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SOCIAL COST OF CARBON: FEDERAL AND CALIFORNIA ACTIVITY

The social cost of carbon (SCC) has been referred to as " . . . the most important figure you've never heard of."[1] The SCC brings together the fields of politics, policy, science, environmental justice, and ethics, and forces society to ask difficult and esoteric questions, such as how much do we care about our impacts on future generations? This report provides an overview on the SCC and discusses recent activity at the federal level and by California state agencies.

BACKGROUND

Social costs generally refer to the total costs to society. Social costs include not only the private costs of producing something but also external costs. For example, the private costs of owning and operating an automobile might include the costs to build, maintain, insure, and fuel the automobile. All of these private costs have associated market prices where consumers agree to pay a certain price for automobile services. External costs of owning and operating an automobile typically are not captured in any actual market price and might include broader societal costs, such as pollution created by the automobile.

One of the largest external environmental costs on society is from greenhouse gas (GHG) emissions, which include carbon dioxide (CO_2) and other gases that cause a gradual rise in the temperature of the Earth's atmosphere. According to the Intergovernmental Panel on Climate Change, which includes more than 1,300 international scientists, "the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time."[2] To estimate the external costs of emitting GHGs, a measurement called the "social cost of carbon" (SCC) has been developed to monetize societal costs associated with carbon emissions. Additionally, the social cost of methane and nitrous oxide are used to estimate the social costs of GHG emissions. For simplicity, this report refers only to the SCC when referring to estimating the social costs of any GHG emissions. The SCC does not represent the actual cost of reducing GHG emissions, nor the non-climate change-related social costs from implementing climate policies. For example, the state's cap-and-trade program potentially has associated non-climate change-related social costs and benefits such as changes in co-pollutant emissions or land-use changes, but these costs are not included in the SCC. Instead, according to

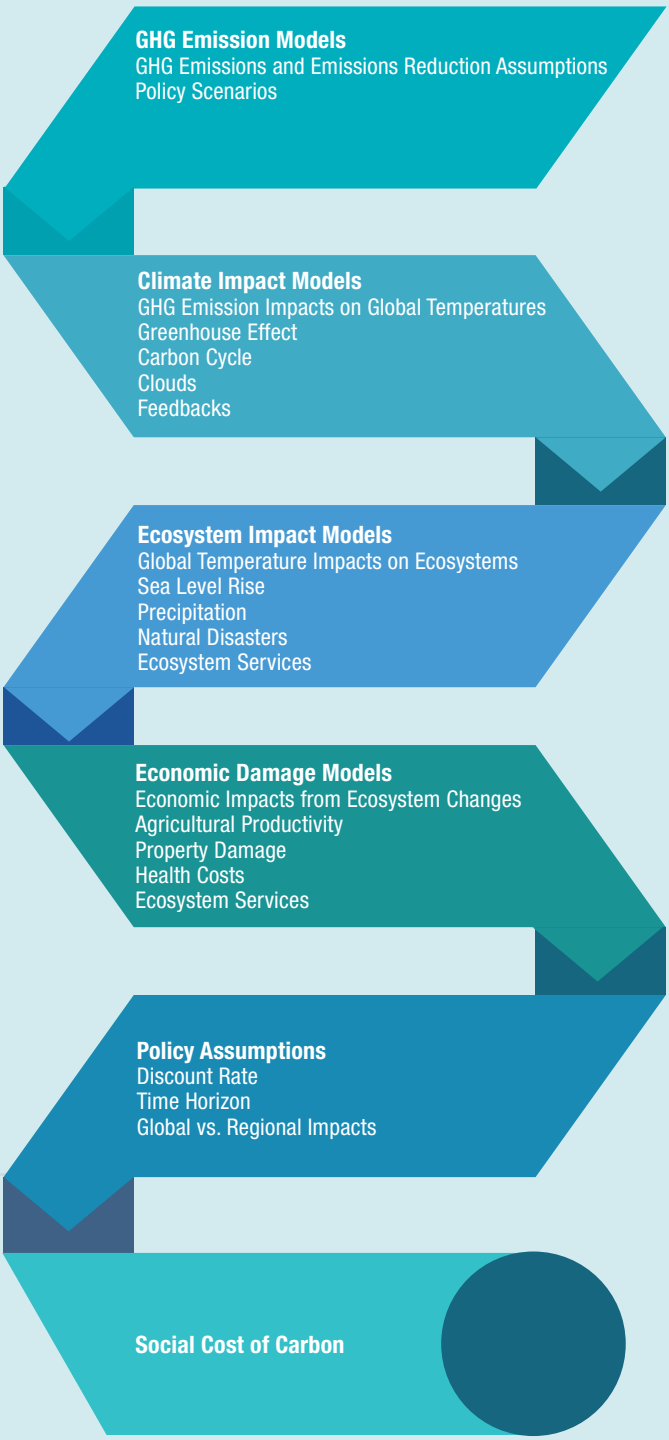
the National Academies of Sciences, Engineering, and Medicine, the SCC represents:[3]

