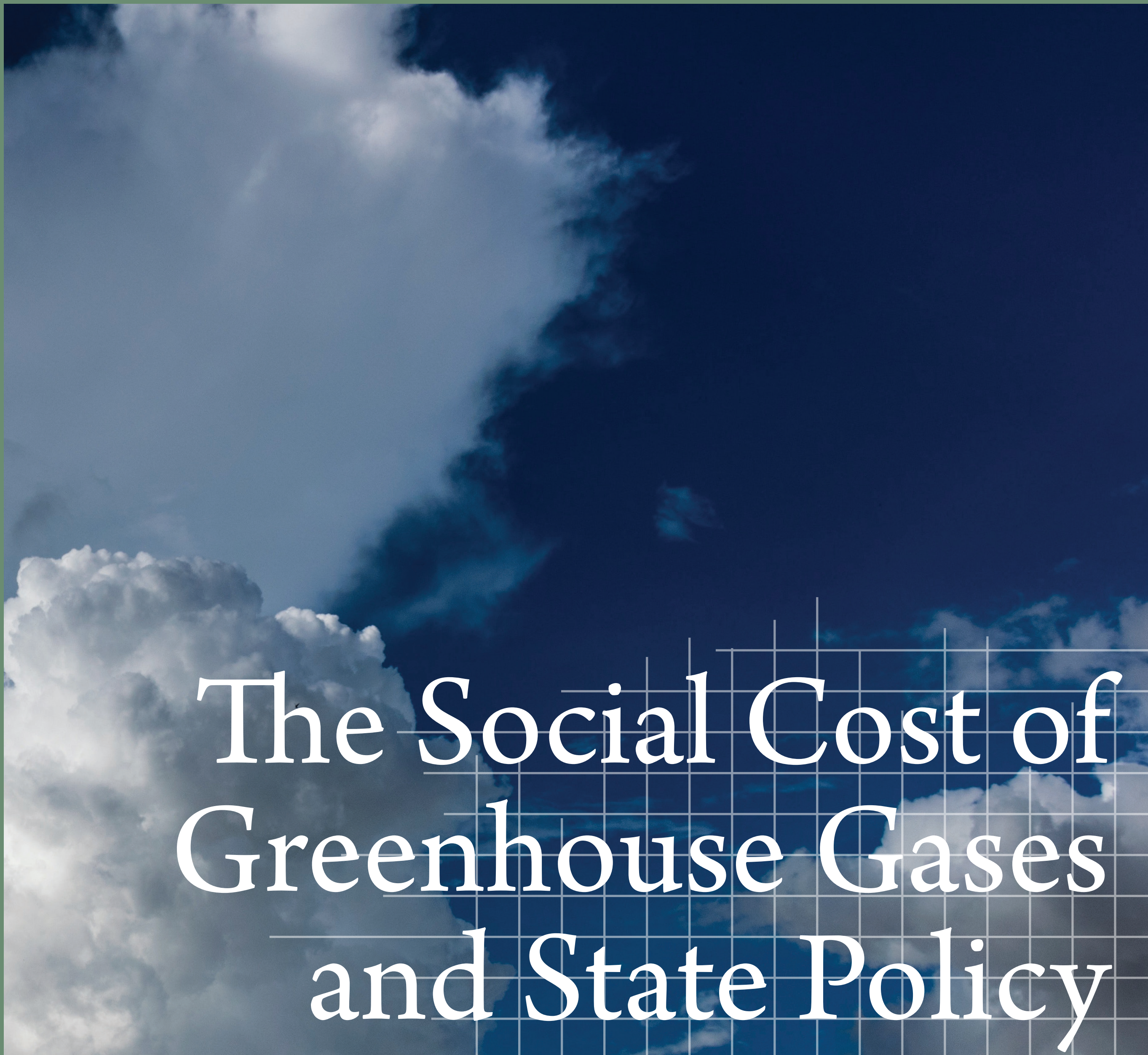

The Social Cost of Greenhouse Gases and State Policy

A Frequently Asked Questions Guide

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Executive Summary

Scientists predict that climate change will have, and in some cases has already had, severe consequences for society, like the spread of disease, decreased food security, and coastal destruction. These damages from emitting greenhouse gases are not reflected in the price of fossil fuels, creating what economists call "externalities." **The social cost of carbon (SCC) is a metric designed to quantify and monetize climate damages, representing the net economic cost of carbon dioxide emissions.** Simply, the SCC is a monetary estimate of the damage done by each ton of carbon dioxide that is released into the air. The SCC can be used to evaluate policies and guide decisions that affect greenhouse gas emissions.

At the federal level, the SCC has been used by numerous agencies for regulatory impact analysis and in environmental impact statements; however, the SCC can also be used across a range of other areas, including electricity ratemaking, resource management policy and royalty setting, setting emissions caps, and establishing a carbon price. States should use the SCC in a number of different contexts to aid in making rational policy decisions in a transparent manner. Many states are already using the SCC in their decisionmaking.

The best estimates of the SCC for states to draw from are currently the 2016 estimates from the federal government's Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), despite the fact that this group was recently disbanded. The 2016 IWG estimates are based on the most up-to-date science and economics and were arrived at through an academically rigorous, transparent, and peer-reviewed process. The National Academies of Science, Engineering and Medicine (NAS) conducted a thorough review of the IWG estimates in 2016, and a group of scholars at the nongovernmental organization Resources for the Future has begun a project to update the SCC based on the NAS recommendations.

State decisionmakers can benefit from an understanding of several issues related to the SCC, including discount rates, time horizons, and the global nature of the IWG estimate. States should also know that the IWG calculated additional estimates specifically for the social cost of methane and the social cost of nitrous oxide, which are more precise quantifications of the social costs of emissions of those greenhouse gases than simply multiplying the SCC by the global warming potential of those gases, and can be used in all of the scenarios where the SCC can be used.

There are many misguided critiques of the SCC made by those who would prefer less regulation of greenhouse gases, but this should not deter decisionmakers from using the SCC. In fact, there are a wide range of resources that decisionmakers can use while exploring how and why to use the SCC.

What Is the SCC?

Scientists predict that climate change will have, and in some cases has already had, severe adverse consequences for society, like the spread of disease, decreased food security, and coastal destruction. These damages from emitting greenhouse gases are not reflected in the price of fossil fuels, creating what economists call "externalities." **The social cost of carbon (SCC) is a metric designed to quantify and monetize climate damages, representing the net economic cost of carbon dioxide emissions.** Simply, the SCC is a monetary estimate of the damage done by each ton of carbon dioxide[1] that is released into the air.

The SCC can be used to evaluate policies and guide decisions that affect greenhouse gas emissions.

What is the best estimate of the SCC for states to use?

The federal government's Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), which operated from 2009-2017, remains the best source for SCC estimates. Its methodology, and why its estimates are the best available values for the SCC, are discussed below. Values for the social cost of other greenhouse gases are also discussed in a later section.

Table 1 is from the Interagency Working Group's 2016 Technical Support Document and shows the SCC estimates, in 2017 dollars, at five-year intervals. In all of the IWG technical support documents, their figures are given in 2007 dollars, but the values presented here in Table 1 are inflated to current (2017) dollars for ease of reference.

Table 1: Social Cost of CO_2 (in 2017 dollars per metric ton of CO_2)[2]

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 (95^{th} percentile estimate at 3% discount rate)
2020	$14	**$50**	$74	$148
2025	$17	**$55**	$82	$166
2030	$19	**$60**	$88	$182
2035	$22	**$66**	$94	$202
2040	$25	**$72**	$101	$220
2045	$28	**$77**	$107	$236
2050	$31	**$83**	$114	$254

1 Note that a metric ton (2,204 pounds, also known as the tonne) is slightly different from both a short ton (2,000 pounds) and a long ton (2,240 pounds). There are many ways to conceptualize a metric ton (2,204 pounds) of carbon dioxide. A metric ton of carbon dioxide is 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). An important distinction is that, because carbon dioxide consists of carbon and oxygen, 3.67 metric tons of carbon dioxide is equivalent to 1 metric ton of carbon.

2 Interagency Working Grp. on Soc. 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) [hereinafter TSD 2016], at 4, *available at* https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

Note that the value of the SCC increases over time. This is because the further in the future greenhouse gases are emitted, the greater the damages they will cause, due to the effects of accumulation. Therefore, it is important to calculate the full stream of climate effects, i.e., to take into consideration the emissions from every year of a policy, so that these increasing damages are reflected. The importance of calculating a full stream of future effects, rather than choosing only one year for analysis, is discussed in a later section.

What's included in the SCC number? What isn't?

The numbers in Table 1 reflect climate damages as estimated by combining three "Integrated Assessment Models"—specifically, DICE, FUND, and PAGE. These models translate carbon dioxide emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and temperature changes into economic damages.[3]

DICE calculates the effect of temperature on the global economy using a global damage function that is not disaggregated by impacts to specific sectors.[4] Alternately, PAGE, looks at economic, noneconomic, and catastrophic damages. Finally, FUND considers a number of specific market and nonmarket sectors, including: agriculture, forestry, water, energy use, sea level rise, ecosystems, human health, and extreme weather.[5]

Quantified impacts represented in the models include: changes in energy demand (via cooling and heating); changes in agricultural output and forestry due to alterations in average temperature, precipitation levels, and CO_2 fertilization; property lost to sea level rise; increased coastal storm damage; changes in heat-related illnesses; some changes in disease vectors (e.g. malaria and dengue fever); changes in fresh water availability; and some general measures of catastrophic and ecosystem impacts.

