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## Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide

When federal agencies are considering rules or regulations that affect carbon dioxide emissions (CO<sub>2</sub>), they are required to analyze the emissions' impact on climate change and the resulting net damage or cost to society. Such analyses rely on a measure known as the social cost of carbon.

The federal Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) developed a method for estimating the social cost of carbon that has been used by agencies since 2010. The group asked the National Academies of Sciences, Engineering, and Medicine to recommend potential approaches for a comprehensive update to the methodology to ensure the estimates reflect the best available science.

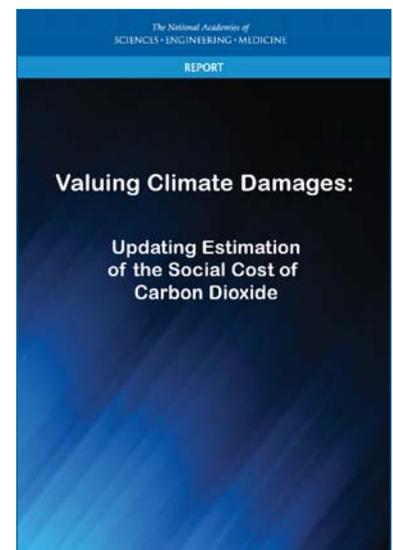
The study committee's report, *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide* (2017), recommends both short-term and longer-term updates to the methodology to strengthen the scientific basis, provide greater transparency, and improve characterization of the uncertainties in the estimates.

### WHAT IS THE SOCIAL COST OF CARBON?

The social cost of carbon (SC-CO<sub>2</sub>) is an estimate, in dollars, of the net damage to society caused by a 1-metric ton increase in carbon dioxide emissions. Net damages equal the costs minus the benefits associated with climate change impacts, such as changes in agricultural productivity, risks to human health, and damage from floods.

Agencies use estimates of the social cost of carbon as they analyze the costs and benefits of potential rules and regulations that affect carbon emissions—for example, standards for automobile fuel economy or for air pollution from power plants.

The method for estimating the SC-CO<sub>2</sub> developed by the IWG has been used since 2010. The method uses three existing models to estimate the economic consequences of CO<sub>2</sub> emissions. First, a baseline level of CO<sub>2</sub> emissions is defined along with projections of underlying socioeconomic factors—global economic growth and population—decades into the future. Then, for each of the three models, an incremental increase in CO<sub>2</sub> emissions is added to the base-



line, which is translated into an increase in atmospheric CO<sub>2</sub> and a resulting increase in global mean temperature. These results are used to estimate potential net damages in dollars, using discounting to convert future damages into present dollars. The CO<sub>2</sub> values that result from running the three models using different socioeconomic scenarios and incorporating other uncertainties are averaged across model runs for each of three different discount rates.

The IWG’s current estimate of the social cost of carbon in the year 2020 for a 3 percent discount rate is \$42 per metric ton of CO<sub>2</sub> emissions in 2007 US dollars. If, for example, a particular regulation were projected to reduce CO<sub>2</sub> emissions by 1-million metric tons in 2020, the estimated value of those CO<sub>2</sub> emissions-reduction benefits would be \$42 million.

### RECOMMENDATIONS FOR UPDATING THE SC-CO<sub>2</sub>

The report recommends a new framework that “unbundles” the steps in the IWG’s current process into a series of modules that are integrated with one another. Under this approach, each step in estimating the SC-CO<sub>2</sub> is developed as a module that reflects the state of scientific knowledge in that portion of the analysis. Each module would be developed based on expertise within the disciplines relevant to that part of the analysis.

- **Socioeconomic module.** This module projects population and GDP, which in turn drive projections of CO<sub>2</sub> and other greenhouse gases that are input into the climate module. Population and GDP estimates are also input directly into the damages module and the discounting module.
- **Climate module.** This module takes the outputs of the socioeconomic module—particularly emissions of CO<sub>2</sub> and other greenhouse gases—and estimates their effects on the physical climate, such as on global mean surface temperature and sea level rise.
- **Damages module.** This module translates the outputs from the socioeconomic module (e.g., estimates of population and GDP) and the climate module (e.g., estimates of changes in temperature and sea level) into estimates of the net damages in dollar terms over time.
- **Discounting module.** Changes in CO<sub>2</sub> emissions today will affect economic outcomes for several centuries. Discounting determines how much dollar value to attach to net damages avoided in the future and translates that future value into present value.

