Applied Economics Clinic
Economic and Policy Analysis of Energy, Environment and Equity

MEMO

To: Friends of Earth U.S.
From: Elizabeth A. Stanton, PhD; Chirag Lala, and Tanya Stasio
Date: June 21, 2021
Re: Comments on 2021 Guidance Towards Updating the U.S. Social Cost of Greenhouse Gases

Overview

The U.S. Interagency Working Group (IWG) was established in 2009 to produce harmonized social cost of carbon (SCC) estimates to be used by all federal agencies. SCC represents the cost to society at large of one additional ton of greenhouse gas emissions and is included in cost-benefit analyses to assess proposed federal policies that increase or decrease emissions. In assessing regulations, an SCC that undercounts future climate damages results in weaker emissions reduction policies being given preference over more stringent ones.

The IWG first published their SCC estimates in 2010 and updated them in 2013. Social costs of methane and nitrous oxide were introduced in 2016 (and SCC is now referred to as SC-GHG). In 2017, the Trump Administration disbanded the IWG, forbade assessment of global impacts from U.S. emissions by federal agencies, and reduced the central SC-GHG values percent to about one-fifth of their previous values. The Biden Administration re-established the IWG in a January 20, 2021 executive order and is now requesting expert and technical advice on updating the SC-GHG estimates to account for climate risk, environmental justice, and intergenerational equity. These comments were prepared by the Applied Economics Clinic (AEC) on behalf of Friends of the Earth U.S. (FOE), which advocates for the United States to do its fair share of the global effort to limit global temperature rise to 1.5°C. This requires the United States to reduce the equivalent of 195 percent emissions from 2005 levels by 2030 (i.e., 14 gigatonnes of greenhouse gas emissions annually by 2030)—which can be achieved by cutting domestic emissions 70 percent (5 gigatonnes) and providing international funding to enable the equivalent of an additional 125 percent reduction in developing countries (9 gigatonnes).[1]

In summary, AEC and FOE recommend that the current revision to the U.S. SC-GHG:

- **Estimate climate damages in a single model:** Use one complex model, vetted in a public process, and including green investment as a boon to economic growth.
- **Include climate damages around the world:** Include worldwide climate damages in SC-GHG valuation.
- **Value far future climate impacts:** Use a discount rate of 1 percent (or lower) that shrinks over time to represent present generations' ethical obligation to future generations.

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[1] Reyes, Oscar, Karen Orenstein, Tom Athanasiou, Tara Daniel, Christian Holz, Sivan Kartha, Erika Lennon, Victor Menotti, Doreen Stabinsky, Kelly Stone, Brandon Wu. April 2021. *United States of America: Fair Shares Nationally Determined Contribution*. Report published by Friends of the Earth. Available at: https://foe.org/wp-content/uploads/2021/04/USA_Fair_Shares_NDC.pdf.

- **Place equal value on all people, all families, and all communities:** AEC and FOE recommend strongly against modeling practices that weigh a lost human life or other climate damages in proportion to local income or economic output.
- **Set fair and effective emission reduction targets:** Begin SC-GHG modeling with national levels of emissions reductions determined by scientific analysis, historical responsibility, and capacity to act to be consistent with a high likelihood of limiting global temperature rise to 1.5° Celsius.
- **Have a clear process for updating the SC-GHGs over time:** SC-GHG estimates should be updated every five years in a three-step process with a review of the underlying data, a comment period, and a review of the SC-GHG methodology, with inclusion of vulnerable communities in the comment process.

History of the Federal SC-GHG Process

President Clinton's 1993 Executive Order (E.O. 12866) requires federal agencies to compare costs and benefits in proposed and adopted regulations to confirm that the benefits of the intended policy justify its costs. In 2008, the U.S. Ninth Circuit Court of Appeals remanded a fuel economy rule because CO_2 emission reductions were not monetized in its regulatory assessment. Under the Obama Administration in 2009, an Interagency Working Group (IWG) was established to establish a consistent set of SCC values to be used across all federal agencies.

In 2010, the IWG published SCC estimates developed by averaging together adapted versions of three established integrated assessment models (IAMs): DICE, PAGE, and FUND. Each IAM estimates economic damages from global climate change using a set of assumptions relating to population and economic growth, increases in greenhouse gas emissions, and changes in temperature, precipitation, and sea level rise. The IWG estimates were updated in 2013 following the release of new IAM versions. In 2016, the IWG published estimates of the social costs of methane and nitrous oxide using methodologies consistent with the social cost of carbon dioxide.

In January 2017, the National Academies of Sciences, Engineering, and Medicine (NASEM) published a report with recommendations aimed at ensuring that SC-GHG estimates reflect the best available science. However, in March 2017, the Trump Administration disbanded the IWG through E.O. 13783 and agencies were instructed to monetize changes in greenhouse gas emissions based on the Office of Management and Budget's (OMB) 2003 Circular A-4. As a result of E.O. 13783, SC-GHG estimates could only include domestic impacts of climate change (and not global impacts) and were required to use 3 and 7 percent discount rates per OMB's Circular A-4.