It is important to note, however, that these models omit or poorly quantify some highly significant damage categories, and therefore, the SCC values in Table 1 should be considered lower-bound estimates of the actual costs of marginal carbon emissions. In fact, many experts believe the IWG SCC values are severe underestimates (even while endorsing their continued use for the time being as the best currently available estimates).

Damages that are poorly quantified or omitted from the IAMs are listed in Table 2.

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[3] Interagency Working Grp. on Soc. Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2010) [hereinafter TSD 2010], at 5, *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

[4] TSD 2010, *supra* note 3, at 6.

[5] TSD 2010, *supra* note 3, at 7.

Table 2: Damages Omitted from the SCC[6]

Category	Specific Impacts Missing from the SCC*
Health	Respiratory illness from increased ozone pollution, pollen, and wildfire smoke
	Lyme disease
	Death, injuries, and illness from omitted natural disasters and mass migration
	Water, food, sanitation, and shelter
Agriculture	Weeds, pests, and pathogens
	Food price spikes
	Heat and precipitation extremes
Oceans	Acidification, temperature, and extreme weather impacts on fisheries, species extinction and migration, and coral reefs
	Storm surge interaction with sea level rise
Forests	Ecosystem changes such as pest infestations and pathogens, species invasion and migration, flooding and soil erosion
	Wildfire, including acreage burned, public health impacts from smoke pollution, property losses, and fire management costs (including injuries and deaths)
Ecosystems	Biodiversity***, habitat**, and species extinction**
	Outdoor recreation** and tourism
	Ecosystem services**
	Rising value of ecosystems due to increased scarcity
	Accelerated decline due to mass migration
Productivity and economic growth	Impacts on labor productivity and supply from extreme heat and weather, and multiple public health impacts across different damage categories
	Impacts on infrastructure, capital productivity, and supply from extreme weather events, and diversion of financial resources toward climate adaptation
	Impact on research and development from diversion of financial resources toward climate adaptation
Water	Availability and competing needs for energy production, sanitation, and other uses
	Flooding
Transportation	Changes in land and ocean transportation
Energy	Energy supply distributions
Catastrophic impacts and tipping points	Rapid sea level rise**
	Methane releases from permafrost**
	Damages at very high temperatures***
	Unknown catastrophic events

6 Peter Howard, Cost of Carbon Project. Omitted Damages: What's Missing From the Social Cost of Carbon (2014), *available at* http://costofcarbon.org/reports/entry/omitted-damages-whats-missing-from-the-social-cost-of-carbon [hereinafter "Omitted Damages"].

Category	Specific Impacts Missing from the SCC*
Inter- and intra-regional conflict	National security
	Increased violent conflicts from refugee migration from extreme weather, and food, water, and land scarcity

* Climate impacts that have been largely unquantified in the economics literature and are therefore omitted from SCC models.

** These impacts are represented in a limited way in one or more of the SCC models: 1) they may be included in some models, and not others; 2) they may be included only partially (e.g., only one or several impacts of many in the category are estimated); 3) they may be estimated using only general terms not specific to any one damage—in these instances, estimated damages are usually very small relative to their potential magnitude, and relative to the impacts explicitly estimated in the models. See complete report for details.

*** While technically represented in SCC models through extrapolations from small temperature changes, there are no available climate damage estimates for large temperature changes, and these may be catastrophic.

Is there a state-specific SCC we can use?

No, there is no SCC estimate that only reflects climate damages to individual states. No models can accurately calculate a domestic-only, let alone a state-only SCC (see more below). Furthermore, as detailed in the next section, it is in your state's best interest to use an estimate of the global damages of a ton of CO_2. Your state benefits tremendously from actions of other states and other countries to mitigate climate change, and for numerous reasons discussed below, the use of a global SCC helps encourage reciprocal policy choices. Your state's citizens and businesses also have financial and other interests that extend far beyond your physical borders. If all states or countries used jurisdiction-specific numbers, the result would be significant underregulation.

Why should our state use a global number?

Not only is it best economic practice to estimate the global damages of U.S. greenhouse gas emissions in regulatory analyses and environmental impact statements, but no existing methodology for estimating a "domestic-only" value is reliable or complete. If a state agency is required to provide a domestic-only estimate, the existing, deficient methodologies must be supplemented to reflect international spillovers to the United States, U.S. benefits from foreign reciprocal actions, and the extraterritorial interests of U.S. citizens including financial interests and altruism. The same applies to any attempt to use a state-specific SCC value.

From 2010 through 2016, federal agencies based their regulatory decision and National Environmental Policy Act (NEPA) reviews on global estimates of the social cost of greenhouse gases. Though agencies often also disclosed a "highly speculative" range that tried to capture exclusively U.S. climate costs, emphasis on a global value was recognized as more accurate given the science and economics of climate change, economic practices, and consistency with U.S. strategic goals.[7]

To avoid a global "tragedy of the commons" that could irreparably damage all countries, including the United States, every government worldwide should ideally set policy according to the global social cost of greenhouse gases.[8] Because greenhouse pollution does not stay within geographic borders but rather mixes in the atmosphere and affects the climate

7 *See generally* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017) [hereinafter "Howard & Schwartz 2017"].

8 *See* Garrett Hardin, *The Tragedy of the Commons*, 162 Science 1243 (1968) ("[E]ach pursuing [only its] own best interest . . . in a commons brings ruin to all."), 1244.

worldwide, each ton emitted by the United States or a particular U.S. state not only creates domestic harms, but also imposes large externalities on the rest of the world. Conversely, each ton of greenhouse gases abated in another country benefits the United States along with the rest of the world. A Policy Integrity report, "Foreign Action, Domestic Windfall," calculates that global actions on climate change—particularly by Europe, and including efforts of the United States and other countries—already benefited the United States by over $200 billion as of 2015. Furthermore, the report finds that, as of 2015, climate policies worldwide—including efforts by Europe, Canada, and many other countries, as well as U.S. policies from the time—could generate upwards of $2 trillion in direct benefits to the United States by 2030.[9]

If all countries set their greenhouse emission levels based on only domestic costs and benefits, ignoring the large global externalities, the aggregate result would be substantially sub-optimal climate protections and significantly increased risks of severe harms to all nations, including the United States. The same concept would apply to state policies where global externalities are not taken into account. Thus, basic economic principles demonstrate that the United States stands to benefit greatly if all countries apply global social cost of greenhouse gas values in their regulatory decisions and project reviews. Indeed, the United States stands to gain hundreds of billions or even trillions of dollars in direct benefits from efficient foreign action on climate change.[10]

Therefore, a rational tactical option in the effort to secure an economically efficient outcome is for the United States and individual states to continue using global social cost of greenhouse gas values.[11] The United States is engaged in a repeated strategic dynamic with several significant players—including the United Kingdom, Germany, Sweden, and others—that have already adopted a global framework for valuing the social cost of greenhouse gases.[12] For example, Canada and Mexico have explicitly borrowed the U.S. estimates of a global SCC to set their own fuel efficiency standards.[13] States have also entered into this international dynamic, with California coordinating with Canada on its cap-and-trade program and with a coalition of states and cities agreeing to uphold the pledges from the Paris Agreement. For the United States or any individual state to now depart from this collaborative dynamic by selecting to a domestic-only estimate could undermine the country's long-term interests and could jeopardize emissions reductions underway in other countries, which are already benefiting all 50 U.S. states and territories.

There are significant, indirect costs to trade, human health, and security likely to "spill over" to the United States as other regions experience climate change damages.[14] Due to its unique place among countries—both as the largest economy with trade- and investment-dependent links throughout the world, and as a military superpower—the United States is particularly vulnerable to effects that will spill over from other regions of the world. Spillover scenarios could entail a

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9 Peter Howard & Jason Schwartz, Inst. for Pol'y Integrity, Foreign Action, Domestic Windfall: The U.S. Economy Stands to Gain Trillions from Foreign Climate Action (2015), at 2, *available at* http://policyintegrity.org/files/publications/ForeignAction-DomesticWindfall.pdf.

10 *Id.*

11 *See* Robert Axelrod, The Evolution of Cooperation 10-11 (1984) (on repeated prisoner's dilemma games).

12 *See* Howard & Schwartz 2017, *supra* note 7, at 260.

13 *See* Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations, SOR/2013-24, 147 Can. Gazette pt. II, 450, 544 (Can.), *available at* http://canadagazette.gc.ca/rp-pr/p2/2013/2013-03-13/html/sor-dors24-eng.html ("The values used by Environment Canada are based on the extensive work of the U.S. Interagency Working Group on the Social Cost of Carbon."); Jason Furman & Brian Deese, *The Economic Benefits of a 50 Percent Target for Clean Energy Generation by 2025*, White House Blog (June 29, 2016) (summarizing the North American Leader's Summit announcement that U.S., Canada, and Mexico would "align" their SCC estimates).

14 Indeed, the integrated assessment models used to develop the global SCC estimates largely ignore inter-regional costs entirely, *see* Omitted Damages, *supra* note 6; though some positive spillover effects are also possible, such as technology spillovers that reduce the cost of mitigation or adaptation, *see* S. Rao et al., *Importance of Technological Change and Spillovers in Long-Term Climate Policy*, 27 Energy J. 123, 123–39 (2006); overall spillovers likely mean that the U.S. share of the global SCC is underestimated, *see* Jody Freeman & Andrew Guzman, *Climate Change and U.S. Interests*, 109 Columbia L. Rev. 1531 (2009).

variety of serious costs to the United States as unchecked climate change devastates other countries. Correspondingly, mitigation or adaptation efforts that avoid climate damages to foreign countries will radiate benefits back to the United States as well.[15]

For more details on the justification for a global value of the social cost of greenhouse gases, see Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*.[16] Another strong defense of the global valuation as consistent with best economic practices appears in a letter published in the March 2017 issue of *The Review of Environmental Economics and Policy*, co-authored by Nobel laureate Kenneth Arrow.[17]

How and why states should use the SCC?

