External Peer Review of EPA draft technical report, "Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances"

Context and Scope of Review

A robust and scientifically founded assessment of the positive and negative impacts that an action can be expected to have on society provides important insights into the policy-making process. One specific input to EPA analyses – the social cost of greenhouse gases (SC-GHG) – combines climate science and economics to put the effects of climate change into monetary terms to help EPA and the public understand the societal consequences of actions that would increase or decrease greenhouse gas emissions. The SC-GHG is the monetary value of the net harm to society associated with adding a small amount of that GHG to the atmosphere in a given year. In principle, it includes the value of all climate change impacts, including (but not limited to) changes in net agricultural productivity, human health effects, property damage from increased flood risk natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. The SC-GHG, therefore, also reflects the societal value of reducing emissions of the gas in question by one metric ton and is the theoretically appropriate value to use in conducting benefit-cost analyses of policies that affect GHG emissions. EPA and other Federal agencies began regularly incorporating SC-GHG estimates in their benefit-cost analyses conducted under Executive Order (E.O.) 12866[1] since 2008, following a Ninth Circuit Court of Appeals remand of a rule for failing to monetize the benefits of reducing CO_2 emissions.

In 2017, the National Academies of Sciences, Engineering, and Medicine published a report that provides a roadmap for how to update SC-GHG estimates used in Federal analyses going forward to ensure that they reflect advances in the scientific literature (National Academies 2017). The National Academies' report recommended specific criteria for future SC-GHG updates, a modeling framework to satisfy the specified criteria, and both near-term updates and longer-term research needs pertaining to various components of the estimation process. The research community has made considerable progress in developing new data and methods that help to advance various components of the SC-GHG estimation process in response to the National Academies' near-term recommendations.

In a first-day executive order (E.O. 13990), *Protecting Public Health and the Environment and Restoring Science To Tackle the Climate Crisis*, President Biden called for a renewed focus on updating estimates of the social cost of greenhouse gases (SC-GHG) to reflect the latest science, noting that "it is essential that agencies capture the full benefits of reducing greenhouse gas emissions as accurately as possible." Important steps have been taken to begin to fulfill this directive of E.O. 13990. In February 2021, the Interagency Working Group on the SC-GHG (IWG) released a technical support document (TSD) that

[1] Benefit-cost analyses have been an integral part of executive branch rulemaking for decades. Presidents since the 1970s have issued executive orders requiring agencies to conduct analysis of the economic consequences of regulations as part of the rulemaking development process. E.O. 12866, released in 1993 and still in effect today, requires that for all economically significant regulatory actions, an agency provide an assessment of the potential costs and benefits of the regulatory action, and that this assessment include a quantification of benefits and costs to the extent feasible. Many statutes also require agencies to conduct at least some of the same analyses required under E.O. 12866, such as the Energy Policy and Conservation Act which mandates the setting of fuel economy regulations.

provided a set of IWG recommended SC-GHG estimates while work on a more comprehensive update is underway to reflect recent scientific advances relevant to SC-GHG estimation (IWG 2021).[2]

The EPA has applied the IWG's recommended interim SC-GHG estimates in the Agency's regulatory benefit-cost analyses published since the release of the February 2021 TSD. In addition, in the regulatory impact analysis of EPA's November 2022 supplemental proposal for oil and gas standards, the Agency included a sensitivity analysis of the climate benefits of the proposed rule using SC-GHG estimates from a new, EPA draft technical report, "Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances." This draft report presents a set of updated SC-GHG estimates that aims to incorporate the recent advances in the climate science and economics literature for use in the Agency's analyses. Specifically, the draft report incorporates new literature and research consistent with the near-term National Academies' recommendations on socioeconomic and emissions inputs, climate modeling components, discounting approaches, and treatment of uncertainty, and an enhanced representation of how physical impacts of climate change translate to economic damages in the modeling framework based on the best and readily adaptable damage functions available in the peer reviewed literature.