The IWG was re-established by President Biden on January 20, 2021 through the issuance of E.O. 13990, which requires that SC-GHG estimates used by the federal government reflect 2017 recommendations from the National Academies on using the best available science and accounting for climate risk, environmental justice, and intergenerational equity. E.O. 13990 also reversed policies enacted during the Trump Administration by requiring accounting for global damages in SC-GHG estimates, and reverting to discount rates of 2.5, 3, and 5 percent. The IWG is required to publish a final update of SC-GHG values by January

2022 and provide recommendations on an on-going review process for updating these estimates to ensure that the best available economics and science are used by June 2022.

AEC's and FOE's Recommendations

1. **Estimating climate damages**

Summary: IWG's SC-GHG values average together the results of three separate models that each integrate climate damages, climate investment, and the economy. AEC and FOE recommend that: the IWG rely on one, more complex model to estimate the SC-GHGs; the model's assumptions be vetted in a public process; and the model include treatment of spending on emissions reductions as a boon to economic growth and employment (and not a sacrifice that harms consumer spending).

TSD Guidance

The TSD bases its SC-GHG estimates on the results of three integrated assessment models (IAMS): DICE, PAGE, and FUND. IWG notes that these models simplify much of the complexity underlying the relationship between the climate and the economy and that the versions of these models used in 2013 and 2016 did not reflect the "tremendous increase in scientific and economic understanding of climate-related damages" over the past decade.[2] According to the TSD's assessment, limitations in these models include:

- an incomplete treatment of catastrophic and non-catastrophic impacts,
- adaptation and technological change,
- inter-regional and intersectoral linkages,
- uncertainty when extrapolating high temperatures, and
- an inadequate representation of the relationship between discount rates and economic growth in the long term.

The IWG argues that these deficiencies result in current SC-GHG values underestimating the impact of climate damages and recommends the use of simpler climate models that could offer a meaningful improvement over the three IAMs currently in use. They cite the FAIR model as an example of good earth system modeling. (NASEM also notes that FAIR satisfies its own criteria on the representation of climate system dynamics.) IWG also recommends continuing to take stock of the growing literature on climate damages and damage functions while incorporating equity, distributional effects, and intergenerational equity impacts. Finally, the TSD calls out the need for updating baseline socioeconomic and emissions scenarios; in particular, IWG cites efforts to build probability distributions for potential future population, economic output, and emissions growth.

The TSD recommends that uncertainty be addressed transparently in climate modelling. Its current SC-GHG estimates account for uncertainty using a multi-model ensemble, probabilistic analysis, and scenario

[2] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Pg. 22. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

analysis. The IWG's rationale for combining the result of three different IAMs is that they believe no single model includes all quantified economic damages. They use Monte Carlo techniques to run the IAMs a large number of times and plot the distribution of results at the 2.5, 3, and 5 percent discount rates. They report the average result among all runs for each discount rate and the 95th percentile value of damages at the 3 percent discount rate. The TSD also acknowledges that additional sources of uncertainty remain to be explored, some of which are not reflected in the interim SC-GHG estimates, and notes that "evaluating the damages using the mean outcome does not account for the benefits of reducing uncertainty."[3]

NASEM Guidance

The IWG obtained SC-GHG estimates by pooling estimates from the DICE, PAGE, and FUND models. NASEM recommends that rather than averaging the results from multiple models, IWG use a new, single integration of four "modules" to improve the transparency and consistency of assumptions used in the SC-GHG estimation. The four modules that would combine to form a new model are:

- *Socioeconomic and emissions projections:* Multiple scenarios of population, economic output, and related greenhouse gas emissions;
- *Climate modeling:* Greenhouse gas concentrations in the atmosphere and ocean, surface temperatures, and sea level rise;
- *Estimation of climate impacts and damages:* Monetary value of net damages by year; and
- *Discounting net monetary damages:* Calculation of net present value of damages given uncertainty represented in the other modules.

NASEM recommends the following criteria be applied in evaluating a new integrated framework for SC-GHG modeling. The new model should: (1) reflect the current state of scientific knowledge, (2) make clear the key uncertainties and assumptions within each module (socioeconomic, climate, damages, discounting), and (3) provide sufficient transparency as to its methods and assumptions to allow assessment of the model by others.

NASEM further recommends that each model incorporate feedback and interaction with the other modules. For example, the socioeconomic module should incorporate results from the climate and damages modules that may impact population, economic output, or emissions. Finally, NASEM recommends that market and nonmarket damage estimates be disaggregated by geographic region and economic sector. Inputs including population, economic output, temperature, and sea-level rise projections must also be disaggregated by region and sector to provide the necessary level of detail to represent global climate damages, which differ across geographic regions and economic sectors, and are expected to worsen over time.