Why should my state use the SCC?

As noted above, the SCC is a tool for internalizing externalities; specifically, it provides a monetary value for the cost of carbon emissions that will result from a particular decision. Without having this value on hand, a decisionmaker is faced with imperfect, incomplete information and may struggle to make a policy choice that maximizes net social welfare. The economic literature supports monetizing climate effects to achieve these goals because monetization helps put the impact of climate damages in context.

If an analysis only qualitatively discusses the effects of global climate change, decisionmakers and the public will tend to overly discount that specific action's potential contribution. Without context, it is difficult for decisionmakers and the public to assess the magnitude and climate consequences of a proposed action. Quantification of these emissions and the monetization of their effects makes it easier to compare costs and benefits.

Monetization provides much-needed context for otherwise abstract consequences of climate change. It allows decision-makers and the public to weigh all costs and benefits of an action—and to compare alternatives—using the common metric of money. Monetizing climate costs, therefore, better informs the public and helps "brings those effects to bear on [an agency's] decisions."[18] The tendency to ignore non-monetized effects is the result of common but irrational mental heuristics like probability neglect. For example, the phenomenon of probability neglect causes people to reduce small probabilities entirely down to zero, resulting in these probabilities playing no role in the decision-making process.[19] This heuristic applies even to events with long-term certainty or with lower-probability but catastrophic consequences, so long as their effects are unlikely to manifest in the immediate future. Weighing the real risks that, decades or centuries from now, climate change will fundamentally and irreversibly disrupt the global economy, destabilize earth's ecosystems, or compromise the planet's ability to sustain human life is challenging; without a tool to contextualize such risks, it is far easier to ignore them. Monetization tools like the social cost of carbon (and the social cost of other greenhouse gases) are designed to solve this problem: by translating long-term costs into present values, concretizing the harms of climate change, and giving due weight to the potential of lower-probability but catastrophic harms.

15 *See* Freeman & Guzman, *supra* note 14, at 1563-93.

16 Howard & Schwartz 2017, *supra* note 7.

17 Richard Revesz, Kenneth Arrow et al., *The Social Cost of Carbon: A Global Imperative*, 11 Review of Environmental Economics and Policy 172 (2017).

18 *See* Baltimore G. & E. Co. v. NRDC, 462 U.S. 87 (U.S. 1983) at 96.

19 Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law* (John M. Olin Law & Economics, Working Paper No. 138, 2001), *available at* http://ssrn.com/abstract=292149.

Finally, the SCC enables regulators and policymakers to take into account the effect of their decisions on society as a whole, as climate change is a global problem. This consideration can encourage reciprocal actions from other actors, including other U.S. states and other countries. We discuss more above why the "global" SCC estimates are the best ones.

What are the possible applications of the SCC in state policymaking?

Even though the IWG estimates were developed for use in regulatory analysis, there is wide support for use of the SCC in other contexts. The SCC is useful for evaluating nearly all energy regulations and environmental rules and actions. In general, using the SCC allows us to compare the costs of limiting carbon dioxide pollution to the costs of climate change. The SCC should be used in all appropriate instances, including but not limited to rulemaking that addresses greenhouse gas emissions, electricity ratemaking and regulation, natural resource valuation and royalty setting, regulatory cost-benefit analysis for climate actions, environmental impact statements, and setting carbon emissions caps or taxes.

In market-based emissions reduction schemes, the SCC should be fully internalized to allow the environmental attributes of clean energy resources to be more accurately valued and to ensure carbon-free resources are not under-valued. For states that are members of the Regional Greenhouse Gas Initiative (RGGI), for example, a state-level effort to price carbon should take into account the SCC minus the RGGI price of carbon. Note that if the RGGI carbon price were as high as the SCC, then this additional step would not be necessary.

The SCC can also allow state policymakers to compare the costs and benefits of a proposal or set the stringency of a regulation. If a state wants to set a greenhouse gas emissions cap, for example, legislators can use the SCC to determine what the cap should be. Overall, using the SCC gives states information on which measures will ultimately improve societal well-being vis-à-vis climate change.

Finally, using the SCC to gauge the climate impacts of coal and natural gas leases can help determine new royalty rates, helping the states to improve their leasing programs. Using the SCC can help ensure that taxpayers get a fair deal out of the use of their state's lands, rather than having a disproportionate amount of benefits fall to privates companies while costs fall to the public.

The emissions from my state/this leasing decision/this regulation/this project are so small, does the SCC still apply?

The SCC absolutely still applies. The argument that individual projects are too small to monetize misunderstands the tools available for valuing climate effects. The social cost of greenhouse gases protocols were developed to assess the cost of actions with "marginal" impacts on cumulative global emissions, and the metrics estimate the dollar figure of damages for one extra ton of greenhouse gas emissions.[20] The integrated assessment models used to derive the estimates work by first running a climate-economic-damage calculation for a baseline scenario, and then adding a single additional unit of greenhouse gas emissions to the model and rerunning the calculation. The approach assumes that the marginal damages from increased emissions will remain constant for small emissions increases relative to gross global emissions.[21] In other words, the monetization tools are in fact perfectly suited to measuring the marginal effects—that is, the effects of one additional unit—of emissions from smaller-scale decisions, as well as from nationwide policies.

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[20] TSD 2010, *supra* note 3, at 1.

[21] *Id.* at 2.

Which states are already using the SCC, and how?

It may be helpful for state decisionmakers to understand how other states have begun to use the SCC to date. States including—but not limited to—California, Colorado, Illinois, Minnesota, Maine, New York, and Washington have all begun using the federal SCC in energy-related analysis, recognizing that the SCC is the best available estimate of the marginal economic impact of carbon emission reductions. Several states and municipalities have used the SCC in the context of renewable energy decisionmaking, and Illinois and New York State have used the SCC to assess the value of the avoided carbon emissions from using nuclear generation rather than fossil fuel generation.

California

California uses the SCC in the Air Resources Board's scoping plan for the state's updated climate change policy. In the January 2017 draft of the scoping plan, the economic analysis uses the IWG SCC with a range of discount rates (2.5-percent to 5-percent).[22] Two companion bills were passed in the California legislature in the summer of 2016 to renew the policy, one of which mandates the Air Resources Board to consider the "social costs of greenhouse gases" in the analysis that underlies the new policy's accompanying regulations.[23] The Board is still finalizing the scoping plan as of October 2017.

The use of the SCC is also being discussed in a proceeding on the value of integrated distributed energy resources at the California's Public Utilities Commission.[24]

Colorado

In March 2017, the Colorado Public Utilities Commission ordered that the Public Service Company of Colorado, also knowns as Xcel Energy, take into account the IWG's social cost of carbon in its Energy Resource Plan (ERP).[25] ERPs include information on costs associated with generation resources, as well as alternatives. Advocates for the use of the "federally developed" SCC noted that the Colorado PUC had considered externalities, like public health effects, in other ERP proceedings. The PUC has authority under §40-2-123(1)(b), C.R.S to include such considerations in resource planning. One SCC advocate, Western Resource Advocates (WRA), argued that §40-2-123(1)(b) should be read to permit the Colorado PUC to "consider two distinct categories: (1) the likelihood of new environmental regulation; and (2) the risk of higher future costs associated with the emission of greenhouse gas pollution." The Colorado PUC ultimately agreed with WRA's reading and cited it as support for their decision.[26]

Illinois

Illinois has recently used the SCC in its "zero emissions credit" (ZEC) policy. In late 2016, the state legislature passed a comprehensive energy bill, which included provisions for valuing the social benefits of energy from zero-emissions

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[22] Cal. Air Res. Bd., The 2017 Climate Change Scoping Plan Update: The Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target (Jan. 20, 2017).

[23] Cal. Health & Safety Code §§ 38562.5 & 38562.7.

[24] Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Distributed Energy Resources ("IDER") (Rulemaking No. 14-10-003).

[25] Colorado PUC, Decision No. C17-0316, In the Matter of the Application of Public Service Company of Colorado for Approval of its 2016 Electric Rersource Plan, Proceeding No. 16A-0396E, *available at* https://www.dora.state.co.us/pls/efi/efi_p2_v2_demo.show_document?p_dms_document_id=863402.

[26] *Id*. at 84.

facilities. This bill uses the SCC to make this calculation, using an SCC value of $16.50/MWh, based on the IWG SCC estimates.[27]

Maine[28]

Maine enacted the Act to Support Solar Energy Development in Maine during its 2014 legislative session.[29] Section 1 of the Act states that it is "in the public interest to develop renewable energy resources, including solar energy, in a manner that protects and improves the health and well-being of the citizens and natural environment of the State while also providing economic benefits to communities, ratepayers and the overall economy of the State."[30] Section 2 of the Act instructs the Public Utilities Commission to determine the value of distributed solar energy generation in the State, evaluate implementation options, and deliver a report to the Legislature. Maine has a statute that calls for calculating "the societal value of the reduced environmental impacts of the energy."[31] Maine uses the federal SCC, as well as other monetized costs and benefits, to make this calculation. Because carbon costs are already partially embedded in existing energy valuation as a result of carbon emissions caps under RGGI, the net SCC is calculated by subtracting the embedded carbon allowance costs from the total SCC. The Maine Public Utilities Commission uses the federal SCC, with a "central" 3-percent discount rate estimate.