EPA requests independent expert review of this draft technical report that explains the methodology underlying the new set of estimates. This peer review is designed to be consistent with EPA's Peer Review Handbook 4th Edition, 2015.[3] The reviewers are asked to respond to each of the questions in each section below consistent with the reviewer's experience and areas of expertise. EPA is primarily interested in the reviewers' views on how well the methodological decisions draw on the best available research to fulfill the National Academies' near-term updating recommendations. Separately, the Agency is also interested in the reviewers' longer-term recommendations for further improving SC-GHG

[2] The SC-GHG estimates presented in the February 2021 TSD are reported in 2020 dollars but are otherwise identical to those presented in the previous version of the TSD and its Addendum, released in August 2016 (IWG 2016a, 2016b), which relied on methodologies and inputs developed in 2010 and 2013. As discussed in the February 2021 TSD, the IWG concluded that these interim estimates reflected the immediate need to have SC-GHG estimates available for agencies to use in regulatory benefit-cost analyses and other applications that were developed using a transparent process, peer reviewed methodologies, and the science available at the time of that process.

[3] This peer review is being managed by a contractor to EPA, Versar. Versar reviewed the public nominations received in response to a 21-day call for peer reviewer nominations that ended on February 15, 2022 [federalregister.gov/d/2022-01387] to ensure they have the types of disciplinary expertise listed in the notice and used traditional techniques (*e.g.,* a literature search) to identify additional qualified candidates in the disciplines described below. Versar then developed a list of 14 candidate reviewers, collected public comments on the candidates, and used the comments received to select up the final panel of experts in a manner consistent with EPA's Peer Review Handbook 4th Edition, 2015 (EPA/100/B-15/001), based on the following factors:
(1) Demonstrated expertise through relevant peer-reviewed publications in one or more of the following areas: environmental economics, climate science, integrated assessment modeling, and benefit-cost analysis; (2) professional accomplishments and recognition by professional societies; (3) demonstrated ability to work constructively and effectively in a committee setting; (4) absence of conflicts of interest; (5) no appearance of partiality; (6) willingness to commit adequate time for a thorough review of the draft report, including preparation of individual written comments that will be made publicly available; and (7) availability to participate virtually in a public peer review meeting and to provide subsequent revised individual comments. Versar has independently conducted a conflict of interest (COI) screening of the candidates and final selected reviewers to confirm that those listed have no COI in conducting this review. Versar has ensured that the peer reviewers have not participated in the development of the product being reviewed and are independent of EPA as required under OMB's Final Information Quality Guidelines for Peer Review (p. 38)

estimation in future updates. EPA will use the results of this peer review both to improve the utility, transparency, and accessibility of this near-term update as well as to inform our continuing efforts to update the scientific basis of the SC-GHG estimates used in EPA analyses.

If helpful to their review, the reviewers may also consult the replication instructions and computer code for the estimates which are publicly available on EPA's website and any public comments on the draft report.[4]

Charge Questions:

1. Use of a modular approach to the methodological updates

Consistent with the National Academies' near-term recommendations, EPA separately updates the methodology in each step of the SC-GHG estimation—socioeconomic and emissions projections, climate science, economic damages, and discounting— increasing transparency and ease of updating each component to reflect the latest expertise from the scientific disciplines relevant to that component. Using this modular approach, EPA updated each step in SC-GHG estimation to improve consistency with the current state of scientific knowledge, enhance transparency, and allow for a more explicit representation of uncertainty.

   a. Does the modular approach taken in this draft report offer an improved opportunity to draw on expertise from the wide range of scientific disciplines relevant to SC-GHG estimation relative to the estimation approach underlying the IWG methodology to date (which relies on the default bundled structure of the DICE, PAGE, and FUND integrated assessment models)? Why or why not?
   b. Was the modular approach described clearly in the draft report? Do you have any recommendations for improving the presentation in the draft report?
   c. Are there alternative, superior approaches that EPA should consider using to achieve its goals for this update? Please describe the advantages of these approaches.
   d. Do you have longer term recommendations regarding approaches the EPA should consider for future updates?

2. Socioeconomic and emissions module

The socioeconomic and emissions module used in the draft report relies on a new set of socioeconomic and emissions projections developed under the Resources for the Future Social Cost of Carbon Initiative (collectively referred to as the RFF-SPs) (Rennert et al. 2022a). The RFF-SPs are an internally consistent set of probabilistic projections of population, GDP, and GHG emissions (CO_2, CH_4, and N_2O) to 2300 that were generated using statistical and structured expert judgement methods and accounting for future polices and interdependencies. The country-level population projections extend the fully probabilistic statistical approach used by the United Nations for official population forecasts, while incorporating improvements recommended by a panel of expert demographers (Raftery and Ševčíková 2021). The country-level empirical economic growth projections (Müller, Stock, Watson 2020) were extended in time using expert elicitation (Rennert et al. 2022a). The emissions projections are conditioned on future economic growth and a reflection of an "Evolving Policies" case (Rennert et al. 2022a).