AEC and FOE recommendations

[3] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Pg. 34. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

AEC and FOE support the recommendations of the TSD and NASEM report that revised SC-GHG development should:

- Update socioeconomic and emissions scenarios, and address: modelling limitations including intersectoral and interregional linkages, the relationship between discount rates and economic growth, and model uncertainty when extrapolating high temperatures.
- Apply NASEM's three-part criteria for evaluating a new integrated framework: (1) reflect the current state of scientific knowledge, (2) make clear the key uncertainties and assumptions, and (3) provide transparency.
- Use one single, unified IAM model with integrated modules instead of averaging together results of three discrete models.
- Disaggregate modular inputs and results by geographic region and economic sector.

and recommends the following additional changes:

- SC-GHG should include treatment of green investment as a boon to the economy, not a detriment.

The IAMs used to calculate SC-GHGs make a technical assumption referred to as the "full employment" of economic resources. That is, investments in climate stabilization are only available at the cost of present-day consumption or investment in alternative policies. This tradeoff, however, does not accurately reflect an economy that experiences periods of protracted unemployment, unused capacity, or low employment to population ratios. This lack of "full employment" describes the United States economy since the early 2000s. Both the Great Recession and the COVID-19 pandemic resulted in devastating increases in unemployment and falling labor force participation, particularly for women during the pandemic. Weaknesses in the labor market cause businesses to curtail additional investment, reduce productivity growth, and to slow future hiring further. In short, those weaknesses are not self-correcting without government assistance.

In conditions of under-employment of labor and production capacity, additional climate investment is a boon to economic growth. Green investment in emission reduction measures does not come at the cost of alternate policy choices because it marshals unused capacity in the economy, entices businesses to raise their own investment in response to the increased capacity of consumers to purchase their products and services, provides employment, and attracts workers back into the formal labor force. To the extent that climate investments reduce spending on energy usage and the operation of fossil fuel capacity, it provides fiscal space for additional investment to make up for losses in the economy's total spending.

Models calculating the SC-GHG values should acknowledge and incorporate the expansionary potential of spending on emissions reductions and the long-term harm to the macroeconomy that comes from failing to sufficiently spend such that the economy may rapidly approach full employment. Current investment should translate to future gains in new investment or consumption and, in the long run, a failure to address climate change would be more costly than investment in mitigation measures. This change in approach would likely raise SC-GHG values; higher SC-GHG values drive the model to invest more with the result of higher economic output (the criteria for success within IAM models).

To achieve a representation of under-employment, models estimating SC-GHG values must undergo methodological adjustments together with publicly available model documentation that transparently explains constraints added to prevent the economy from growing ever more rapidly without the artificial limitation of a full employment assumption. Growth rate constraints varied over time are one potential modeling solution.

AEC and FOE also endorse recommendations of Nicholas Stern and Joseph Stiglitz regarding what acceptable climate models must be able to accomplish:[4]

- Account for extreme tail-risk events, including the possibility of large-scale and unforeseen consequences. This echoes the implications of economist, Marty Weitzman's own recommendations to account for so-called "fat tail" events.[5] Economist James K. Boyce notes that current models extrapolate too heavily from low-damage events and that total losses to economic output therefore understate the impact on environmental justice populations.[6]
- Recognize that certain markets have important failures or are, in some cases, absent altogether.
- Embody rapid technological and systemic change, allowing for the possibility of increasing returns and corresponding rapid changes that accompany them.
- Factor in large distributional variances in impacts across individuals, countries and regions within countries, and on a global scale.

2. Climate damages around the world

Summary: Climate damages that occur in other countries have very direct impacts on U.S. consumers, businesses, prices, trade agreements, military spending, and expected immigration patterns. The SC-GHGs used in U.S. regulatory assessment should recognize the reality of our international economy as well as the global nature of greenhouse gas emissions. AEC and FOE also recognize the United States' ethical responsibility to other nations and recommend that SC-GHG valuation include worldwide climate damages.

TSD Guidance

The TSD argues that SC-GHG estimates should not be limited to climate impacts that occur within U.S. borders. Greenhouse gas emissions contribute to damages everywhere regardless of where they originate. Climate impacts outside the United States directly impact the U.S. economy through trade, tourism, supply chains, and other impacts on international markets. The IWG asserts that "GHG emissions contribute to damages around the world regardless of where they are emitted. The global nature of GHGs means that U.S. interests, and therefore the benefits of the U.S. population of GHG mitigation, cannot be defined solely

[4] Stern, Nicholas, and Joseph E. Stiglitz. 2021. The social cost of carbon, risk, distribution, market failures: An alternative approach. No. w28472. National Bureau of Economic Research. Available at: https://www.nber.org/papers/w28472

[5] Weitzman, Martin L. 2014. "Fat tails and the social cost of carbon." American Economic Review 104, no. 5: 544-46. Available at: https://www.aeaweb.org/articles?id=10.1257/aer.104.5.544

[6] Boyce, James K. "Carbon pricing: Effectiveness and equity. "Ecological Economics150 (2018): 52-61. Available at: https://www.umass.edu/economics/sites/default/files/Boyce%20Ecol%20Econ%202018.pdf

by the climate impacts that occur within U.S. borders."[7] Furthermore, a 2020 Government Accountability Office study notes that these IAMs were not built to provide SC-GHG estimates based solely on domestic damages. The IWG points out that, if SC-GHG values are to be based purely on domestic damages, a more robust methodology must be developed for this purpose but continues to recommend the use of global damages estimates in developing SC-GHG values for federal regulatory assessment.

