMF-22 scenarios use "ten well-recognized models to evaluate substantial, coordinated global action to meet specific stabilization targets . . . [in which] GDP, population, and emission trajectories are internally consistent for each model and scenario evaluated."[22] As the IWG notes, EMF-22 is "recent, peer-reviewed, published, and publicly available."[23] The EMF-22 scenarios have been commented on and assessed by climate economists across a range of national and international sectors.[24]

In choosing to use EMF-22, the IWG declined to adopt the IPCC's four SRES scenarios from AR4, citing concerns of age (the SCRES scenarios date back to 1997, EMF-22 to 2009) and what it considers to be outdated assumptions in SRES. In general, the Sierra Club urges federal policymakers to adopt to the scientific and economic assumptions used in the IPCC's reports, which represent the most authoritative and rigorous assessments of climate change now available. Although the IWG's concerns about the age of SRES are understandable, the updated SCC values were completed before the IPCC issued its first draft scientific report for the Fifth Assessment Report (AR5) September 2013. The draft AR5 report utilizes a new set of scenarios known as the Representative Concentration Pathways (RCPs) that "largely replace the SRES scenarios" and incorporate the newest modeling, research, and policy developments.[25] While the IWG's use of EMF-22 represents a carefully considered and scientifically defensible decision, the Sierra Club urges the IWG to study in detail AR5's RCP scenarios and incorporate them into future updates to the SCC.

For the reasons discussed above, the IWG's SCC updated SCC values reflect rigorous scientific and economic modeling and analysis, and thereby rest on sound legal footing. *See Coalition for Responsible Regulation,* 684 F.3d at 119-123 (upholding federal climate change policies that based on rigorous, peer-reviewed science). We now discuss

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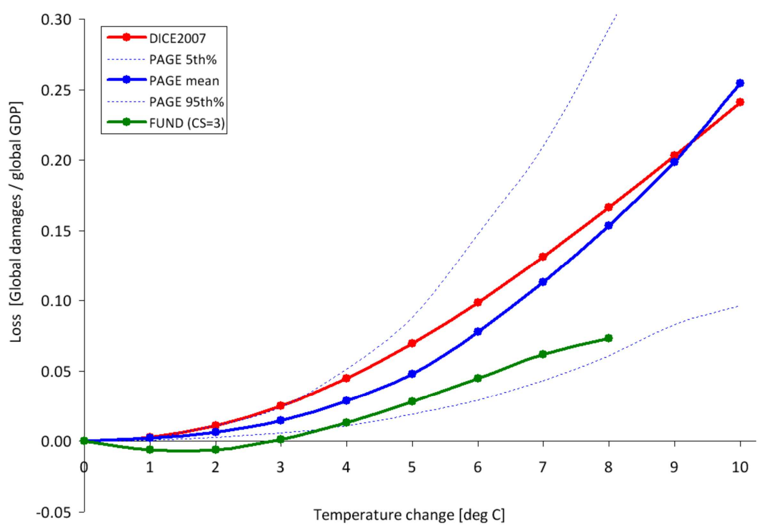
[21] *Id.* at 15.
[22] *Id.*
[23] *Id.*
[24] *See, e.g.*, Clarke, et al., *International climate policy architectures: Overview of the EMF 22 International Scenarios*, 31 Energy Economics S64 (2009), **attached as Ex. 6**; Fawcett, et al., *Overview of EMF 22 U.S. transition scenarios*, 31 Energy Economics S198 (2009), **attached as Ex. 7.**
[25] IPCC, *Working Group I Contribution to the IPCC Fifth Assessment Report—Climate Change 2013: The Physical Science Basis—Final Draft Underlying Scientific-Technical Assessment* (2013), **attached as Ex. 8**, at T43-T44.

a number of ways in which the IWG's SCC estimates could be improved to more accurately model the true impacts that carbon emissions and climate change will have on society.