[4] EPA will help expedite transfer of public comments to the peer reviewers via the contractor, Versar, as they are received by EPA during the course of this peer review.

a. Does the socioeconomic and emissions module in this draft report offer an improved approach for reflecting uncertainty and account for future policies and dependencies between variables than the approach used in the IWG methodology to date (which relies on four business-as-usual and one 550 ppm stabilization scenario from the Stanford Energy Modeling Forum exercise, EMF-22)? Why or why not?
b. Are there additional or alternative existing sources of probabilistic socioeconomic projections that EPA should consider for this update? Please describe the advantages of these approaches.
c. Do you have recommendations for improving the clarity and accessibility of the updated socioeconomic and emissions module? Do you have recommendations for increasing transparency and strengthening the characterization of uncertainty for this module in this update?
d. Do you have longer-term recommendations for improvements to this module in future updates?

3. Climate module

EPA's goal for this update of the climate module was to adopt a widely used, transparent climate model that could reflect the latest scientific understanding of the relationships between CO_2 emissions, atmospheric CO_2 concentrations, and global mean surface temperature change (and any other climatic variables required as inputs to the damage module) over time while accounting for non-CO_2 forcing and allowing for the evaluation of uncertainty. The climate module used in the draft report relies on the open source and widely used Finite amplitude Impulse Response (FaIR) climate model (Millar et al. 2017, Smith et al. 2018) to generate projections of global mean surface temperature change. The estimates presented in the report rely on FaIR version 1.6.2 as used by the IPCC (2021a, 2021b), in which the uncertain parameters have been calibrated to be consistent with the most recent assessment of the IPCC, such as the IPCC AR6 assessed likely range of 2.5 to 4°C for the equilibrium climate sensitivity.

a. Does the climate module in this draft report offer an improved representation of how GHG and other forcing agent emissions translate into climatic variables that are needed by the damage module relative to the estimation approach underlying the IWG methodology to date (which relies on the default climate process in the DICE, PAGE, and FUND integrated assessment models, except for a common probability distribution for the climate sensitivity parameter)? Why or why not?
b. Are there additional or alternative existing climate models that can be used to reflect the latest scientific consensus on the relationships between GHG emissions, atmospheric GHG concentrations, and surface temperature change, as well as their uncertainty, and can project their profiles over time, that the EPA should consider for this update? Please describe the advantages of these approaches.
c. Are there other models/methods for projecting sea level impacts resulting from temperature change than those used in the draft report that the EPA should consider for this update? Please describe the advantages of these approaches.
d. Do you have recommendations for strengthening the presentation of this module, e.g., with respect to increasing transparency or characterization of uncertainty in the draft report? Do you have recommendations for how to enhance the discussion of earth system changes and resulting impacts that are not yet reflected in the climate module (either in Section 2.2 or 3.2)?
e. Do you have longer-term recommendations for improvements to this module in future

updates?

4. Damages module

Damage functions translate changes in temperature and other physical impacts of climate change into monetized estimates of net economic damages. EPA's goal for this module is to evaluate the large increase in research on climate impacts and damages in the time since the models underlying the IWG methodology to date were published. The damages module in this draft report relies on three damage functions to synthesize the existing literature. They are:

- a subnational-scale, sectoral damage function estimation (based on the Data-driven Spatial Climate Impact Model (DSCIM) developed by the Climate Impact Lab (CIL 2022, Carleton et al. 2022, Rode et al. 2021)),
- a country-scale, sectoral damage function estimation (based on the Greenhouse Gas Impact Value Estimator (GIVE) model developed under RFF's Social Cost of Carbon Initiative (Rennert et al. 2022b)), and
- a meta-analysis-based global damage function estimation (based on Howard and Sterner (2017)).