NASEM Guidance

NASEM finds that full estimation of the potential damages caused by U.S. carbon emissions must include impacts that occur beyond U.S. borders. Climate change and economic conditions in other regions of the world affect the United States and vice versa. Climate change impacts in other countries may change global migration patterns or cause economic or political destabilization that spills over to the United States. For example, in the early stages of the COVID-19 pandemic, when the virus was present only in China, economic and trade disruptions were felt in the United States, despite there not yet being a single reported U.S. case. For these reasons, NASEM recommends that future estimation of the SC-GHG incorporate the climate and economic interactions between the United States and other countries.

AEC and FOE recommendations

AEC and FOE endorse the recommendations of the TSD and NASEM report to include global impacts from U.S. emissions in all assessments of climate impacts and the resulting SC-GHG values. The aftermath of the COVID-19 pandemic has demonstrated the extent to which supply chains and manufacturing capacity are truly global in nature. Shortages of key primary and intermediate inputs as well as lack of prior investment into capacity hobbled the production of tests, vaccines, and protective equipment. During the economic recovery, outbreaks in key manufacturing centers exacerbated shortages for critical global products like semiconductors. The following interlinkages should be highlighted in models assessing climate damages:

- The risk to globalized supply chains from both mean and high tail risks.
- The exacerbation of even minor climate damage events due to the concentration of manufacturing capacity for both final products and intermediate inputs in a small number of firms or in localities beset with geopolitical risk.

Highlighting these linkages and correcting the climate models' approaches to spending on emissions reductions will improve the accuracy of U.S. SC-GHG estimates. Climate investment does not just increase future growth in periods where the economy operates at full capacity, it also secures global businesses, physical infrastructure, and cities against future damages that are likely to occur. Addressing sea-level rise protects key global shipping facilities for instance. Lowering the risk of drought protects the viability of human settlement and economic activity. To be effective, these investments cannot occur only in the United States.

[7] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Pg. 15. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

3. Valuing far future climate impacts

Summary: Climate damage mitigation requires investment today to solve problems in future years—with some impacts occurring hundreds of years from now in a difficult-to-predict future. AEC and FOE recommend that sources of uncertainty in the SC-GHG estimation be made clear and transparent. The discount rate measure of how much we value present spending relative to future damages is one key source of uncertainty. AEC and FOE recommend the use of a discount rate that starts at 1 percent (or lower) and shrinks over time to represent present generations' ethical obligation to future generations.

TSD Guidance

Climate change creates an ongoing stream of damages to societies that occurs over centuries. Damages that occur in far future years may not have the same value to present-day society as they would were that same damage to occur tomorrow. Discount rates are used to convert future damage values to their value to society in the year the emissions were released. A discount rate of 0 percent would mean that society values present events in exactly the same way that it values future events. A $1 million damage event 100 years from now would be worth $1 million at a 0 percent discount rate, about $370,000 at a 1 percent rate, $52,000 at a 3 percent rate, and $1,200 at a 7 percent rate. The higher the discount rate, the more society places a higher value on present damages in comparison to future damages.

Since climate damages occur over a long time horizon while investment in emissions mitigation are needed in the short run, the selection of a discount rate is a key influence on calculated SC-GHG values. The current TSD uses the same rates as those used during the Obama Administration: 2.5, 3, and 5 percent. The TSD acknowledges that 3 percent, which is the IWG's default rate, "is likely an over-estimate and warrants reconsideration in future updates of the SC-GHG."[8] The TSD argues that lower interest rates in bond markets since 2003 would mean that future SC-GHG analysis should use both a lower "consumption rates of interest" and discount rate of at most 2 percent.[9] The TSD cites the New York Department of Environmental Conservation's use of 2 percent discount rates along with sensitivity analysis done at 1 and 3 percent in their 2020 guidelines for state agencies on establishing a value of carbon.[10]

In climate models, the discount rate itself is also subject to uncertainty especially if anticipated climate impacts get worse over time. If that uncertainty persists, discount rates have been shown to decline over time as society's concerns grow regarding ever-worse climate impacts in the future. The TSD notes that

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[8] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Pg. 17. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

[9] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Pg. 20. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

[10] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Pg. 35. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

creating a schedule of declining discount rates over time is an active area of research. In 2010, the IWG used the 2.5 percent discount rate to account for discount rate uncertainty. In 2017, both the National Academies and the EPA's Science Advisory Board recommended establishing an explicit declining discount rate schedule that would be applied to all regulatory impact analysis; no proposed range was suggested. In the interim, the TSD recommends that agencies describe the limitations of the current rates of 2.5, 3, and 5 percent in their analyses of climate impacts, and recommends additional sensitivity analysis on discount rates below 2.5 percent.