IV. Suggestions for an Improved SCC

a. The IWG Should Utilize A Modified Damage Function Based On Weitzmann's Critique of DICE

One of the most important steps in calculating an SCC is modeling the relationship between global temperature increases and the resulting economic consequences. All three IAMs discussed above utilize a damage function—a mathematical formula that calculates the loss of worldwide gross domestic product (GDP) as a function of increased global surface temperature. Each model's damage function considers the effects that an increased surface temperature will have on the world economy via its impact on both market and non-market sectors, including agriculture, energy, human health, coastal regions, recreation, and ecosystems.[26] The graph below depicts the three models' damage functions, showing the percent of GDP loss in relation to increased global temperatures.[27]



The current SCC relies on unmodified application of the three IAMs' damage functions, although the IWG affirms "the need for a thorough review of damage functions . . . As knowledge improves, the Federal government is committed to exploring how these (and other) models can be modified to incorporate more accurate estimates of damages."[28] In fact, modifications are appropriate even under the current

[26] See IWG, **Ex. 5**, *supra*, at 6, 8-10.
[27] Id. at 9, Fig. 1A.
[28] *Id.* at 9.

circumstances, since all three damage functions underestimate the economic damage that will result from an increased global surface temperature. Even considering just the DICE model's damage function (which, as the graph above shows, generally predicts the greatest economic loss from surface temperature increases), it is clear that a modified damage function would more accurately depict the economic damage that will result from a changing climate.

Like the other two IAMs, DICE uses a quadratic formula for its damage function. That is, it predicts that economic damages will be proportionate to the square of the temperature increases, regardless of how high those increases actually are. However, as several scholarly papers have discussed, this assumption lacks an evidentiary basis, and ignores the fact that economic damages are likely to intensify at a much faster rate once the global surface temperature increases past a certain threshold (approximately 3° C above pre-industrial levels).[29]

Furthermore, as an absolute matter, DICE's damage function drastically underestimates the severity of damage that will occur due to higher order temperature increases. As the graph above illustrates, DICE's damage curve is so gradual that it assumes global GDP losses will not reach the 50% mark until an increase of 18.8° C, despite the fact that life on earth will likely be unsustainable at far lower temperature increases.[30] Noted Harvard economist Professor Martin Weitzmann has observed that a global temperature increase of 12° above pre-industrial levels "has a good chance of going far beyond an absolute heat-stress limit that could extinguish many mammals on Earth and impair very seriously human functioning."[31] Weitzmann persuasively asserts that GDP losses of 50% are most likely to occur at temperature increases of around 6° C, painting a much more ominous picture of climate change and its economic impacts.[32]

To address these concerns, Weitzmann has recommended an alternative damage function that modifies DICE's approach in two regards. First, Weitzmann's formula adds a higher-power component to DICE's quadratic model such that lower increases in temperature (i.e., those below approximately 3° C) follow an essentially