Maine's statute requires the PUC to assess how to maximize social welfare in its policy options. Maine addresses this requirement by weighing market costs and benefits with the monetized values of societal benefits in a cost-benefit analysis.[32]

Minnesota

The Minnesota Public Utilities Commission is statutorily mandated to consider externalities for all proceedings.[33] Between 1993, when this provision was enacted, and 2014, Minnesota used its own methodology to determine the costs of $PM_{2.5}$, SO_2, NO_x, and CO_2.[34] In 2014, after environmental advocacy groups filed a motion requesting that the Minnesota Public Utility Commission update these figures, the commission referred the issue to the Office of Administrative Hearings to assess how to value externalities, including whether the state should use the federal SCC.[35]

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27 20 I.L.C.S. 3855 §§ 1-75(d-5)(1)(B). ("(i) Social Cost of Carbon: The Social Cost of Carbon is $16.50 per megawatthour, which is based on the U.S. Interagency Working Group on Social Cost of Carbon's price in the August 2016 Technical Update using a 3% discount rate, adjusted for inflation for each year of the program. Beginning with the delivery year commencing June 1, 2023, the price per megawatthour shall increase by $1 per megawatthour, and continue to increase by an additional $1 per megawatthour each delivery year thereafter.")

28 For more details, *see* Maine Public Utilities Commission, Maine Distributed Solar Valuation Study (2015) [hereinafter "MPUC Distributed Solar Valuation Study"], *available at* http://www.maine.gov/mpuc/electricity/elect_generation/documents/MainePUCVOS-FullRevisedReport_4_15_15.pdf .

29 Maine P.L ch. 562 (Apr. 24, 2014) (codified at 35-A M.R.S.A. §§ 3471-3474).

30 *Id.* at § 3472(1).

31 *Id.* at § 2(1).

32 MPUC Distributed Solar Valuation Study, *supra* note 28, at 4.

33 ("The [Public Utilities] commission shall, to the extent practicable, quantify and establish a range of environmental costs associated with each method of electricity generation. A utility shall use the values established by the commission in conjunction with other external factors, including socioeconomic costs, when evaluating and selecting resource options in all proceedings before the commission, including resource plan and certificate of need proceedings.") 2016 Minnesota Stat. § 216B.2422 subd. 3.

34 State of Minnesota, Office of Administrative Hearings, In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statutes Section 216B.2422, Subdivision 3, Docket No. OAH 80-2500-31888, MPUC E-999/CI-14-643, Findings of Fact, Conclusions, and Recommendations: Carbon Dioxide Values, 2-3 (Apr. 15, 2016) [hereinafter "Minnesota Opinion"].

35 *Id.* at 4.

The Administrative Judge who reviewed the matter[36] recommended that "the Commission adopt the Federal Social Cost of Carbon as reasonable and the best available measure to determine the environmental cost of CO_2, establishing a range of values including the 2.5 percent, 3.0 percent, and 5 percent discount rates . . . ."[37]

The decision to use the federal SCC, with some adjustments, was recently upheld, and the Minnesota PUC will use a range of $9.05 to $43.06 per short ton by 2020. Notably, Minnesota has decided to adjust the federal SCC estimates by using a range between the IWG's "central" 3-percent estimate and a lower bound that uses a 5-percent discount rate and a shortened timeline of only 100 years. As discussed below, uncertainty does not support the argument for shortening the time horizon for the SCC.

New York

The New York Public Service Commission first used the SCC in January 2016 in the benefit-cost analysis order for the Reforming the Energy Vision proceeding. The PSC chose the SCC, as opposed to other methods suggested by commenters, as the tool to monetize marginal climate damage costs in the benefit-cost analysis of a resource portfolio. New York's Clean Energy Standard and accompanying Zero Emissions Credit ("ZEC") take into account the SCC in calculating the value of using emission-free nuclear power, rather than carbon-emitting fossil fuel power.[38] The New York Public Service Commission's program is designed to compensate nuclear plants based directly on the value of the carbon-free attributes of their generation.[39]

The commission recognized that the federal SCC is the "best available estimate of the marginal external damage of carbon emissions."[40] It then designed the ZEC based upon the difference between the average April 2017 through March 2019 projected SCC, as published by the IWG in July 2015 and a fixed baseline portion of the cost that is already captured in the market revenues received by the eligible nuclear facilities under RGGI.[41] The New York Public Service Commission uses the federal SCC, with a "central" 3-percent discount rate estimate.[42] This approach was upheld in June 2017 by the United States District Court for the Southern District of New York.[43]

Washington

In April 2014, Governor Jay Inslee issued an executive order on climate change. Executive Order 14-04 on Washington Carbon Pollution Reduction and Clear Energy Action requires the state's agencies to "[e]nsure the cost-benefit tests for energy-efficiency improvements include full accounting for the external cost of greenhouse gas emissions."[44] With these requirements in mind, the Washington State Energy Office, in consultation with the Washington State Department of Ecology, recommended that all state agencies use the federal SCC estimates.

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[36] The Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statutes Section 216B.2422, Subdivision 3.

[37] Minnesota Opinion, *supra* note 34, at 123.

[38] *See* Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard, New York Public Service Comm'n Case No. 15-E-0302, Order Establishing a Clean Energy Standard 131 (Aug. 1, 2016) [hereinafter "CES Order"].

[39] Denise Grab & Burcin Unel, "New York's Clean Energy Standard Is a Key Step Toward Pricing Carbon Pollution Fairly," Utility Dive (Aug.18, 2016), *available at* http://www.utilitydive.com/news/new-yorks-clean-energy-standard-is-a-key-step-toward-pricing-carbon-pollut/424741/.

[40] CES Order, *supra* note 38, at 134.

[41] *Id.* at 129.

[42] New York State Department of Public Service's Staff White Paper on Benefit-Cost Analysis in the Case No. 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision.

[43] Coalition For Competitive Electricity et al v. Zibelman et al. (S.D.N.Y., Jul. 27, 2017).

[44] State of Washington, Exec. Order 14-04 at 6, *available at* http://www.governor.wa.gov/sites/default/files/exe_order/eo_14-04.pdf.

The Energy Office noted that the federal SCC estimates do not capture the total cost of emitting carbon dioxide into the atmosphere (total future climate damages), and because of omitted damages and uncertainty about the full scope of the consequences of climate change, the Office recommended using the lower 2.5-percent discount rate.[45]

The Energy Office supports using the 2.5-percent discount rate for a number of reasons.[46] First, the 2.5-percent discount most closely matches with the existing Office of Financial Management real discount rate of 0.9 percent. Second, the IWG models focus only on the damages of climate change that can be easily monetized and since the trend seems to be that additional impacts are monetized with each federal SCC update, Washington can stay ahead of this trend by choosing the lowest IWG discount rate. Third, because the discount rate applied to greenhouse gas emissions is an "intergenerational" discount rate applied to society as a whole, the discount rate used in this context should be substantially lower than private sector discount rates. Fourth, there is a higher risk associated with underestimating the SCC than with overestimating it. Fifth, Washington State wants to lead on climate issues, so it makes sense for the Energy Office to put forth the higher associated SCC.

Washington state agencies have begun following the recommendation of the state's energy office and using a 2.5-percent discount rate for their economic analyses involving greenhouse gas emissions. The Department of Ecology uses the 2010 IWG estimates, with a value of $78 per metric ton for 2020 emissions.[47]

My state already has a climate policy or a renewable energy policy in place, so why should we still use the SCC?

There is nothing that should prevent a state from using the SCC, even if there is already a climate or renewable energy policy, like a renewable portfolio standard (RPS) or clean energy standard (CES). In fact, states can use the SCC in setting RPSs or CESs or other renewable resource mandates. RPSs and CESs alone can be economically problematic, as such policies effectively "'pick winners" in electricity markets. The first-best public policy tool to promote clean energy resources and achieve greenhouse gas reductions is to use a carbon price that would lead the power generators that use dirtier energy resources to internalize the externalities caused by greenhouse gas emissions fully. Using a carbon price to achieve greenhouse gas reductions would be the least-cost way of achieving carbon emission reductions compared to other alternatives.[48] However, using the SCC to set the standard can make RPSs or CESs more efficient. When state agencies are determining standards, the SCC and other externalities, including other societal costs and benefits, should be incorporated into the analysis. We elaborate on this process below.

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45 Washington State Department of Commerce, Social Cost of Carbon: Washington State Energy Office Recommendation for Standardizing the Social Cost of Carbon When Used for Public Decision-Making Processes, at 3 (2014).

46 *Id.* at 3-5.

47 *See, e.g.,* State of Washington, Department of Ecology, Preliminary Cost-Benefit and Least-Burdensome Alternative Analysis: Chapter 173-442 WAC Clean Air Rule & Chapter 173-441 WAC Reporting of Emissions of Greenhouse Gases (2016), at 38, *available at* https://fortress.wa.gov/ecy/publications/documents/1602008.pdf; inflated from 2007 dollars to 2017 dollars.