> *. . . a comprehensive measure of the net damages—that is, the monetized value of the net impacts—from global climate change that result from an additional ton of (CO_2). These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society.*

The process of estimating the SCC is a complex endeavor that integrates numerous models within the academic fields of Earth sciences, economics, atmospheric chemistry, and policy analysis. Figure 1 shows a simplified schematic of some of the different scientific models and policy assumptions that are integrated when estimating the SCC.

Social costs frequently are used in policy analysis and regulatory activity. For regulations that are expected to reduce GHG emissions, the SCC becomes an avoided social cost and is therefore included as a benefit in a benefit-cost analysis. Benefit-cost analyses that do not include the SCC are implicitly valuing the benefit of reducing GHG emissions as having a value of zero. In a legal challenge to include the SCC in a federal regulatory impact analysis for a vehicle fuel economy rule, the U.S. 9th Circuit Court of Appeals stated that "[w]hile the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero."[4]

FIGURE 1
Modeling Process for Estimating the SCC



Complicating Issues

As Figure 1 shows, estimating the SCC is a complicated process that has numerous interacting layers of complexity and uncertainty. Some scientific fields are not developed enough to estimate the climate change impacts and associated costs, likely making the current SCC estimation undervalued.[5] The majority of issues complicating an estimate of the SCC are found in the scientific models, which are highly technical. For example, there is significant uncertainty over the effect future cloud formation or melting permafrost will have on global temperatures and GHG emissions because the scientific fields are complex and not well understood. Therefore, many of the scientific areas that contribute to estimating the SCC are constantly developing and evolving, and the models require continuous updating as the research progresses.

Additionally, the policy assumptions in estimating the SCC contain complex and complicating issues that can have significant effects on the results, although they are not necessarily scientific in nature. A short discussion of some of the most challenging policy assumptions in estimating the SCC follows.

> ***Discount Rate.*** Traditionally, discount rates are used to analyze financial investments by determining the present value of all future cash flows. Because money generated in the future has less value than in the present, discount rates are used to "discount" expected future cash flows to present-day values. This is not only because inflation erodes the value of future cash flows but also because people prefer to have a dollar in their pockets now rather than in the future. By comparing the discounted present value of future cash flows with the costs, investors can make better-informed present-day financial decisions.

  The choice of a discount rate can have a significant impact on estimating present-day values. For example, $10,000 received 10 years from now has a present-day value of $9,053 using a 1 percent discount rate but is worth only $3,885 using a 10 percent discount rate. A higher discount rate will produce a smaller present-day value.

  Discount rates frequently are used in regulatory benefit-cost analyses to "discount" the expected future societal damages or benefits to present-day values. However, choosing discount rates for regulatory policy analysis is more challenging than for investment analysis because the timeline for regulatory impacts is much longer. This raises serious ethical questions because choosing traditional discount rates used for investment purposes places very low present-day values on costs borne by future generations. For this reason, many climate researchers and economists recommend using an alternative, very low or even zero discount rate to ensure impacts to future generations are properly accounted for in the present day.[6]

> ***Time Horizon.*** Choosing a time horizon when estimating the SCC can have dramatic effects on the results. According to the IPCC's fourth assessment report, "About 50 percent of a (CO_2) increase will be removed from the atmosphere within 30 years and a further 30 percent will be removed within a few centuries. The remaining 20 percent may stay in the atmosphere for many thousands of years."[7] Because carbon emitted today has long-lived impacts on future generations, there is strong justification to model projected impacts out hundreds of years. Projecting scientific and economic models out hundreds of years creates significant uncertainties, though, and there is no consensus on how long the models should project impacts.