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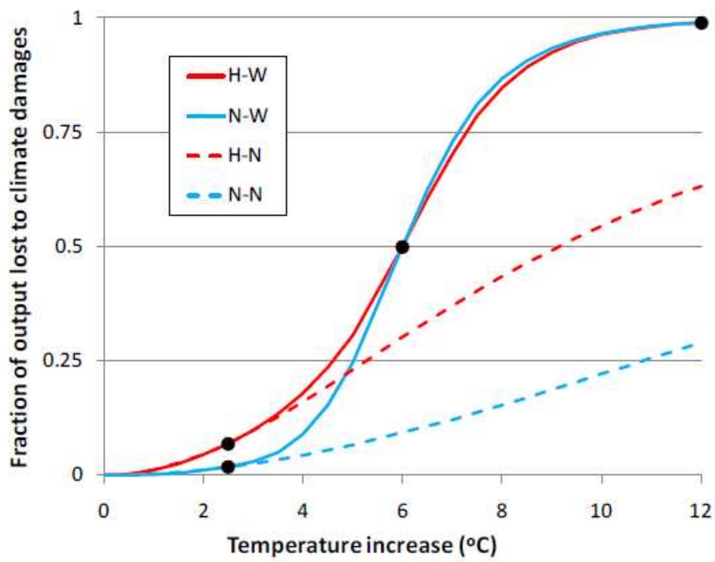
[29] *See* Kopp, et al., *The Influence of the Specification of Climate Change Damages on the Social Cost of Carbon*, Economics Discussion Papers, No. 2011-22 (2011), **attached as Ex. 9**; Weitzmann, M.L., *GHG Targets as Insurance Against Catastrophic Climate Damages*, National Bureau of Economic Research Working Paper No. 16136 (2010), **attached as Ex. 10**, at 12-16; Ackerman, F. and Stanton, E.A., *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon*, Economics Discussion Papers, No. 2011-40 (2011), **attached as Ex. 11**, at 6-9.
[30] *See* Weitzmann, **Ex. 10**, *supra*, at 12-16; Ackerman, **Ex. 11**, *supra*, at 7;
[31] Weitzmann, **Ex. 10**, *supra*, at 13 (citing Sherwood, S.C. and Huber, M., *An adaptability limit to climate change due to heat stress*, Proceedings of the National Academy of Sciences (2010)).
[32] *Id.*

quadratic pattern similar to the DICE formula, while higher temperature increases correspond to increasingly severe levels of economic damage.[33] Second, Weitzmann recalibrates the formula such that a 6° C temperature increase corresponds to a GDP loss of 50%, and a 12° C increase entails a GDP loss of 99%.[34] Climate economist Frank Ackerman has provided a graph comparing the original DICE function (dotted blue) with Weitzmann's modified alternative (solid blue).[35]

Figure 3: Damages as a share of GDP in four damage functions



As the graph indicates, Weitzmann's formula—which corrects two key shortcomings of the DICE function while otherwise retaining its stronger elements—suggests that the IWG's current SCC estimates may significantly understate the economic damage that climate change will inflict when global temperatures increase above a threshold of 3° C. The Sierra Club strongly urges the IWG to adopt Weitzmann's modification not only for the DICE damage function, but for the PAGE and FUND damage functions as well. Otherwise, the SCC will reflect an overly optimistic view of just how devastating climate change will be on the global economy if and when surface temperature increases surpass 3° C above pre-industrial levels.

a. The IWG Should Modify the Selected Discount Rates

When considering the cost-benefit analysis supporting a significant regulatory decision or policy, it is difficult to overstate the importance of the policymaker's selected discount rate. Many regulations—especially those aimed at reducing environmental damage—entail immediate costs to society in exchange for benefits that

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[33] *Id.* at 15-16.
[34] *Id.* at 15-16.
[35] Ackerman, **Ex. 11**, *supra*, at 9, Fig. 3.

will not accrue until some future date. However, all else being equal, money today is worth more than money in the future due to interest and economic growth.[36] Thus, to provide an apples-to-apples comparison of the regulatory costs and benefits, analysts discount those future benefits at a rate that reflects the declining time value of money. As the IWG rightly observes, "[t]he choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law."[37]

Indeed, when regulations address phenomena (such as climate change) that occur not over years or even decades, but over centuries, the discount rate assumes heightened significance. For instance, at a discount rate of 3%, benefits worth $100 that accrue one century from now would be worth $5.20 in today's money; those that accrue two centuries from now would be worth just twenty-seven cents today. Apparently small adjustments to the discount rate make a large difference on an extended time frame. Hence, at a discount rate of 2%, these figures increase to approximately $13.80 and $1.91, respectively. Not surprisingly, these magnified affects have generated much controversy over the appropriate discount rate for the social cost of carbon.[38]