48 Erik Paul Johnson, *The Cost Of Carbon Dioxide Abatement From State Renewable Portfolio Standards*, 36 Res. Energy Econ. 332, 349–50 (2014); Karen Palmer & Dallas Burtraw, *Cost-Effectiveness Of Renewable Electricity Policies*, 27 Energy Econ. 873, 893 (2005); Carolyn Fischer, Richard G. Newell, Environmental And Technology Policies For Climate Migration, 55 J. of Envtl. Econ. Mgmt. 142, 160 (2008) (finding that lowest cost emissions reductions come from a combination of an emissions price with a small "learning subsidy").

Are the federal IWG numbers still the best?

The "central" SCC estimate of around $50 per ton of CO_2[49] is the best currently available estimate for the external cost of carbon dioxide emitted in the year 2020. Of course, there is uncertainty over the science and economics of climate change. This uncertainty is due to the complexity of the climate system, the difficulty of placing a monetary value on environmental services, the long time horizon over which climate change occurs, and the unprecedented amount of carbon emissions that have entered the atmosphere since the industrial revolution. As science and economics improve and progress, this uncertainty will decline, but uncertainty can never be fully eliminated from future predictions. The fact that there is uncertainty does not mean that there is no social cost of carbon dioxide emissions. If anything, this uncertainty implies that we should take stronger action, as discussed in the below section on uncertainty.[50]

We discuss at length below why the IWG estimates still represent the best methodology and are based on the best available science and economics. Recent executive orders do not change this fact.

How were the IWG numbers developed?

A federal court ruling spurred the development of the SCC. A 2008 ruling by the U.S. Court of Appeals for the Ninth Circuit required the federal government to account for the economic effects of climate change in a regulatory impact analysis of fuel efficiency standards.[51] As a result, President Obama convened the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) in 2009 to develop an SCC value for use in federal regulatory analysis.

The SCC was developed through an academically rigorous, regularly-updated, and peer-reviewed process. The SCC values were developed using the three most widely cited climate economic impact models that link physical impacts to the economic damages of carbon dioxide emissions. All of these IAMs—DICE, FUND, and PAGE[52]—have been extensively peer reviewed in the economic literature.[53] The newest versions of the models were also published in peer-reviewed literature.[54] The IWG gives each model equal weight in developing the SCC values.[55] The IWG also used peer-reviewed inputs to run these models.[56] The IWG conducted an "extensive review of the literature . . . to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates."[57] For each parameter, the IWG documented the inputs it used, all of which are based on peer-reviewed literature.[58]

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49 For 2020 emissions in 2017 dollars, from TSD 2016, Table 2, inflated with the Bureau of Labor Statistics Inflation Calculator, *available at* https://data.bls.gov/cgi-bin/cpicalc.pl.

50 William D. Nordhaus, *Projections and Uncertainties about Climate Change in an Era of Minimal Climate Policies*. National Bureau of Economic Research (2016), *available at*: http://www.nber.org/papers/w22933.pdf.

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

52 More specifically: DICE (Dynamic Integrated Climate and Economy), developed by William D. Nordhaus (more information *available at* http://www.econ.yale.edu/~nordhaus/); PAGE (Policy Analysis of the Greenhouse Effect), developed by Chris Hope; and FUND (Climate Framework for Uncertainty, Negotiation, and Distribution), developed by Richard Tol (more information *available at* http://www.fund-model.org/). *See* TSD 2010, *supra* note 3, at 5.

53 *See* TSD 2010, *supra* note 3, at 4-5.

54 *See* TSD 2016, *supra* note 2, at 6; *see also* William Nordhaus, *Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches*, 1 J. Ass'n Envtl. & Resource Economists 273 (2014).

55 TSD 2016, *supra* note 2, at 5.

56 *Id.* at 5-29.

57 *Id.* at 6.

58 *See* TSD 2010, *supra* note 3, at 12-23.

The analytical methods that the IWG applied to its inputs were also peer-reviewed, and the IWG's methods have been extensively discussed in academic journals.[59]

The IWG's analytical process in developing the SCC was transparent and open, designed to solicit public comment and incorporate the most recent scientific analysis. Beginning in 2009, the Office of Management and Budget and the Council of Economic Advisers established the IWG, composed of scientific and economic experts from the White House, Environmental Protection Agency, and Departments of Agriculture, Commerce, Energy, Transportation, and Treasury, to develop a rigorous method of valuing carbon dioxide reductions resulting from regulations.[60] In February 2010, the IWG released estimated SCC values, and an accompanying Technical Support Document that discussed the IAMs, their inputs, and the assumptions used in generating the SCC estimates.[61] In May 2013, after all three IAMs had been updated and used in peer-reviewed literature, the IWG released revised SCC values, with another Technical Support Document.[62] The U.S. Government Accountability Office examined the IWG's 2010 and 2013 processes, and found that these processes were consensus-based, relied on academic literature and modeling, disclosed relevant limitations, and incorporated new information via public comments and updated research.[63]

To further enhance the academic rigor of the process, the IWG requested that the NAS undertake a review of the latest research on modeling the economic aspects of climate change to help the IWG assess the technical merits and challenges of potential approaches for future updates to the SCC.[64] In mid-2016, the NAS issued an interim report to the IWG that recommended against conducting an update to the SCC estimates in the near term, but that included recommendations about enhancing the presentation and discussion of uncertainty regarding particular estimates.[65] The IWG responded to these recommendations in its most recent Technical Support Document from 2016,[66] which included an addendum on the social cost of methane and the social cost of nitrous oxide.[67] The NAS issued a report in January 2017 that contained a roadmap for how SCC estimates should be updated.[68] In the 2017 report, the NAS recommended future improvements to the IWG three-model methodology, but in the meantime, the NAS supported the continued near-term use of the existing social cost of greenhouse gas estimates based on the DICE, FUND, and PAGE models, as used by federal agencies to

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59 *See, e.g.*, Michael Greenstone *et al.*, *Developing a Social Cost of Carbon for U.S. Regulatory Analysis: A Methodology and Interpretation*, 7 Rev. Envtl. Econ. & Pol'y 23 (2013); Frank Ackerman & Elizabeth Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon*, Econ.: The Open-Access, Open-Assessment E-Journal (Apr. 2012), at 6 (reviewing the IWG's methods and stating, "[T]he Working Group analysis is impressively thorough.")

60 TSD 2010, *supra* note 3, at 2-3.

61 *See generally* TSD 2010, *supra* note 3.

62 *See* Interagency Working Group on the Social Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2013) [hereinafter TSD 2013].

63 Gov't Accountability Office, Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates (2014) [hereinafter Gov't Accountability Office].

64 *See* TSD 2016, *supra* note 2, at 2.

65 National Academies of Sciences, Engineering and Medicine, Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update (2016) [hereinafter NAS First Report].

66 TSD 2016, *supra* note 2.

67 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (2016) [hereinafter "TSD 2016 Addendum"], *available at* https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/august_2016_sc_ch4_sc_n2o_addendum_final_8_26_16.pdf.

68 The National Academy of Sciences accepted public comment during its review process. Policy Integrity submitted comments during that process. Institute for Policy Integrity, Recommendations for Changes to the Final Phase 1 Report on the Social Cost of Carbon, and Recommendations in Anticipation of the Phase 2 Report on the Social Cost of Carbon (Apr. 29, 2016) [hereinafter "Policy Integrity NAS comments"] *available at* http://policyintegrity.org/documents/Comments_to_NAS_on_SCC.pdf.

date.[69] The SCC estimates will need to be updated over time to reflect the best-available science and changing economic conditions, and, as we discuss below, a nongovernmental organization Resources for the Future plans to undertake this project based on the NAS 2016 and 2017 recommendations.

How have the IWG numbers been used to date?

The IWG numbers have been used extensively in federal regulatory analysis, on more than one hundred occasions since the first estimates were published in 2010.[70] In fact, the mandate for federal agencies to use the IWG SCC values was ended only recently, on March 28, 2017, with Executive Order 13,783. The SCC has, in fact, been used in a range of contexts aside from federal regulatory impact analysis, which we discuss above.

Who has endorsed the IWG numbers?

The IWG SCC numbers have been endorsed or otherwise supported by the NAS, the Government Accountability Office, and the federal courts. The NAS has supported the continued near-term use of the existing social cost of greenhouse gas estimates based on the DICE, FUND, and PAGE models, as federal agencies have done to date.[71] Additionally, the Government Accountability Office found in 2014 that the estimates derived from these models and used by federal agencies are consensus-based, rely on peer-reviewed academic literature, disclose relevant limitations, and are designed to incorporate new information via public comments and updated research.[72] In fact, the social cost of greenhouse gas estimates used in federal regulatory proposals and EISs have been subject to approximately 100 distinct public comment periods.[73] The economics literature confirms that estimates based on these three IAMs remain the best available estimates.[74] Finally, in 2016, the U.S. Court of Appeals for the Seventh Circuit held the estimates used to date by agencies are "reasonable," and other courts have supported agencies' use of these values.[75]

Did a recent Trump Executive Order delegitimize the IWG numbers?

Absolutely not. While the IWG was disbanded and its guidance was withdrawn, which is unfortunate, the IWG still used the best data, the best models, and the best methodologies that are currently available. Accordingly, the IWG estimates are still the best numbers for states to use and still the only numbers endorsed by the NAS.

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[69] Specifically, NAS concluded that a near-term update was not necessary or appropriate and the current estimates should continue to be used while future improvements are developed over time. NAS First Report, *supra* note 66.

