Primer on the Social Cost of Carbon

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by the

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What is the Social Cost of Carbon?

Carbon dioxide and other greenhouse gases (GHGs) trap the sun's heat in the earth's atmosphere. This radiative forcing changes the earth's climate — increasing air and water temperatures, shifting precipitation patterns, raising sea levels, acidifying oceans, and increasing the frequency and intensity of extreme events such as heat waves, heavy downpours, and droughts. [1] These climate hazards pose significant costs to society, including economic damages that result from harming human health, interrupting business operations, damaging infrastructure and environmental resources, and decreasing net agricultural productivity (e.g., from droughts, floods, and pests, despite near-term increases in photosynthesis from elevated levels of carbon dioxide). [2,3] For example, more frequent downpours increase the frequency of road closures, while more frequent and intense heat waves increase the number of power outages, affecting both local and regional communities. [4]

In economic terms, the negative effects of emitting GHGs represent an externality, meaning that the prices of goods and services that cause GHG emissions do not typically incorporate the cost of these emissions to society. The social cost of carbon (SCC) is a measurement of the long-term economic costs associated with emitting an additional ton of carbon dioxide. It can be used to evaluate the costs and benefits of implementing projects or policies that either increase or decrease carbon emissions. This marginal cost — the cost of an incremental unit of carbon dioxide emissions — can be aggregated to fit the scale of a specific project or policy. For example, it can be included in a cost-benefit analysis used to evaluate whether to develop a new (small or large) power generation facility or in a policy to determine an appropriate sector-wide cap on emissions.

How is the Social Cost of Carbon Calculated?

The SCC represents the net present value of the economic damages associated with emitting one ton of carbon dioxide. Calculating the SCC involves translating carbon dioxide emissions into changes in atmospheric greenhouse gas concentrations, and then in turn translating atmospheric concentrations into changes in temperature, temperature changes into other climate hazards, and climate hazards into economic damages.

The calculation of SCC involves various inputs, including:

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[1] IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

[2] Tol, R. S. (2011). The social cost of carbon. *Annu. Rev. Resour. Econ.*, *3*(1), 419-443

[3] IPCC, 2019: Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla et al, (eds.)].

[4] U.S. Department of Energy (2013). U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather.

- Projected growth of the economy, population, and emissions (incorporating assumptions about potential changes in technology and our ability to mitigate and sequester carbon dioxide in the future);
- Models of the earth's climate that assess the degree of warming resulting from a certain concentration of GHGs in the atmosphere;
- Integrated Assessment Models (complex equations), which measure the expected effect of climate hazards on economic sectors, as well as the probability and impact of catastrophic events; and the
- Social discount rate(s).

The social discount rate is one of the key factors influencing the dollar value of the SCC. The discount rate represents the value of economic losses today versus in the future (e.g., in 50 or 100 years). It reflects how much the damages to the welfare of future generations caused by carbon emissions are valued today. For example, a higher discount rate (e.g., 5%) lowers the SCC and implies that we place a relatively low value on economic losses in the more distant future compared to losses in the near future. A lower discount rate (e.g., 2%) implies the opposite. The social discount rate does not reflect inflation.

However, the SCC increases over time, regardless of the discount rate. This is because the concentration of carbon dioxide in the atmosphere accumulates over time as emissions continue and the earth's capacity to absorb heat in sinks, like the ocean, diminishes. Higher concentrations of carbon dioxide increasingly alter the earth's climate and lead to more economic damages.

Dollar Values of the Social Cost of Carbon

In 2009, the U.S. Office of Management and Budget established the federal Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), which has created one of the most sophisticated frameworks for calculating the SCC using best scientific practices (e.g., from the International Panel on Climate Change). [5] The IWG's latest estimates (provided in 2007 dollars and adjusted here to 2020 dollars in Table 1), have been adopted by most researchers and jurisdictions as the standard for use in analyzing the impacts of policies and programs. [6] Table 1 shows average estimates of the SCC for different social discount rates, as well as a high-end estimate which reflects a worst-case scenario in terms of the sensitivity of the climate to emissions and possible impacts on the economy.

These estimates account for a wide range of costs to society resulting from carbon dioxide emissions, including, but not limited to:

- Additional energy demand (via additional cooling) under rising temperatures;
- Increased property damage from rising sea levels and more frequent coastal flooding;

[5] National Academies of Sciences, Engineering, and Medicine 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. Washington, DC: The National Academies Press.