The IWG has selected four discount rates to represent a range of possible values: 2.5%, 3%, 5%, and 3% at the 95th percentile. As we discuss below, these rates artificially diminish the SCC for at least three reasons. First, they do not accord a sufficient measure of equity between current and future generations. Second, the rates presume a constant measure of positive economic growth, even though the IAMs predict significant (and in some cases enormous) GDP losses due to climate change. Finally, the IWG's selected rates do not accurately reflect the level of risk aversion that policymakers are likely to exhibit in the face of increasing harm from climate change. By addressing these three concerns, the IWG can greatly improve their current SCC estimates.

i. The Discount Rates Must Provide Intergenerational Equity

The first challenge in selecting a proper discount rate is deciding the proper theoretical approach. Citing OMB's Circular A-4,[39] the IWG correctly notes that regulatory decisions that primarily affect private consumption should use a discount

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[36] Johnson, L.T. and Hope, C., *The social cost of carbon in U.S. regulatory impact analyses: an introduction and critique*, 3:2 Journal of Environmental Studies and Sciences 205, 209 (2012), **attached as Ex. 12.**

[37] IWG, **Ex. 5**, *supra*, at 17.

[38] *See generally* Arrow, K.J. et al., *How Should Benefits and Costs Be Discounted in an Intergenerational Context?*, Resources for the Future Discussion Paper 12-53 (2010), **attached as Ex. 13.**

[39] OMB, Circular A-4: *Regulatory Impact Analysis: A Primer* (2003), **attached as Ex. 14**, at 11-12.

rate that parallels consumption rates of interest, rather than return on capital investments.[40] In other words, when a regulation will primarily reduce private consumption by (for instance) increasing the price of goods and services, the discount rate should reflect the extent to which each marginal unit of future consumption is less valuable to society than a unit of present-day consumption would be.[41] By contrast, if the regulation will primarily reduce private capital allocation by (for instance) depressing real estate prices and corporate capital, the discount rate should match the average market return on investment.[42] Theoretically, these values should be identical, but market imperfections, taxation, and other distortions "drive a wedge" between them.[43]

OMB instructs that, in general, agencies should use a 7% discount rate for regulations that primarily affect capital allocation and 3% for those that affect private consumption.[44] The IWG adhered largely to this recommendation in setting its four discount rates, selecting 3% as its "central rate."[45] The other three interest rates—2.5%, 5%, and 3% at the 95th percentile—were selected to account for varying climate and economic environments that may arise in the future.[46] Yet by choosing 3% as the "central rate," the IWG effectively ignored that OMB's recommendations were developed with *intra*generational timeframe in mind, not an *inter*generational one. In Circular A-4, OMB is clear on this point:

> Special considerations arise when comparing benefits and costs across generations. Although most people demonstrate time preference in their own consumption behavior, it may not be appropriate for society to demonstrate a similar preference when deciding between the wellbeing of current and future generations. Future citizens who are affected by such choices cannot take part in making them, and today's society must act with due consideration of their interests. Many people have argued for a principle of intergenerational neutrality, which would mean that those in the present generation would not treat those in later generations as worthy of less concern. Discounting the welfare of future generations at 7 percent or even 3 percent could create serious ethical problems.[47]

To better understand the problem of intergenerational equity, it is helpful to consider in more detail the mathematical underpinnings of a consumption discount

[40] IWG, **Ex. 5**, *supra*, at 17-19.
[41] OMB, **Ex. 14**, supra, at 11.
[42] *Id.*
[43] IWG, **Ex. 5**, *supra*, at 17.
[44] OMB, **Ex. 14**, supra, at 11.
[45] IWG, **Ex. 5**, *supra*, at 23.
[46] *Id.*
[47] OMB, **Ex. 14**, *supra*, at 11-12.

rate. In the 1928, British mathematician and economist Frank Ramsey developed an influential formula to model consumption discount rates:

$$r = \rho + \eta \cdot g$$

Here, r is the discount rate, ρ the pure rate of time preference η the elasticity of marginal utility, and g the per capita rate of growth in consumption.[48] In essence, ρ represents the simple fact that, as a matter of human psychology, people generally prefer to consume goods and services sooner rather than later.[49] By contrast, η·g represents the extent to which a unit of future consumption has more or less marginal value than a unit of present consumption.[50] If the figure g is positive—meaning the economy grows—then each unit of consumption in the future will have less marginal value than it does today, since consumers in the future will be wealthier overall. On the other hand, if the economy shrinks, each unit of consumption will be more valuable to future consumers, since they will be less wealthy than consumers are now.