  Choosing a time horizon also has a significant impact on discounting expected future costs to present-day value. For example, using a 5 percent discount rate, $10,000 received in 10 years is worth $6,139 today, but the same

amount received in 100 years is worth just $76 today, and $10,000 received in 200 years is worth only 58 cents today. This example shows how discount rates can drastically erode the value of money over long periods.

> ***Global vs. Regional Impacts.*** In regulatory benefit-cost analysis, impacts usually are estimated only within the agency's jurisdiction. For instance, California agencies are required only to assess economic impacts within the state borders, and federal agencies typically assess only domestic impacts. GHG emissions present a regulatory challenge because climate change affects populations across the entire globe. This again raises legal and ethical questions as to whether sources of GHG emissions should be held accountable for global or only regional damages and impacts.

TABLE 1

2015 Interagency Working Group Estimates of the SCC

(in 2015$ per metric ton of CO_2)[9]

Year	5% Discount Rate	3% Discount Rate	2.5% Discount Rate	High Impact
2015	$13	$42	$65	$121
2020	$14	$48	$72	$142
2025	$16	$53	$79	$159
2030	$18	$58	$84	$176
2040	$24	$69	$97	$211
2050	$30	$80	$110	$245

FEDERAL ACTIVITY

Interagency Working Group

In 2009, the Council of Economic Advisers and the Office of Management and Budget convened the federal Interagency Working Group (IWG) on the SCC. IWG met on a regular basis to consider the scientific literature and policy assumptions in order to generate SCC estimates. According to IWG, "The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature."[8] Last updated in 2015, Table 1 shows a sample of the most recent SCC modeling estimates by IWG, which used integrated models to estimate the monetized damages associated with emitting 1 metric ton of carbon in a given year using three discount rates. For purposes of capturing uncertainty with the SCC estimates, IWG also included a high impact estimate, which represents lower-probability but more harmful outcomes from climate change.

Some examples of the U.S. Environmental Protection Agency (U.S. EPA) using IWG-recommended estimates of the SCC to analyze GHG impacts of rule-makings since 2010 include:

> Vehicle GHG emission standards and corporate average fuel economy standards

> Clean Power Plan

> New source performance standards

> Mercury and air toxics standards

In 2014, a U.S. district court judge decided to rescind the U.S. Bureau of Land Management's granting of a coal mining lease because the agency did not include costs associated with GHG emissions. The judge cited documents produced by IWG and concluded the decision to value the SCC as zero was "arbitrary and capricious."[10]

National Academies of Sciences, Engineering, and Medicine Recommendations

In 2015, IWG asked the National Academies of Sciences, Engineering, and Medicine (NAS) to review the latest research on modeling and economic aspects of climate change to inform its future revisions to the SCC. NAS published the requested report, "Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide," in January 2017. The report provides numerous recommendations for IWG on wide-ranging topics, including issues related to choosing discount rates, time horizons, and global vs. regional impacts. NAS also provided numerous recommendations on updating IWG's integrated models used to estimate the SCC based on recent developments in scientific research.

President Trump's Executive Order

President Trump signed an executive order, "Promoting Energy Independence and Economic Growth," on March 28, 2017. The executive order immediately disbanded IWG and declared its documents would no longer be representative of government policy. The order also instructed agencies to refer to a 2003 guiding document on regulatory analysis for estimating the SCC or other impacts from GHG emissions.

This change has led to SCC estimates that are drastically lower than previously estimated by IWG. Table 2 shows the SCC estimates produced by the U.S. EPA in October 2017 for its regulatory impact analysis to repeal the Clean Power Plan. The estimates are much lower than previous IWG estimates shown in Table 1, partly because the U.S. EPA chose to represent only domestic impacts and included a higher discount rate of 7 percent. The U.S. EPA considers these to be interim estimates until it can incorporate the best available science, including the NAS recommendations. These estimates are being used to support the U.S. EPA's primary argument that the Clean Power Plan is too costly and should be repealed.