[6] IAWG Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (US Government, 2013).

- Increased heat-related illnesses from rising temperatures;
- Additional deaths and injuries from disease vectors (e.g., malaria and dengue fever) from rising temperatures;
- Reduced freshwater availability resulting from decreasing snowpack; and
- Net changes in agricultural productivity from increasing temperatures and carbon dioxide concentrations, as well as from changes in precipitation.

Because these damages are only a subset of the damages expected to occur under a changing climate, the SCC values are considered to represent a lower-bound estimate of the true cost of carbon. For example, these values exclude some damages that are difficult to quantify, such as respiratory illnesses from increased wildfire smoke, degradation of forests from increased pest infections, and declines in fisheries from ocean acidification.

Table 1: Social cost of carbon (in 2020 dollars per metric ton of CO_2) [7,8]

Year of Emission	Average estimate at 5% discount rate	Average estimate at 3% discount rate (IWG's central estimate)	Average estimate at 2.5% discount rate	High-impact estimate (95th percentile estimate at 3% discount rate)
2020	$15	$53	$78	$156
2025	$18	$58	$87	$175
2030	$20	$63	$93	$192
2035	$23	$70	$99	$213
2040	$26	$76	$107	$232
2045	$30	$81	$113	$249
2050	$33	$88	$120	$268

[7] Note that a metric ton (2,204 pounds) of carbon dioxide is equal to how much a typical car emits after 2,397 miles or about 15% of a typical home's emissions from electricity use for a year (see EPA Greenhouse Gas Equivalencies Calculator at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator).
[8] Reproduced (adjusting for inflation using the U.S. Bureau of Labor Statistics CPI Inflation Calculator) from the Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2016), available at: https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

Applications of the Social Cost of Carbon

The SCC can be used to evaluate and implement a wide range of policies and programs that may result in: (1) a change in the amount of GHGs emitted, or (2) the ability for GHGs to be sequestered (e.g., by forests or agricultural soils). For example, applications of SCC include electricity ratemaking, establishing resource management royalties, and setting emissions caps.

The federal government began requiring use of the SCC in 2008, by Executive Order, in federal rulemakings to value the costs and benefits associated with changes in carbon dioxide emissions (e.g., used by federal agencies in regulatory impact analyses and environmental impact statements). [9] The SCC is still used in federal rulemakings. Although, as of 2017, federal agencies are no longer required to use the IWG's SCC estimates, many agencies still use estimates based on the IWG's framework.

In addition, a growing number of states use the SCC when evaluating public sector investments and policies. Table 2 illustrates various applications of the SCC by different states. For example, the SCC has been increasingly used in the energy sector to:

- Help evaluate proposals for new power plants (e.g., in Colorado, Nevada, Minnesota, and Maine);
- Provide incentives for facilities to generate low-carbon electricity (e.g., in Illinois and New York); and
- Set compensation for owners of solar panels that supply surplus power to the grid (e.g., in Minnesota and New York).

Table 2: Examples of how states are using the social cost of carbon. [10]

State	Application	SCC value
Oregon	In 1997, Oregon became the first state to establish a price on carbon. House Bill 3283 required new fossil fuel plants to meet a carbon dioxide emissions standard set by the Energy Facility Siting Council (EFEC). The standard is set at 17% below the most efficient natural gas-fired facility operating in the country. New facilities must displace, offset, or pay for each ton of carbon dioxide the facility is projected to emit above the standard over its lifetime. [11] Oregon's price on carbon preceded the IWG's framework for calculating the SCC and does not reflect social	$1.90 per short ton (for emissions above the standard) *(Note: ODOE staff recommended in April 2020 that the EFSC initiate rulemaking to increase the price 50% to $2.85.)*

[9] National Academies of Sciences, Engineering, and Medicine 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. Washington, DC: The National Academies Press.

[10] Information on state applications is from the Institute for Policy Integrity. The Cost of Carbon. New York University School of Law (2020), available at: http://costofcarbon.org/states.