Considering, for a moment, just the pure rate of time preference, many commenters have argued persuasively that ρ should be set to zero, or near zero, since there is no defensible basis on policy, law, or ethics to give any inherent preference to current generations of consumers over future generations. As climate economists Laurie Johnson and Chris Hope have argued,

> ρ represents an individual's preference for when *he* or *she* consumes wealth and income, not when others do; the person emitting greenhouse gases today is not the same person experiencing climate damages in the future. Ramsey himself argued that it is "ethically indefensible" to apply a positive rate of pure time preference across different generations. To our knowledge, the only potentially ethical justification put forth for doing so is the unlikely possibility that the human race becomes extinct in the future (for a reason unrelated to climate change).[51]

British economist Nicholas Stern (Lord Baron Stern of Brentford) raised a similar point in his report on climate change to the British Government: "[W]e treat the welfare of future generations on a par with our own. It is, of course, possible that people actually do place less value on the welfare of future generations, simply on the grounds that they are more distant in time. But it is hard to see any ethical justification for this."[52] Accordingly, Lord Stern recommended a pure rate of time preference equal to 0.1%,

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[48] *See* Johnson, **Ex. 12**, *supra*, at 210.
[49] *Id.*
[50] *Id.*
[51] *Id.*
[52] Stern, N., *Stern Review: The Economics of Climate Change*, report prepared for HM Treasury, United Kingdom (2006), **excerpts attached as Ex. 15**, at 31.

which has a small positive value only to account for the chance that human life ceases to exist at some point in the next several centuries.[53]

Although the IWG discussed Lord Stern's approach and the problem of intergenerational equity in its 2010 Technical Support Document,[54] it ultimately dodged the issue by adhering to a "descriptive" approach instead of a "prescriptive one."[55] According to the IWG, the descriptive approach tracks how people "actually behave," rather than "should behave," and is therefore ethically neutral.[56] Yet there is no way to arrive at a discount rate but avoid the necessarily ethical issue of the pure rate time preference. The discount rates that the IWG selected do not strictly follow the Ramsey formula, but they do correspond to Ramsey-generated values that include a pure rate of time preference significantly higher than 0 or .01%. As such, the IWG tacitly staked out a preference for today's generations over future generations, but offered no ethical rationale for doing so.

In short, we encourage the IWG to modify its SCC values to provide for true intergenerational equity and fairness. Doing so will require discount rates that correspond to a pure rate of time preference of either 0 or close to 0. Any other approach will unjustly shortchange future generations.

ii. The Discount Rates Must Account for GDP Loss Due To Climate Change

As discussed above, the Ramsey equation includes a term that describes the change in marginal utility of consumption over a prescribed period of time: $\eta \cdot g$, where η is the elasticity of marginal utility and g is the rate of economic growth. Assuming (as we do) that the pure rate of time preference should be at or near zero, a consumption-based discount rate under the Ramsey framework should be entirely determined by the $\eta \cdot g$ term. When economic growth is net positive, the discount rate should also be positive; when growth is negative, the discount rate should be negative.

Generally speaking, regulatory discount rates that use the Ramsey formula assume a constant and positive rate of economic growth over the applicable time period. The IWG notes that "[a] commonly accepted approximation [for g] is around 2 percent per year. For the socio-economic scenarios used for this exercise, the EMF models assume that g is about 1.5-2 percent to 2100."[57] However, this assumption of constant positive economic growth belies the fact that climate change itself will have significant—and possibly catastrophic—impacts on the national and world economies.