Analysis of climate mitigation is complicated by its costs and benefits occurring at different times: Costs of mitigation occur in the present because the models assume that climate investments can only be had at the expense of forgoing consumption; benefits (or avoided damages) can occur centuries in the future. The TSD proposes two methods to harmonize benefits and costs over time. The first discounts future costs and benefits using a special "consumption rate of interest." The second method compares the benefits of climate investment to the returns of investing that same amount of money in private markets. The IWG will use the first method going forward, which is consistent with the recommendations of the National Academies. If the IWG uses bond market interest rates as a reference, then both the consumption rate of interest and discount rate would be lower in future SC-GHG calculations.

NASEM Guidance

Sources of uncertainty—including inputs, outputs, the structure, and parameters of the model—and how they are addressed in SC-GHG modeling must be clear and transparent. NASEM recommends that best judgement from experts in the field be used to determine uncertain inputs and their respective probabilities.

The IWG uses a discount rate to represent how much society values present relative to future damages. NASEM recommends that a "Ramsey-like formula" be used to generate low, middle, and high discount rates representing a range of rates that take into consideration (1) how much society discounts the well-being of future generations in its present-day decision making, (2) the value of goods and/or services today, and (3) how quickly consumption is expected to grow in the future.

NASEM recommends that the time horizon used in SC-GHG estimation extend far enough into the future to cover most climate damages. The actual length of the time horizon depends on the discount rate and the rate at which undiscounted damages grow over time. The longer the time horizon, the more climate impacts can be considered (e.g., sea level rise, carbon cycle changes), but at the cost of added uncertainty. NASEM suggests that IWG report the share of SC-GHG values accruing over different time horizons but does not suggest any particular length of time to model.

AEC and FOE recommendations

AEC and FOE recommend the use of a discount rate of 1 percent or lower in the estimation of SC-GHG values. AEC and FOE agree with the recommendation of the IWG and NASEM to define an explicit schedule for declining rates, especially as the world approaches 2030 or 2050, years when ever more stringent climate targets must be met and as climate damages are continuously revised upward. Automatic reductions in the rate should be built in at regular intervals to account for the increasing urgency of addressing climate damages and the duty of intergenerational equity.

AEC and FOE also support the consideration of SC-GHG valuation that forgoes time-based discounting altogether, treating impacts to all generations equally.[11] Alternate welfare functions instead give additional weight to populations more vulnerable to climate damages (see Section 4 below).

4. Place equal value on all people, all families, and all communities

Summary: Climate economic models often include dollar values placed on human lives, health impacts, and ecosystem damages. The questionable ethical import of this practice is compounded in models that make these dollar values proportional to local incomes (such that a higher value is placed on the same climate damages when they occur in richer countries, states, or neighborhoods). AEC and FOE recommend strongly against modeling practices weigh the value of a lost human life or other climate damages in proportion to local income or economic output.

NASEM Guidance

NASEM calls for the use of the most up-to-date scientific literature to populate assumptions in the climate damage module and for this module to incorporate comprehensive welfare impacts, climate adaptation costs, and catastrophic events.

AEC and FOE recommendations

AEC and FOE strongly recommend against methodologies such as Negishi welfare weights, which calculate the welfare contribution of emission reductions or the damage cost based on per capita income of regions in which the emission reduction or damage occurs.[12] This weighting scheme devalues the benefits of avoided damages in low-income countries. To remove these discriminatory assumptions from impacting climate modeling results, SC-GHG values, and policy decisions regarding the appropriate amount of emissions mitigation to fund, the following steps are necessary:[13]

- The use of Negishi welfare weights and other similar techniques that devalue lives, livelihoods, and ecosystems in poorer nations or regions should be discontinued in climate models that inform the U.S. SC-GHG. Other IAMs can be selected that avoid equity weighting or even optimization entirely.
- If the first recommendation to remove welfare weighting from SC-GHG calculation is not followed, then all results calculated with welfare weights should be clearly labelled and the impact of the weights on the model results should be described in detail.

[11] Adler, Matthew, David Anthoff, Valentina Bosetti, Greg Garner, Klaus Keller, and Nicolas Treich. 2017. "Priority for the worse-off and the social cost of carbon." Nature Climate Change 7, no. 6: 443-449. Available at: https://www.nature.com/articles/nclimate3298

[12] Stanton, Elizabeth A. 2011. "Negishi welfare weights in integrated assessment models: the mathematics of global inequality." Climatic Change107, no. 3. Available at: https://link.springer.com/article/10.1007/s10584-010-9967-6

[13] Ibid.