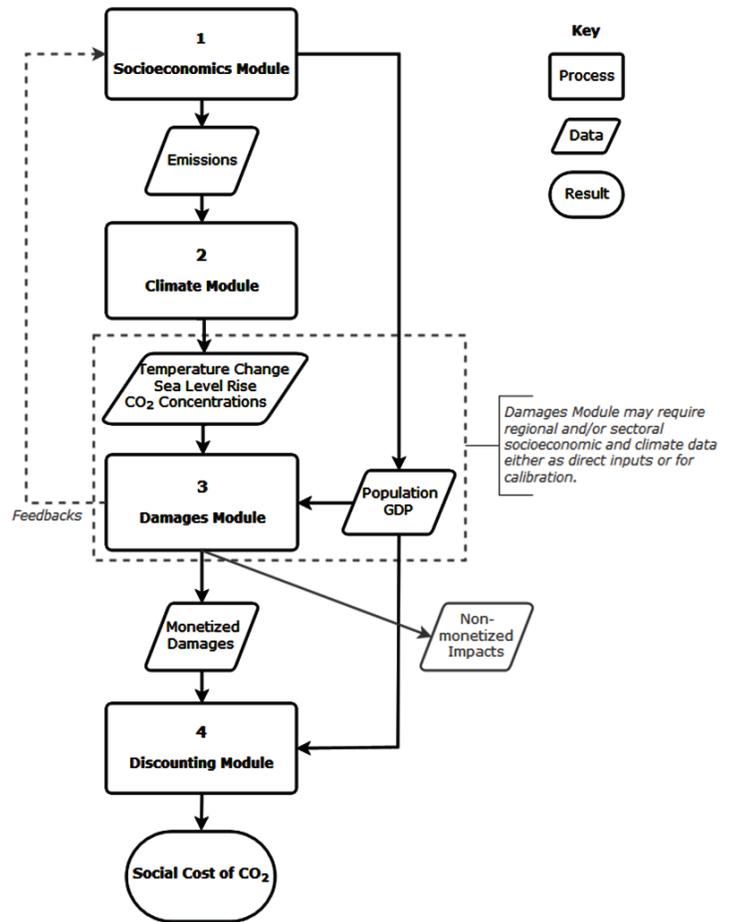


Figure 1 An integrated, modular framework for estimating the social cost of carbon (SC-CO<sub>2</sub>).

Figure 1 illustrates how these modules are linked together in one framework. The report offers detailed recommendations about how the IWG should develop each of these modules and how the proposed framework could include feedbacks between and interactions within the modules.

### NEAR-TERM AND LONGER-TERM UPDATES

The committee outlines a set of near-term recommendations that would be feasible to implement in the next 2 to 3 years and would improve each part of the analysis:

- The socioeconomic module should use statistical methods and expert elicitation for projecting distributions of economic activity, population growth, and emissions into the future.
- The climate module should employ a simple Earth system model that satisfies well-defined diagnostic tests to confirm that it properly captures the relationships over time between CO<sub>2</sub> emissions, atmospheric CO<sub>2</sub> concentrations, and global mean surface temperature change and sea level rise.

- The damages module should improve and update existing formulations of climate change damages; this update should draw on recent scientific literature related to both empirical estimation and process-based modeling of damages.
- The discounting module should incorporate the relationship between discount rates and economic growth to help account for uncertainty surrounding discount rates over long time periods.

The committee also outlines longer-term steps that should be taken to improve each module, including incorporating feedbacks across modules. These advances will require significant investments in both economic and climate modeling research, particularly related to the assessment of climate damages and to socioeconomic and emissions projections.

### PROCESS FOR UPDATES

The committee recommends that the IWG use three primary criteria to evaluate the modules as they are considered for integration into the framework and for subsequent updates to the methodology:

- **Scientific basis:** Modules, their components, their interactions, and their implementation should be

consistent with the state of scientific knowledge as reflected in the body of current, peer-reviewed literature.

- **Uncertainty:** Key uncertainties and sensitivities, including functional form, parameter assumptions, and data inputs should be adequately identified and represented in each module. Uncertainties that cannot be or have not been quantified should be identified.
- **Transparency:** Documentation and presentation of results should be adequate for the scientific community to understand and assess the modules. Documentation should explain and justify design choices. The extent to which features are evidence based or judgment based should be explicit. Model code should be available for review, use, and modification by researchers.

SC-CO<sub>2</sub> estimates should be updated using a three-step process at regular intervals of approximately 5 years, the report says. This process is illustrated in Figure 2 below. This timing would balance the benefit of incorporating evolving research against the need for a thorough and predictable process.

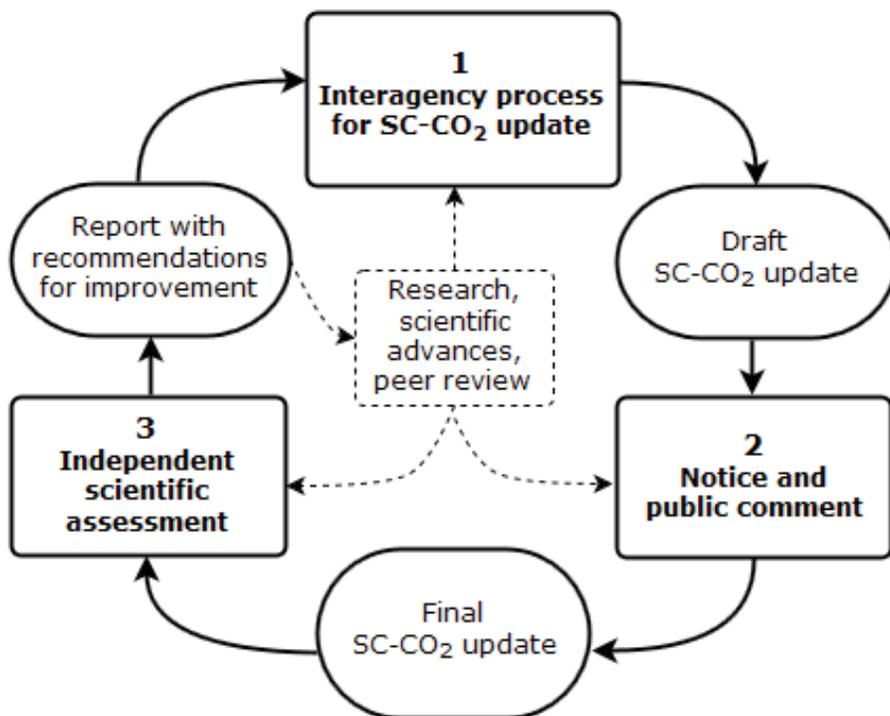


Figure 2 Regularized process for SC-CO<sub>2</sub> updates.

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**For More Information . . .** This report highlights was prepared by the Board on Environmental Change and Society (BECS) based on the report *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon* (2017). The study was sponsored by the U.S. Department of Energy. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the report are available from the National Academies Press, (800) 624-6242; <http://www.nap.edu> or via the BECS page at <http://nas.edu/valuing-climate-damages>.

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