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[53] *Id.*, *Postscript*, at 11.
[54] *See* IWG, **Ex. 5**, *supra*, at 20-22.
[55] *See id.* at 18-23.
[56] See *id.*
[57] *Id.* at 21.

As the two graphs provided above demonstrate, nearly all scenarios for future climate change correspond to worldwide GDP losses, which (according to Weitzmann's modification of the DICE damage function) surpass 10% at about 4° C and increase rapidly immediately thereafter.[58] While the United States may have a greater capacity to adapt to climate change than most countries, the assumption of constant positive growth simply ignores the very problem the SCC is meant to target: damage to the global economy due to climate change.

Once again, although the IWG's selected discount rates are not the strict product of a Ramsey formulation, they nonetheless rely on the assumption that the global economy will continue to grow at a steady rate over coming centuries. The IWG should remedy this problem by adopting discount rates that respond dynamically to the exact economic conditions that the IAMs predict across the range of model runs. At the very least, the discount rates should reflect the fact that, without serious mitigation of carbon emissions, climate change will significantly (or even severely) depress global rates of GDP growth. We cannot assume constant positive economic growth over the coming decades, let alone the next two centuries, and the IWG must respond to this reality as it continues to develop and update the SCC.

i. The Discount Rates Must Include a Proper Risk Premium and Account for Risk Abatement

Our third and final recommendation for improving the SCC concerns the way in which the discount rates reflect uncertainty and risk aversion. This topic is treated more fully by Dartmouth economist Professor Richard Howarth, who is submitting comments to OMB in a separate report; these comments are available in OMB's docket for the Social Cost of Carbon (Docket No. OMB-2013-0007-0001) at www.regulations.gov. Thus, we need only touch on this issue briefly. In short, the IWG's chosen discount rates do not properly represent the level of risk aversion that decisionmakers generally adopt in response to conditions of heightened uncertainty. Specifically, these rates do not incorporate any kind of risk premium, which is an additional price that society is willing to pay in order to avoid some negative eventuality. Furthermore, the discount rates (and hence the SCC itself) do not respond dynamically to the degree of climate change abatement that policymakers have adopted at any particular moment in time, which should significantly impact the level of risk aversion that factors into the discount rate at that time.

In an academic paper that touch on these points, Professor Howarth and colleagues propose a formula that incorporates into the IWG's discount rates a risk premium that varies depending on the given level of risk abatement (i.e., the stringency

[58] Ackerman, **Ex. 11**, *supra*, at 9, Fig. 3.

of emissions limitations).[59] As Professor Howarth discusses, when risk abatement is zero, and carbon emissions proceed on a "business as usual" path, the risk premium that society is willing to pay skyrockets, resulting in a negative discount rate and a social cost of carbon that reaches into the thousands of dollars per metric ton.[60] However, when deep and prolonged cuts are made to carbon emissions, the risk premium drops, and the SCC stabilizes at a level approximating OMB's estimates.[61]

We urge the IWG to incorporate Professor Howarth's research and recommendations into its efforts to develop an appropriate SCC. Any future discount rates should, in some significant manner, incorporate a risk premium and account for risk abatement measures. Likewise, we reiterate our earlier suggestions that the IWG account for GDP loss and intergenerational equity in its discount rates and adopt Weitzmann's modified damage function. By making these changes, the IWG can ensure that the SCC values it has carefully developed rest on a more solid footing from a standpoint of science, economics, and social ethics.

Respectfully submitted,

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[59] Howarth, R.B., et al., *Risk mitigation and the social cost of carbon*, Global Environmental Change (in press) (2013), **attached as Ex. 16**, at 4-7.
[60] *Id.* at 7.
[61] *Id.* at 7-8.