Another alternative modelling practice to consider is the use of a "prioritarian" social welfare function which gives extra weight to worse-off individuals.[14] Such models obviate the need for discounted social welfare functions that assign less weight to impacts on future generations.[15] Prioritarian social welfare functions result in a more equal distribution of well-being and prioritize the more egalitarian distribution during calculation.[16]

5. Set fair and effective emission reduction targets

Summary: The Intergovernmental Panel on Climate Change (IPCC)—representing an overwhelming majority opinion among scientists worldwide—states unequivocally that global average temperature change greater than 1.5° Celsius above pre-industrial levels will result in extreme heat waves, as well as more frequent and more intense precipitation and droughts, more rapid sea level rise, and more common ice-free summer seas in the Arctic. Given the U.S. "fair share" of the global mitigation effort—due to its capacity to act based on its standing as the world's wealthiest country and as the world's largest historical greenhouse gas emitter—the United States bears a greater responsibility for contributing to global emissions reductions to minimize harm to the development prospects of developing countries. Climate economic models typically choose the SC-GHG values and level of emission reductions associated with the highest global economic output (and assume that green investment detracts from economic growth).

TSD Guidance

The TSD acknowledges a strand of research investigating the cost of setting specific climate targets.[17] These targets might include capping emission or temperature increases to a certain level, after which IAM models can calculate the cost of limiting emissions to that cap. The TSD states that "a policy that specifies an environmental target implicitly requires a valuation of damages when setting the constraint even though it is not explicitly modeled or estimated. For example, a target set to keep temperature increases below a certain threshold implicitly places value on damages incurred beyond that threshold."[18] IWG does not address whether or not placing such an implicit valuation is the reason its calculations do not employ this target-based approach.

AEC and FOE recommendations

AEC and FOE recommend that the model used to inform the U.S. SC-GHGs instead begin with a level of emissions reductions consistent with a high likelihood of limiting global temperature rise to 1.5° Celsius. While AEC and FOE do not disagree with the TSD's assertion that setting a science-based climate target implicitly contains an a-priori value judgement on the level of emissions, there is little practical use to

[14] Adler, Matthew, David Anthoff, Valentina Bosetti, Greg Garner, Klaus Keller, and Nicolas Treich. 2017. "Priority for the worse-off and the social cost of carbon." Nature Climate Change 7, no. 6: 443-449. Available at: https://www.nature.com/articles/nclimate3298
[15] Ibid.
[16] Ibid.
[17] Interagency Working Group on Social cost of Greenhouse Gases, United States Government. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. Footnote 7, pg. 9. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf
[18] Ibid.

climate valuations that accept the possibility of warming greater than 1.5° Celsius. The purpose of valuing carbon emissions is to internalize as much of their negative externalities—including public health impacts, food and clean water insecurity, and the potential for mass casualty events and to permanently harm the capacity of the planet to support human life. IAMs that fail to set a clear target for emissions or temperature reductions are themselves making value judgements about the scale of damages that are acceptable to policymakers and the public. Because those judgements are unavoidable, it is crucial to make them using the best available scientific information, most notably the international scientific community's goal of avoiding the possibility of warming greater than 1.5° Celsius. Country-specific levels of emission reductions necessary to meet that target should be determined by scientific analysis, historical responsibility, and capacity to act. On that basis, the IWG should estimate U.S. SC-GHG values associated with the most cost-effective method of achieving the 1.5°C emission reduction goal. The selected model should recognize that climate investment can increase economic output without sacrificing present consumption.

6. Have a clear process for updating the SC-GHGs over time

Summary: AEC and FOE echo National Academy of Sciences, Engineering, and Medicine's recommendation that SC-GHG estimates be updated every five years in a three-step process with a review of the underlying data, a comment period, and a review of the SC-GHG methodology. It is also imperative that vulnerable communities are represented within the SC-GHG comment process. While current SC-GHGs are in urgent need of a swift revision and updating, future reviews and comment periods should include additional fundamental issues including prudency and a precautionary principle, the importance of unmonetized climate mitigation benefits, and the policy implications of a higher (or even infinite) demand for greenhouse gas reductions consistent with well-established science and the U.S. fair share of the global mitigation effort.

NASEM Guidance

NASEM recommends that SC-GHG estimates be updated in a three-step process every five years, providing enough time to ensure a thorough assessment and revision incorporating new scientific knowledge. In the first step of the process IWG would review scientific literature and confer with experts on potential updates to the SC-GHG estimation methodology. The second step would entail proposed revisions to the existing SC-GHG methodology and estimates which will be subject to public review and comment. Finally, the IWG's SC-GHG methodology should be regularly reviewed by an independent scientific assessment panel.

AEC and FOE recommendations

AEC and FOE support NASEM's recommendation of a three-step process occurring every five years to conduct a thorough assessment and revision to incorporate new scientific knowledge. AEC and FOE recommend the following additional updates to the policymaking process.