TABLE 2
2017 U.S. EPA Estimates of SCC
(in 2015$ per metric ton of CO_2)

Year	7% Discount Rate	3% Discount Rate
2015	$1	$5
2020	$1	$6
2025	$1	$7
2030	$1	$7
2040	$2	$10
2050	$2	$11

CALIFORNIA ACTIVITY

Several California state agencies and departments were surveyed on their use of the SCC for this report, including the California Air Resources Board (CARB), Department of Transportation (Caltrans), High-Speed Rail Authority, Environmental Protection Agency (CalEPA), Energy Commission, Public Utilities Commission, and Natural Resources Agency. Although SB 617 (Calderon), Chapter 496, Statutes of 2011, requires agencies to conduct a more extensive economic analysis for major regulations, it does not require including the SCC when applicable. State agencies also do not receive any formal guidance from the Department of Finance to include the SCC in their regulatory economic analyses. Despite this, the SCC is being used by some state

agencies in a variety of ways, most prevalently by CARB and Caltrans.

California Air Resources Board

AB 197 (E. Garcia), Chapter 250, Statutes of 2016, requires CARB to consider the social costs of the emissions of GHGs when adopting rules and regulations and when measuring cost-effectiveness in its scoping plan. CARB interprets the definition of social costs found in AB 197 to refer to the IWG definition of the SCC. In CARB's 2017 Climate Change Scoping Plan, the SCC is used to estimate the benefits of avoided economic damages from the climate plan policies in 2030.[11] CARB estimated the benefits from reducing GHG emissions in 2030 by using a range of estimates provided by IWG in 2015. CARB uses the SCC as an informational metric to quantify some of the avoided social costs of reducing GHGs in the scoping plan.

CARB also recently utilized the 2015 IWG estimates of the SCC in regulatory analysis for the Low Carbon Fuel Standard 2018 amendments,[12] amendments to the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms,[13] and the Greenhouse Gas Emissions Standards for Crude Oil and Natural Gas Facilities.[14] As the proposed regulations are expected to reduce GHG emissions, the SCC was used to monetize these reductions and incorporate them into the benefits for the benefit-cost analysis. The Low Carbon Fuel Standard 2018 amendment is considered a major regulation, meaning the estimated economic impact is greater than $50 million, and CARB included the SCC estimates in its required Standardized Regulatory Impact Assessment.

Caltrans

Caltrans conducts life cycle and benefit-cost analyses for proposed federal interstate, state highway, and public transit projects, and uses the SCC when applicable. Project examples that might use the SCC in their benefit-cost analyses include highway expansion, rail/transit, operational improvement, and transportation management projects. Caltrans uses Cal–B/C, a Microsoft Excel-based tool, to conduct its benefit-cost analysis. Created by Caltrans to help inform project approval decision-making, Cal–B/C is a nationally recognized analytic tool used by local, regional, and other state agencies. Rather than a range of estimates, Cal–B/C incorporates a single 2015 IWG SCC estimate using the 3 percent discount rate to monetize the benefit of reducing GHG emissions when comparing project alternatives.[15]

Other Agencies

Although used less prevalently than at CARB and Caltrans, other state agencies have incorporated use of the SCC in the following ways:

- ***California Energy Commission (CEC).*** In 2016, consultants hired by CEC used the SCC as part of their Standardized Regulatory Impact Assessment on computers, computer monitors, and signage displays.[16] The consultants used a range of SCC estimates provided by the U.S. EPA, but it is unclear which estimates were used because the web page referenced in the assessment has been deleted by the U.S. EPA.
- ***High-Speed Rail Authority (HSRA).*** When analyzing the value of various sustainable design approaches for high-speed rail facilities, HSRA uses the SCC in its benefit-cost analytical software.[17] The software uses a single older 2010 IWG estimate of SCC using the 3 percent discount rate. HSRA also used the 2010 IWG SCC estimate in a supporting document for its 2014 business plan.