Each of the three damage functions is separately estimated in combination with the socioeconomics, climate, and discounting modules. The sectoral damage modules in GIVE and DSCIM are based on different underlying information, data sources, and estimation methods. GIVE and DSCIM are both independent lines of evidence from the meta-analysis-based damage module since the studies underlying each sectoral damage modules in GIVE and DSCIM are not included in Howard and Sterner's (2017) final sample of studies. In Section 4.1 of the draft report, EPA combines the multiple lines of evidence on damages by averaging the results across the three damage module specifications to present SC-GHG estimates for a given range of discount rates.

a. Does the damages module in this draft report offer a more robust representation of the current body of scientific evidence on climate damages than the damage functions embedded in the three integrated assessment models used in the IWG methodology to date (which relies on the default damage functions in the DICE, PAGE, and FUND integrated assessment models)? Why or why not?
b. Does the draft report's use of multiple damage functions reflect the breadth of the current scientific literature on damages for this update? If not, what changes to you recommend? Do you think that there is a better approach for this update?
c. For the damage categories that are represented, are there additional studies or valuation methodologies that the EPA should consider in modeling these categories in this update? Please describe the advantages of these studies relative to the methods used in the draft report.
d. Are there additional categories of damages that should be considered for inclusion in the individual sectoral damage functions in this update? Please describe the peer reviewed literature that could be used to inform the modeling of these damage categories.
e. Do you have recommendations for strengthening the presentation of this module, e.g., with respect to increasing transparency of the damage function calibrations or characterization of uncertainty in the draft report?
f. Do you have longer-term recommendations for improvements to this module in future

updates?

5. Discounting module

The discounting module used in the draft report relies on a set of calibrated dynamic discount rates. These rates were developed using a Ramsey discounting approach that endogenously connects the discount rate and socioeconomic scenarios where the Ramsey formula parameters are empirically calibrated to match near-term consumption interest rates and reconcile long-run interest rate behavior and economic growth uncertainty consistent with the RFF-SPs. Uncertainty in the starting rate is addressed by using three near-term target rates – 1.5, 2.0, and 2.5% - based on multiple lines of evidence on observed interest rate data.

a. Does the discounting module in this draft report adopt an approach that allows the discount rate to better reflect recent quantitative evidence on the consumption rate of interest and capture the long-term relationship between discount rates and economic growth relative to the discounting approach used in the IWG methodology to date (which relies on three constant, exponential discount rates)? Why or why not?
b. Are there discounting approaches other than Ramsey discounting that the EPA should consider for this update? Please describe the advantages of these approaches.
c. Are there other descriptive approaches for calibrating the Ramsey parameters that the EPA should consider for this update? Please describe the advantages of these approaches relative to the methods used in the draft report.
d. Is the discounting module described clearly in the draft report? Do you have recommendations for strengthening the presentation of this module, e.g., with respect to increasing transparency or characterization of uncertainty in the draft report?
e. Do you have longer term recommendations for improvements to this module in future updates?

6. Other

a. Accounting for risk aversion:
    i. Does the methodology in the draft report more explicitly reflect existing evidence on individuals' preferences over risks in the valuation of climate damages than the IWG methodology to date (which maintained an assumption of risk neutrality throughout the analysis and indirectly incorporated risk aversion through exogenous adjustments to the discount rate and through consideration of a fourth value reflecting the 95th percentile of the SC-GHG results under a 3% discount rate)? Why or why not?
    ii. Are there other parameterizations/approaches that have been applied in the empirical literature that the EPA should consider for incorporating risk aversion in this update? Please describe the advantages of these approaches relative to the methods used in the draft report.
    iii. Do you have recommendations for strengthening the presentation of this modeling decision in the draft report, e.g., with respect to increasing transparency of the parameterization and implementation with the damage functions used in this update?
    iv. Do you have longer run recommendations for improved ways to account for risk aversion in future updates?

b. Characterization of distributional impacts and other presentational recommendations for the draft report:
    i. Given the spatial resolution available in the modeling performed for this update, do you have recommendations for ways to provide a more robust characterization of the distributional impacts of climate change in the draft report?
    ii. Do you have recommendations for strengthening the presentation and discussion in the draft report regarding what constitutes damages to U.S. populations in the case of a global pollutant that could have international implications that impact the United States? Is the reporting of damages occurring within U.S. borders based on current modeling capabilities in GIVE and DSCIM described transparently in the draft report? If not, do you have recommendations for how this presentation and discussion could be strengthened?
    iii. Do you have recommendations for strengthening the presentation and discussion of other topics in the draft report?

c. Do you have longer term recommendations, in addition to any discussed in the subparts above, for potential methodological improvements that warrant consideration in future updates of the SC-GHG estimates (e.g., estimation approaches for improved accounting of interactions and feedback effects within and between modules, valuation of climate change impacts (e.g., estimating willingness-to-pay for mortality risk changes), characterization of climate damages to U.S. populations and various subpopulations (e.g., environmental justice communities))?

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