[11] Oregon Department of Energy, Carbon Dioxide Emission Standards, Oregon's Energy Facility Siting Council, March 2018. Available at: https://www.oregon.gov/energy/Get-Involved/rulemakingdocs/2018-03-21-CO2-RAC-Background.pdf

State	Application	SCC value
	costs. The 1997 statute limited any price change to a maximum 50% increase or decrease in any two-year period.	
	PGE and PacifiCorp voluntarily assess the risk posed by incorporating the SCC in their integrated resource planning, but are not required to add the SCC into their resource costs.	PGE: from ~$40 per metric ton for emissions in 2020 to ~$140 per metric ton for emissions in 2050.[12] PAC: from ~$40 per metric ton for emissions in 2020 to ~$110 per metric ton for emissions in 2040.[13] *(based on IWG SCC values in 2007 dollars)*
California	In 2016, California's Air Resources Board was mandated to use the SCC in its analyses of the state's climate change policy, including a cap on emissions.	To be based on IWG SCC values
	As of 2018, California's Public Utility Commission uses the SCC to value integrated distributed energy resources.	$123 per metric ton CO_2e[14] *(equal to the IWG SCC high-impact value for 2020 emissions with a 3% discount rate in 2007 dollars)*
Colorado	In 2017, the Colorado Public Utilities Commission ordered the Public Service Company of Colorado to account for the SCC in its energy resources plan (which includes information on the costs associated with generation resources).	$43 per metric ton CO_2 in 2022; increasing to $69 per metric ton in 2050 *(based on IWG SCC central values with a 3% discount rate in 2007 dollars)*
Illinois	In 2016, the state passed an energy bill which included provisions for valuing the social benefits of emissions-free energy. This analysis will be used in a zero emissions credits program.	$16.50 per megawatt-hour of electricity *(based on IWG SCC central estimate with a 3% discount rate, adjusted for inflation)*
Maine	As of 2015, Maine's Public Utility Commission has used the SCC to calculate the societal value of distributed solar resources.	$21 per megawatt-hour of electricity *(based on IWG SCC central value estimate with a 3% discount rate,*

[12] Portland General Electric. Integrated Resource Plan Draft. May 2019. Available at: https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning

[13] PacifiCorp. Integrated Resource Plan. October 2019. Available at: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2019_IRP_Volume_I.pdf

[14] Note that a ton of carbon dioxide equivalent (CO_2e) is a metric that normalizes other greenhouse gas emissions in terms of carbon dioxide by adjusting for their relative global warming potential.

State	Application	SCC value
		minus the Regional GHG Initiative carbon allowance cost)
Minnesota	As of 2018, the state's Public Utilities Commission requires utilities to use the SCC when planning for new projects. It uses the SCC in all commission proceedings, such as resource planning, acquisition, or diversification.	\$9.05 to \$43.05 per short ton of CO_2e [15] *(based on IWG SCC values)*
Nevada	As of 2018, Nevada's Public Utilities Commission directed utilities to account for the economic and environmental benefits in their integrated resource plans.	IWG SCC values will be used
New Jersey	In 2018, New Jersey enacted a zero emissions credits program (similar to those in Illinois and New York), which uses the SCC to estimate the value of energy from zero-emission facilities.	IWG SCC values are used as a reference
New York	New York's new (2019) climate statute (Climate Leadership and Community Protection Act) set a goal of 100% economy-wide net-zero carbon emissions by 2050. The act requires the Department of Environmental Conservation and the New York State Energy Research and Development Authority to establish a SCC for use by state agencies.	To be determined
	As of 2018, New York's clean energy standard and zero emissions credit use the SCC in calculating the value of using emission-free power rather than carbon-emitting fossil fuel power.	\$32.47 per short ton CO_2e *(based on IWG SCC values)*
	As of 2018, New York's regulators are using the SCC to price carbon in the state's wholesale electricity market. The SCC is used to monetize marginal climate damage costs in the benefit-cost analysis of a resource portfolio.	\$47.30 per short ton for 2020 emissions *(based on IWG SCC values)*
Washington	In 2019, the state enacted a law requiring the use of SCC in utility resource planning.	\$78 per metric ton for 2020 emissions *(based on IWG SCC values with a 2.5% discount rate)*
	The 2014 Executive Order 14-00 on carbon pollution reduction and clear energy action requires the state's agencies to account for the external cost of GHGs when considering costs and benefits of energy efficiency improvements.	IWG SCC values to be used

[15] Note that there is a slight difference between a short ton (2,000 pounds) and a metric ton (2,204 pounds).