- ***California Department of Resources Recycling and Recovery (CalRecycle).*** According to CalEPA, CalRecycle is using the SCC in its regulatory process related to implementing aspects of SB 1383 (Lara), Chapter 395, Statutes of 2016, on short-lived climate pollutants. At the time of this report, the analysis was not yet finalized or publicly available.
- ***California Public Utilities Commission (CPUC).*** Although CPUC is not currently using SCC estimates, staff have discussed using the SCC in both SB 1383 proceedings and cost-effectiveness evaluations. Staff have expressed concerns about incorporating the SCC, considering the Trump administration's termination of IWG. CPUC uses a GHG adder that represents the actual cost to utility ratepayers of reducing carbon emissions, rather than the SCC.[18]

CURRENT SCC STATUS

As time passes since IWG's elimination, the 2015 IWG SCC estimates used by state agencies will become outdated and will fail to reflect recent scientific developments and modeling improvements. For example, the numerous NAS recommendations to IWG are not incorporated in SCC estimates being used by state agencies, as discussed previously. A recent study using updated methods found agricultural impacts from climate change are far more adverse than represented in models that estimate the SCC.[19] The study concludes the SCC values estimated under IWG are outdated and underestimated. Another recent study estimated the SCC could be up to six times greater than estimated by IWG.[20] A recent review of the research literature showed the SCC ranges widely from $7 to $125 per metric ton of CO_2, making it challenging for state agencies to individually derive updated SCC estimates for their use.[21]

Experts outside the federal government, including the Washington, D.C.-based think tank Resources for the Future (RFF), have launched multiyear efforts to advance the SCC.[22] In November 2017, Governor Brown joined 14 other governors in the U.S. Climate Alliance in announcing a partnership with two academic collaborations aimed at updating and improving the SCC, which includes RFF.[22] The U.S. Climate Alliance declared support for the independent work by the research institutions and committed to working together to share information and promote opportunities to use the SCC. California will not provide funding for the SCC research work, and it is unclear what specific involvement California will have through the partnership in directing the work. CARB reports that RFF should provide updated SCC estimates in two to three years.

Endnotes

1 https://www.yaleclimateconnections.org/2015/02/understanding-the-social-cost-of-carbon-and-connecting-it-to-our-lives/.

2 Neil Adger et al., "Summary for Policymakers," Intergovernmental Panel on Climate Change, working group II, 8th session, 4th assessment report, 2017, p. 17.

3 "Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide," National Academies of Sciences, Engineering, and Medicine, 2017, https://doi.org/10.17226/24651.

4 *Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin.,* 538 F.3d 1172 (9th Cir. 2008).

5 https://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch3s3-5-3-3.html.

6 "Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide," National Academies of Sciences, Engineering, and Medicine, 2017, https://doi.org/10.17226/24651.

7 Kenneth L. Denman et al., "Couplings Between Changes in the Climate System and Biogeochemistry," *Climate Change 2007: Physical Science Basis* (United Kingdom and New York: Cambridge University Press), 2007, ch. 7.

8 https://www.epa.gov/sites/production/files/2016-12/documents/scc_tsd_2010.pdf.

9 Bureau of Labor Statistics CPI Inflation Calculator. http://bls.gov/data/inflation_calculator.htm

10 Gilbert D. Metcalf and J.H. Stock, "Integrated Assessment Models and the Social Cost of Carbon: "A Review and Assessment of U.S. Experience," *Review of Environmental Economics and Policy,* vol. 11, no. 1, Winter 2017, p. 80–99.

11 https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

12 http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/LCFS_SRIA_CARB_11-16-17.pdf.

13 https://www.arb.ca.gov/regact/2016/capandtrade16/2nd15daynot.pdf.

14 https://www.arb.ca.gov/regact/2016/oilandgas2016/ogfsor.pdf.

15 http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_cost/files/Cal-BCTechSupplementVol4v4.pdf.

16 http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/SRIA_APPEFF_2016_All.pdf.

17 http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2014_Sec_7_CaHSR_Benefit_Cost_Analysis.pdf.

18 http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M175/K295/175295886.PDF.

19 Frances C. Moore et al., "New Science of Climate Change Impacts on Agriculture Implies Higher Social Cost of Carbon," *Nature Communications,* vol. 8, 2017.

20 Frances C. Moore and D.B. Diaz, "Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy," *Nature Climate Change*, 2015.

21 Dev Millstein et al., "Climate and Air-Quality Benefits of Wind and Solar Power in the United States," *Nature Energy*, no. 9, 2017.

22 http://www.rff.org/research/collection/rffs-social-cost-carbon-initiative.

23 https://www.governor.wa.gov/news-media/us-climate-alliance-partners-resources-future-and-climate-impact-lab-calculating-cost.

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