- Future reviews should ensure that the precautionary principle underlies climate modeling: making prudent choices when faced with uncertain damages and high stakes. All climate models should publish "tail" (low-probability, high damage) SC-GHG estimates by default. Federal agencies should be required to consider tail SC-GHG estimates in policy evaluation. The OMB should publish guidelines on the relevant percentiles to be used if and only if tail estimates are deemed excessive as the default basis for policy analysis. In that instance, that determination and a justification for it must be clearly included with calculation guidelines and must be noted by the agency making the calculation.

- Every effort must be made to quantify "qualitative" or un-monetized benefits and damages from climate change—for example, human lives lost or species made extinct. In the event a procedure for monetizing a specific damage or benefit cannot be determined, alternative guidelines should exist that ensure that difficult-to-monetize values are considered in subsequent analysis.
- All calculations of climate impacts should address the possibility of infinite or limit-approaching SC-GHG values such that society is willing to pay any price to stop climate change. This could occur in two instances. First, agencies should plan for damages in the event certain catastrophic scenarios occur. Second, agencies should create alternative SC-GHG ranges to their default calculations to account for the calculated probability of catastrophic impacts suddenly increasing.

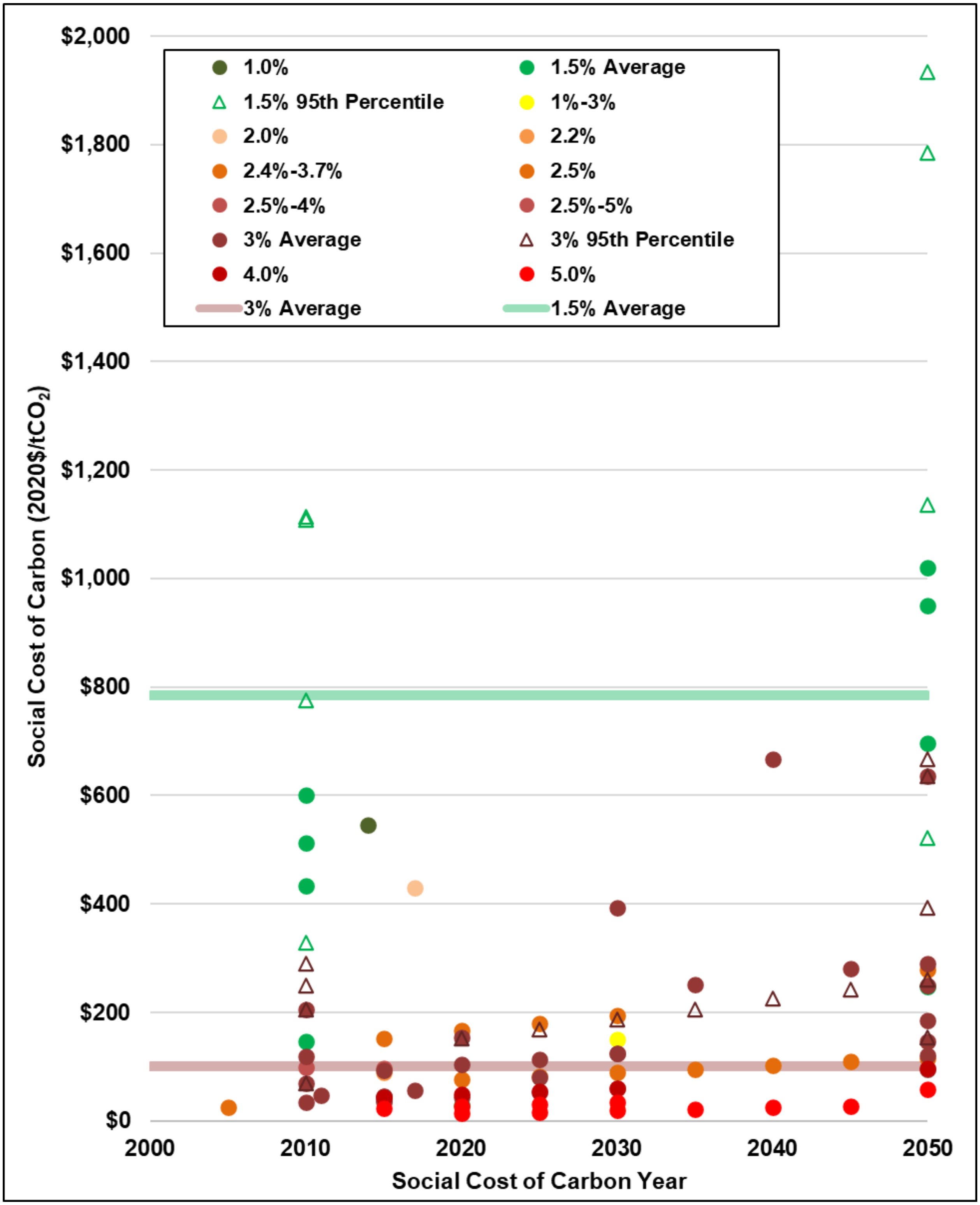
Estimating Revised SC-GHG Values

AEC and FOE recommend that, going forward, U.S. SC-GHG values are modeled:

- Using a single climate model vetted publicly;
- Such that investments in emission reductions add to economic growth (rather than taking away from consumption);
- Including worldwide climate damages;
- Using a discount rate of 1 percent (or lower) that shrinks over time;
- Without any welfare weighting that devalues impact to poorer communities;
- On the basis of emissions reductions determined by scientific analysis, historical responsibility, and capacity and consistent with a high likelihood of limiting global temperature rise to 1.5° Celsius; and
- With a clear process for updating the SC-GHGs over time.

SC-GHG values calculated on this basis would inevitably be higher than current estimates and would therefore result in the selection of more stringent U.S. federal environmental policies that reduce greenhouse gas emissions. The academic literature on SC-GHGs includes examples of modeling with various combinations of AEC's and FOE's recommendations. Figure 1 below presents estimated social cost of carbon dioxide values from 17 such sources, most published in 2017 or later. Each symbol in Figure 1 represents an SC-GHG value from one of these studies presented in 2020 dollars per metric ton of CO_2. The color of the symbol depends on the discount rate; circles are median damage estimates and triangles are high-end (95th percentile) damage estimates. Our review of these recent SC-GHG estimates revealed a range of $14 to almost $2,000 per metric ton of CO_2, using discount rates from 1 to 5 percent at the median and 95th percentile distribution of damages. Overall, lower discount rates (green) and median damages (circles) result in lower SC-GHG values while higher discount rates (red) and high-end damages (triangles) result in higher SC-GHG values.

Figure 1. AEC review of recent SC-GHG estimates



Data sources: See Appendix below.

At discount rates of 1.5 percent and lower, the average SC-GHG estimate is about $800 per metric ton. AEC and FOE find it likely that SC-GHG values calculated based on their recommended changes to climate models would be in this range or higher, indicating a very high social value for reducing greenhouse gas emissions and a strong motivation for higher public spending on emission reduction measures.

At a discount rate of 3 percent (which the IWG contends and AEC and FOE agree is far too high) the average SC-GHG estimate at the median percentile of damage costs is about $100 per metric ton of carbon—still substantially higher than the TSD's SC-GHG estimates ($51 per metric ton of CO_2 for emissions in 2020 up to $85 per ton in 2050), illustrating the tendency of the IWG's modeling approach to underestimate the values of avoiding climate damage.

Conclusion

The social costs of climate change—destroyed livelihoods and homes, negative health impacts and lost lives, reduced access to food sources and clean water—are a crucial input into the policy analysis that determines both how much the U.S. federal government is willing to spend on our behalf to avoid these serious, irreversible impacts and how little it should spend subsidizing fossil fuels. The United States alone emits more than 6.5 billion metric tons of CO_2 every year. The consequences for underestimating the climate damage of a single added ton of greenhouse gas emissions are dire. The lower this value is set, the less the U.S. federal government spends on climate change mitigation. This translates into less urgency and ambition applied to addressing the climate crisis and consequently more devastating impacts on lives and livelihoods in the United States—especially in environmental justice communities—and around the world—especially in developing countries.

The Biden Administration's SC-GHG estimates represent a marked improvement over the Trump Administration's open attempt to reduce the SC-GHGs to as close to zero dollars per ton as possible, effectively arguing that greenhouse gases result in little or no damage to human society. The Biden TSD is an important step toward the United States accepting appropriate responsibility for emission reductions, but there is still room for significant improvement. The IWG must account more effectively for intergenerational and interregional equity (both within the United States and internationally), reduce the devaluation of future climate damages, and ensure that SC-GHG values are based on targets for holding temperature increases below levels identified by scientists as crucial to the continuation of human civilization as we know it. Importantly, climate investments must be appreciated as a benefit rather than a cost to economic growth, and climate models must include an adequate accounting of the risks of catastrophic damages.

Because the scale and intensity of future climate impacts have the potential to irreparably harm human society and the ecosystems on which human and other life depend, society's willingness to pay to stop climate change (and, therefore, SC-GHG estimates) may be viewed as infinite in the context of the worst possible scenarios. But if the U.S. and governments worldwide commit to limit temperature rise to the scientific community's recommendation of 1.5° Celsius, low-discount rate SC-GHG estimates can be useful tools to prioritize climate action. Even if using discount rates below 1 percent, current SC-GHG values are conservative measures that ignore the possibility of catastrophic events. Policymakers must revise and update the SC-GHG estimation process and correct modeling biases that lead towards underestimation. The reforms recommended here on behalf of FOE would be a productive step towards a better U.S. climate policy.

Appendix: Bibliography for Meta-Analysis

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