[70] Howard & Schwartz 2017, Appendix A; Jane A. Leggett. *Federal Citations to the Social Cost of Greenhouse Gases*, Congressional Research Service (Mar 21, 2017), *available at* https://fas.org/sgp/crs/misc/R44657.pdf.

[71] Specifically, NAS concluded that a near-term update was not necessary or appropriate and the current estimates should continue to be used while future improvements are developed over time. NAS First Report, *supra* note 66.

[72] Gov't Accountability Office, *supra* note 63.

[73] Howard & Schwartz 2017, *supra* note 7, at Appendix A.

[74] E.g., Richard G. Newell *et al.*, *Carbon Market Lessons and Global Policy Outlook*, 343 Science 1316 (2014); Bonnie L. Keeler *et al.*, *The Social Costs of Nitrogen*, 2 Science Advances e1600219 (2016); Richard L. Revesz *et al.*, *Global Warming: Improve Economic Models of Climate Change*, 508 Nature 173 (2014) (co-authored with Nobel Laureate Kenneth Arrow, among others).

[75] *See e.g.* Zero Zone v. Dept. of Energy, No. 14-2147 (7th Cir., Aug. 8, 2016), at 44 (finding that the agency "acted reasonably" in using global estimates of the social cost of carbon, and that the estimates chosen were not arbitrary or capricious); High Country Conservation Advocates v. U.S. Forest Service (D. Colo., June 27, 2014); Western Organization of Resource Councils v. U.S. Bureau of Land Management (D. Mont., Jan. 25, 2017).

If the Trump administration comes out with a new number, should we use it?

Only if the number is consistent with best practices and reflects the best available literature and the recommendations of the NAS panel. If a new number uses a discount rate higher than 5-percent, selects only one of the three IAMs used by the IWG or an IAM that does not take into account nonmarket damages, if it only uses a domestic number, or if it dramatically shortens the time horizon, for example, that would be inconsistent with best practices and should not be followed by the states.

How will the numbers be updated?

In May 2017, the environmental economics think tank, Resources for the Future (RFF), launched a program to update the SCC based on the recommendations made by the NAS.[76] The new initiative contains several key elements. RFF will create a new integrated framework for the estimation process and revise some of the socioeconomic projections to better reflect uncertainty. RFF will also convene domestic and international actors and conduct educational outreach on how to use the SCC. States should consider looking to RFF for new SCC estimates in the coming years.

Are there other estimates of the SCC?

While states should be careful not to cherry-pick a single estimate from the literature, it is noteworthy that various estimates in the literature are consistent with the numbers derived from a weighted average of DICE, FUND, and PAGE—namely, with a central estimate of about $50 per ton of carbon dioxide, and a high-percentile estimate of about $148, for year 2020 emissions (in 2017 dollars, at a 3-percent discount rate). The latest central estimate from DICE's developers is $104 (at a 3-percent discount rate);[77] from FUND's developers, $14;[78] and from PAGE's developers, $148, with a high-percentile estimate of $386.[79]

Similarly, a comparison of international estimates of the social cost of greenhouse gases suggests that a central estimate of $50 per ton of carbon dioxide is a very conservative value. Sweden places the long-term valuation of carbon dioxide at $168 per ton; Germany calculates a "climate cost" of $171 per ton of carbon dioxide in the year 2030; the United Kingdom's "shadow price of carbon" has a central value of $118 by 2030; Norway's social cost of carbon is valued at $106 per ton for year 2030 emissions; and various corporations have adopted internal shadow prices as high as $82 per ton of carbon dioxide.[80]

All of this—not to mention the omitted damages that are not included in the SCC—suggests, again, that the IWG estimates, while still the most reliable and most endorsed numbers for federal and state-level U.S. policymaking, should be treated as a lower bound.

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[76] Resources for the Future, "Updating and Improving the Social Cost of Carbon," *available at* http://www.rff.org/research/collection/updating-and-improving-social-cost-carbon; Nat'l Acad. Sci., Eng. & Medicine, Valuing Climate Damages: Updating Estimates of the Social Cost of Carbon Dioxide 3 (2017) [hereinafter "NAS Second Report"].

[77] William Nordhaus, *Revisiting the Social Cost of Carbon*, Proc. Nat'l Acad. Sci. (2017) (estimate a range of $21 to $141).

[78] D. Anthoff & R. Tol, *The Uncertainty about the Social Cost of Carbon: A Decomposition Analysis Using FUND*, 177 Climatic Change 515 (2013).

[79] C. Hope, *The social cost of CO_2 from the PAGE09 model*, 39 Economics (2011); C. Hope, *Critical issues for the calculation of the social cost of CO_2*, 117 Climatic Change, 531 (2013). Values inflated to 2017 dollars.

[80] *See* Howard & Schwartz 2017, *supra* note 7, at Appendix B. All figures in 2017 USD.

What methodological choices went into the IWG numbers?

Which models?

Economists estimate the SCC by linking together a global climate model and a global economic model. The resulting models are called Integrated Assessment Models, or IAMs. This integration helps economists take a unit of carbon emissions and translate that into an estimate of the cost of the impact that emissions have on our health, well-being, and quality of life in terms of dollars. The models are based on the best available science and economics from peer-reviewed publications.

The IWG uses the three most–cited models, which are William Nordhaus' DICE model (Yale University), Richard Tol's FUND model (Sussex University), and Chris Hope's PAGE model (Cambridge University).

Why did the IWG select a 3% discount rate as a "central" estimate?

The IWG produced four different SCC estimates by using different discount rates. According to the IWG's 2010 Technical Support Document, the 3-percent discount rate estimate is considered the central estimate because it uses the central (i.e., middle) discount rate and is based on an average or mean, rather than worse-than-expected, climate outcome. The use of this "central" discount rate is supported by surveys of experts.[81] The IWG further argues that the 3% is consistent with OMB's Circular A-4 guidance, corresponds to the correct discounting concept (i.e., the consumption rate of interest) when damages are measured in consumption-equivalent units, and roughly corresponds to the after-tax riskless interest rate.

The central estimate is an "average" or mean estimate in the sense that the IWG ran its models thousands of times using slightly varying assumptions to reflect uncertainty, and equally weighted the results to produce a mean average. It is important to note that the SCC is an average estimate of marginal damages, and not an average estimate of average damages. In other words, the SCC is the average estimate of the marginal impacts caused by an additional unit of greenhouse gases. It is not appropriate to interpret the SCC as an estimate of the average damages of all greenhouse gases ever emitted. It is how much the next unit of emissions will cost us.

First, what is a discount rate?

It is easiest to explain the idea of discount rates with a simple example: If offered $1 now or $1 in a year, almost everyone would choose to receive the $1 now. Most individuals would only wait until next year if they were offered more money in the future. The discount rate is how much more you would have to receive to wait until next year. Similarly, if individuals were asked to pay $1 now or $1 next year, most individuals would choose to pay $1 later. Most individuals would only pay now if they were asked to pay more money in the future. The discount rate is how much more you would have to pay in the future to be willing to pay $1 in the present.

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[81] Peter Howard & Derek Sylvan, *Expert Consensus on the Economics of Climate Change, Institute for Policy Integrity Report* (Dec. 2015); M.A. Drupp, *et al.*, *Discounting Disentangled: An Expert Survey on the Determinants of the Long-Term Social Discount Rate* (London School of Economics and Political Science Working Paper, May 2015) (finding consensus on social discount rates between 1-3%).

Why is the discount rate important?

The discount rate is one of the most important inputs in models of climate damages, with plausible assumptions easily leading to differences of an order of magnitude in the SCC. The climate impacts of present emissions will unfold over hundreds of years. When used over very long periods of time, discounting penalizes future generations heavily due to compounding effects. For example, at a rate of 1 percent, $1 million 300 years hence equals over $50,000 today; at 5 percent it equals less than 50 cents.[82] The discount rate changed by a factor of five, whereas the discounted value changed by more than five orders of magnitude. Depending on the link between climate risk and economic growth risk, even a rate of 1 percent may be too high.[83] Uncertainty around the correct discount rate pushes the rate lower still.[84]

Why is the IWG correct to exclude a 7% discount rate?

The IWG correctly excluded a 7-percent discount rate, a typical private sector rate of return on capital, for several reasons. First, typical financial decisions, such as how much to save in a bank account or invest in stocks, focus on private decisions and use private rates of return. However, here we are concerned with social discount rates because emissions mitigation is a public good, where individual emissions choices affect public well-being broadly. Rather than evaluating an optimal outcome from the narrow perspective of investors alone, economic theory would require that we make the optimal choices based on societal preferences (and social discount rates). Second, climate change is expected to affect primarily consumption, not traditional capital investments.[85] Guidelines of the federal Office of Management and Budget note that in this circumstance, consumption discount rates are appropriate.[86] Third, 7 percent is considered much too high for reasons of discount rate uncertainty and intergenerational concerns (further discussed below). Fourth, interest rates are at historic lows, with no indication of increasing, so traditional rates of return used to guide discount rate selection are too high at the present time.[87]

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82 Dallas Burtraw & Thomas Sterner, *Climate Change Abatement: Not "Stern" Enough?* (Resources for the Future Policy Commentary Series, Apr. 4, 2009), *available at* http://www.rff.org/Publications/WPC/Pages/09_04_06_Climate_Change_Abatement.aspx.

83 "If climate risk dominates economic growth risk because there are enough potential scenarios with catastrophic damages, then the appropriate discount rate for emissions investments is lower tha[n] the risk-free rate and the current price of carbon dioxide emissions should be higher. In those scenarios, the "beta" of climate risk is a large negative value and emissions mitigation investments provide insurance benefits. If, on the other hand, growth risk is always dominant because catastrophic damages are essentially impossible and minor climate damages are more likely to occur when growth is strong, times are good, and marginal utility is low, then the "beta" of climate risk is positive, the discount rate should be higher than the risk-free rate, and the price of carbon dioxide emissions should be lower." Robert B. Litterman, *What Is the Right Price for Carbon Emissions?*, Regulation, Summer (2013) 38-43, at 41 *available at* http://www.cato.org/sites/cato.org/files/serials/files/regulation/2013/6/regulation-v36n2-1-1.pdf.

84 *See* "Isn't there too much uncertainty around the SCC to use it?" on page 23.

85 "There are two rationales for discounting future benefits—one based on consumption and the other on investment. The consumption rate of discount reflects the rate at which society is willing to trade consumption in the future for consumption today. Basically, we discount the consumption of future generations because we assume future generations will be wealthier than we are and that the utility people receive from consumption declines as their level of consumption increases . . . . The investment approach says that, as long as the rate of return to investment is positive, we need to invest less than a dollar today to obtain a dollar of benefits in the future. Under the investment approach, the discount rate is the rate of return on investment. If there were no distortions or inefficiencies in markets, the consumption rate of discount would equal the rate of return on investment. There are, however, many reasons why the two may differ. As a result, using a consumption rather than investment approach will often lead to very different discount rates." Maureen Cropper, *How Should Benefits and Costs Be Discounted in an Intergenerational Context?*, 183 Resources 30, at 33.

86 *See* Office of Mgmt. & Budget, *Circular A-4*, Nat'l Archives (Sept. 17, 2003), *available at* https://georgewbush-whitehouse.archives.gov/omb/circulars/a004/a-4.html [https://perma.cc/GSV8-TAUR], at 33.

87 Council of Econ. Advisers, Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate at 1 (CEA Issue Brief, 2017) [hereinafter "CEA Brief"], *available at* https://obamawhitehouse.archives.gov/sites/default/files/ page/files/201701_cea_discounting_issue_brief.pdf.

What is a declining discount rate?

The IWG chose as one of its discount rates an estimate based upon declining discount rates. The 2.5-percent discount rate was included by IWG as a constant-rate approximation of a declining discount rate.[88] Since the IWG undertook its initial analysis, a consensus has emerged among leading climate economists that a declining discount rate should be used for climate damages to reflect long-term uncertainty in interest rates.[89] Arrow *et al* (2013) presents several arguments that strongly support the use of declining discount rates for long-term benefit-cost analysis.

But perhaps the best reason is the simple fact that there is considerable uncertainty around which interest rate to use: uncertainty in the rate points directly to the need to use a declining rate, as the impact of the uncertainty grows exponentially over time.[90] The uncertainty about future discount rates could stem from a number of reasons particularly salient to climate damages, including uncertainties in future economic growth, consumption, and the interest rate used by consumers.

Why should the central IWG estimate be interpreted as a lower bound?

A number of factors might result in using a SCC value that is higher than the estimate based on a 3-percent discount rate. Recent research has shown that the appropriate discount rate for intergenerational analysis may be even lower than that reflected in the SCC analysis, which would result in a higher SCC.[91] A jurisdiction might decide that the uncertainty associated with climate damages warrants using a discount rate that declines over time, leading to a higher SCC.[92] A consensus has emerged among leading climate economists that a declining discount rate should be used for climate damages to reflect long-term uncertainty in interest rates, and the NAS January 2017 recommendations to the IWG support this approach.[93] Furthermore, a number of types of damage from climate change are missing or poorly quantified in the federal SCC estimates, meaning that **the federal SCC estimate associated with a 3-percent discount rate should be interpreted as a lower bound on the central estimate**.[94]

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88 TSD 2010, *supra* note 3, at 23 ("The low value, 2.5 percent, is included to incorporate the concern that interest rates are highly uncertain over time. It represents the average certainty-equivalent rate using the mean-reverting and random walk approaches from Newell and Pizer (2003) starting at a discount rate of 3 percent. Using this approach, the certainty equivalent is about 2.2 percent using the random walk model and 2.8 percent using the mean reverting approach. Without giving preference to a particular model, the average of the two rates is 2.5 percent. Further, a rate below the riskless rate would be justified if climate investments are negatively correlated with the overall market rate of return. Use of this lower value also responds to certain judgments using the prescriptive or normative approach and to ethical objections that have been raised about rates of 3 percent or higher.")

89 The arguments here are primarily based on: Kenneth J. Arrow *et al.*, *Determining Benefits and Costs for Future Generations*, 341 Science 349 (2013); Kenneth J. Arrow *et al.*, *Should Governments Use a Declining Discount Rate in Project Analysis?*, Rev Environ Econ Policy 8 (2014); Richard G. Newell & William A. Pizer, *Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations?*, 46 J. Envtl. Econ. & Mgmt. 52 (2003); Maureen L. Cropper *et al.*, *Declining Discount Rates*, American Economic Review: Papers and Proceedings (2014); S.K. Rose, D. Turner, G. Blanford, J. Bistline, F. de la Chesnaye, and T. Wilson. *Understanding the Social Cost of Carbon: A Technical Assessment*. EPRI Report #3002004657 (2014).

90 Martin L. Weitzman, *Gamma Discounting*, 91 Am. Econ. Rev. 260, 270 (2001) [hereinafter "Weitzman 2001"].

91 CES Order, *supra* note 38; CEA Brief, *supra* note 87.

92 *See* Weitzman 2001, *supra* note 90. Kenneth J. Arrow *et al.*, *Determining Benefits and Costs for Future Generations*, 341 Science 349 (2013); Kenneth J. Arrow *et al.*, *Should Governments Use a Declining Discount Rate in Project Analysis?*, 8 Rev Environ Econ Policy 1 (2014); Maureen L. Cropper *et al.*, *Declining Discount Rates*, 104 Am. Econ. Rev. 538 (2014); Christian Gollier & Martin L. Weitzman, *How Should the Distant Future Be Discounted When Discount Rates Are Uncertain?* 107 Economics Letters 3 (2010). Policy Integrity further explores the use of declining discount rates in its recent comments to the National Academies of Sciences. Policy Integrity NAS comments, *supra* note 68.

93 NAS Second Report, *supra* note 76.

94 *See* Omitted Damages, *supra* note 6; Revesz *et al.* 2014, *supra* note 74.

As we discussed above, Washington State agencies have begun following the recommendation of the state's energy office and using a 2.5-percent discount rate for their economic analyses involving greenhouse gas emissions, for a number of reasons, including that the damages omitted from the IWG estimates and the uncertainty surrounding climate consequences warrant more dramatic action.[95]

Why did the IWG select a 300-year time horizon?

In 2017, NAS issued a report stressing the importance of a longer time horizon for calculating the social cost of greenhouse gases, the rationale for which is also included in the 2016 IWG Technical Support Document. The report states that, "[in the context of the socioeconomic damage, and discounting assumptions, the time horizon needs to be long enough to capture the vast majority of the present value of damages."[96] The report goes on to note that the length of the time horizon is dependent "on the rate at which undiscounted damages grow over time and on the rate at which they are discounted. Longer time horizons allow for representation and evaluation of longer-run geophysical system dynamics, such as sea level change and the carbon cycle."[97] In other words, after selecting the appropriate discount rate based on theory and data (in this case, 3 percent or below), analysts should determine the time horizon necessary to capture all costs and benefits that will have important net present values at the discount rate. Therefore, a 3 percent or lower discount rate for climate change implies the need for a 300-year horizon to capture all significant values. NAS reviewed the best available, peer-reviewed scientific literature and concluded that the effects of greenhouse gas emissions over a 300-year period are sufficiently well established and reliable as to merit consideration in estimates of the social cost of greenhouse gases.[98]

The best available science and economics thus supports a 300-year time horizon for climate effects. We note that, so far one state, Minnesota, has chosen a different time horizon. For the reasons above, this should not be considered a best practice.[99]

Why did the IWG recommend a global rather than domestic estimate?

As we discussed above, the IWG recommends using a global estimate for a number of reasons. Generally, a global number is appropriate because climate change is a global phenomenon and emissions that occur in one part of the world affect other parts of the world. The same is true for avoided emissions. Simply, if all countries set their greenhouse emission levels based on only domestic costs and benefits, ignoring the large global externalities, the aggregate result would be substantially sub-optimal climate protections and economically inefficient policies.

Why did the IWG develop separate numbers for methane and nitrous oxide, rather than just adjusting by their global warming potential?

The IWG has also developed robust federal estimates of the **social cost of methane (SCM)** and **social cost of nitrous oxide (SCN_2O)**. Methane and nitrous oxide are two important, and potent, greenhouse gases. Prior to the IWG's work

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95 *See*, e.g., State of Washington, Department of Ecology, Preliminary Cost-Benefit and Least-Burdensome Alternative Analysis: Chapter 173-442 WAC Clean Air Rule & Chapter 173-441 WAC Reporting of Emissions of Greenhouse Gases 38 (2016), *available at* https://fortress.wa.gov/ecy/publications/documents/1602008.pdf.

96 NAS Second Report, *supra* note 76, at 77.

97 *Id.*

98 NAS First Report, *supra* note 66, at 32.

99 See for more information, "Isn't there too much uncertainty around the SCC to use it?" on page 23.

on social costs for the emission of these pollutants, the SCC was multiplied by the Global Warming Potential (GWP) of each gas.[100] But, according to the IWG:

> "While GWPs allow for some useful comparisons across gases on a physical basis, using the [SCC]…to value the damages associated with changes in CO_2-equivalent emissions is not optimal…because non-CO_2 GHGs differ not just in their potential to absorb infrared radiation over a given time frame, but also in the temporal pathway of their impact on radiative forcing, which is relevant for estimating their social cost but not reflected in the GWP."[101]

In other words, because the GWP of each GHG changes over the lifetime of the gas, multiplying the SCC by the GWP in any particular year is inaccurate. The SCM and SCN_2O methodologies build directly on the IWG's SCC methodology, and replace the less accurate methodology of multiplying the SCC by these gases' relative global warming potential. The same rigorous, consensus-based, transparent process used for the federal SCC has shaped the federal SCM and federal SCN_2O estimates. Just as the federal SCC likely underestimates the true social cost of carbon, the federal SCM and SCN_2O are **likely to underestimate the true social cost of these other greenhouse gases** due to omitted damages and uncertainties regarding the scope of the effects in the underlying models.[102] Nonetheless, **the 2016 IWG SCM and SCN_2O are the best available estimates of the social costs associated with the emission of those greenhouse gases**.

Table 3: Social Cost of Methane Estimates (in 2017 dollars per metric ton)[103]

Year of Emission	Average estimate at 5% discount rate	Average estimate at 3% discountrate— IWG's Central Estimate	Average estimate at 2.5% discount rate	95th percentile estimate at 3% discount rate
2020	$648	**$1440**	$1920	$3839
2025	$780	**$1680**	$2159	$4439
2030	$912	**$1920**	$2399	$5039
2035	$1080	**$2159**	$2759	$5879
2040	$1200	**$2399**	$3119	$6598
2045	$1440	**$2759**	$3359	$7318
2050	$1560	**$2999**	$3719	$8038

[100] TSD 2016 Addendum, *supra* note 67, at 2 ("The potential of these gases to change the Earth's climate relative to CO_2 is commonly represented by their 100-year global warming potential (GWP). GWPs measure the contribution to warming of the Earth's atmosphere resulting from emissions of a given gas (i.e., radiative forcing per unit of mass) over a particular timeframe relative to CO_2. As such, GWPs are often used to convert emissions of non-CO_2 GHGs to CO_2-equivalents to facilitate comparison of policies and inventories involving different GHGs.")

[101] TSD 2016 Addendum, *supra* note 67, at 2.

[102] Alex L. Marten et al, *Incremental CH_4 and N_2O Mitigation Benefits Consistent with the U.S. Government's SC-CO_2 Estimates*. 15 Climate Policy 272 (2015). 15(2): 272-298 (2015, published online, 2014) [hereinafter "Marten et al."]; Environmental Defense Fund, Institute for Policy Integrity at New York University School of Law, Natural Resources Defense Council, and Union of Concerned Scientists Comments on EERE-2015-BT-STD-0016, Energy Conservation Standards for WICF Refrigeration System and EERE-2014-BT-STD-0031, Energy Conservation Standards for Residential Furnaces (Nov. 7, 2016).

[103] TSD 2016 Addendum, *supra* note 67, at 7.

Table 4: Social Cost of Nitrous Oxide Estimates (in 2017 dollars per metric ton)[104]

Year of Emission	Average estimate at 5% discount rate	Average estimate at 3% discountrate—IWG's Central Estimate	Average estimate at 2.5% discount rate	95th percentile estimate at 3% discount rate
2020	$5639	**$17,996**	$26,393	$46,788
2025	$6598	**$20,395**	$28,793	$52,787
2030	$7558	**$22,794**	$32,392	$58,785
2035	$8878	**$25,194**	$34,791	$65,984
2040	$10,078	**$27,593**	$38,390	$71,982
2045	$11,397	**$29,993**	$40,790	$79,180
2050	$13,197	**$32,392**	$44,389	$86,379

The SCM and SCN_2O were developed more recently, so have a shorter history of being used by federal—or state—agencies, but the figures were approved by the IWG and appear in an addendum to the group's 2016 Technical Support Document. They were also peer-reviewed by the EPA and by academic journals.[105] For other greenhouse gases beyond methane and nitrous oxide, adjusting the SCC with the gases global warming potential is fine. In fact, for now, it is the best option for state decisionmakers.

Common (but misguided) critiques of the SCC

Aren't there benefits of carbon dioxide emissions?

There are benefits to carbon dioxide, and some of these benefits, such as potential increases in agricultural yields, are captured in the SCC estimate. These benefits reduce the magnitude of the SCC. Other benefits that are the result of climate change are omitted, including the lower cost of supplying renewable energy from wind and wave sources, the increased availability of oil due to higher temperatures in the Arctic, and fewer transportation delays from snow and ice. However, omitted negative impacts almost certainly overwhelm omitted benefits.[106] As a consequence, $50 should be interpreted as a lower-bound central estimate.

The other benefits from the use of carbon fuels that are unrelated to climate change (such as economic output) are omitted from the SCC, but they are always included in any analysis in which the SCC is used. In a benefit-cost analysis, the cost of regulations, such as the potential loss of output, is always balanced against the benefits of carbon reductions as partially measured by the SCC.

If we adapt to climate change or develop new technologies, then won't the value of avoiding emissions be zero?

No. Adaptation and technological change are included in the IAMs already, explicitly or implicitly. In fact, DICE and FUND may overestimate the potential for adaptation by assuming high levels of costless adaptation. Additional research

[104] *Id.*

[105] Marten et al., *supra* note 102.

[106] Revesz *et al.* 2014, *supra* note 74; Omitted Damages, *supra* note 6.

on adaptation—particularly the ability of technological change and climate impacts to lower and raise, respectively, the cost of adaptation—is necessary. According to the 2010 IWG Technical Support Document,[107] future research may lead to an increase or decrease in future damages. But even under the overly optimistic assumptions about adaptation made by some models, in none of the IAMs is adaptation effective enough to significantly eliminate climate damages.

Isn't there too much uncertainty around the SCC to use it?

Absolutely not. Decisionmakers should not throw up their hands because of uncertainty. As the Ninth Circuit has held: "[W]hile the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero."[108] On the whole, uncertainty suggests an even higher SCC than estimated.

Uncertainty around climate change generally warrants more stringent climate policy and raises the SCC. Current integrated assessment models (IAMs) used to calculate the SCC show that the net effect of uncertainty about economic damage resulting from climate change, costs of mitigation, future economic development, and many other parameters raises the SCC compared to the case where models simply use our current best guesses of these parameters.[109] Even so, IAMs still underestimate the impact of uncertainty on the SCC by ignoring fundamental features of the climate problem: the irreversibility of climate change, society's aversion to risk and other social preferences, and many catastrophic impacts.[110] The next generation of numerical models designed to capture these features of the climate problem currently focus on the optimal tax (i.e., the SCC on the optimal emissions path) and require key simplifying assumptions, though existing results indicate that uncertainty leads to an increase in the optimal tax under uncertainty for realistic parameter values. Rather than being a reason not to take action, if anything, uncertainty increases the SCC and should lead to more stringent policies to address climate change.

While the 2016 IWG estimate is the best available SCC figure, it likely represents a lower bound for the costs of climate change because the models that are used to get the estimates leave out several categories of climate damages, which we discussed earlier. Again, damages currently omitted from the models include, but are not limited to, the effects of climate change on fisheries; the effects of increased pest, disease, and fire pressures on agriculture and forests; and the effects of climate-induced migration. Additionally, these models omit the effects of climate change on economic growth and the rise in the future value of environmental services due to increased scarcity.[111]

Uncertainty is also no reason to shorten the SCC time horizon. In 2017, NAS issued a report stressing the importance of a longer time horizon for calculating the social cost of greenhouse gases. The report states that, "[i]n the context of the socioeconomic, damage, and discounting assumptions, the time horizon needs to be long enough to capture the vast majority of the present value of damages." The report goes on to note that the length of the time horizon is dependent "on the rate at which undiscounted damages grow over time and on the rate at which they are discounted. Longer time

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[107] TSD 2010, *supra* note 3, at 30. *Also see*, Omitted Damages, *supra* note 6, at 42-43.

[108] *Ctr. for Biological Diversity* 548 F.3d, *supra* note 51, at 1200.

[109] Richard S. Tol, *Safe policies in an uncertain climate: an application of FUND*, Global Environmental Change, 9(3), 221-232 (1999); Peterson, S. (2006). Uncertainty and economic analysis of climate change: A survey of approaches and findings. Environmental Modeling & Assessment, 11(1), 1-17; TSD 2016, *supra* note 2.

[110] Robert S. Pindyck, *Uncertainty in environmental economics*, Review of Environmental Economics and Policy (2007), 1(1), 45-65; A. Golub *et al.* Uncertainty in integrated assessment models of climate change: Alternative analytical approaches. Environmental Modeling & Assessment (2014), 19(2), 99-109; D. Lemoine, & I. Rudik. Managing Climate Change Under Uncertainty: Recursive Integrated Assessment at an Inflection Point. Annual Review of Resource Economics(2017) 9:18.1-18.26.

[111] *See* Omitted Damages, *supra* note 6, for a more complete list.

horizons allow for representation and evaluation of longer-run geophysical system dynamics, such as sea level change and the carbon cycle." In other words, after selecting the appropriate discount rate based on theory and data (in this case, 3% or below), analysts should determine the time horizon necessary to capture all costs and benefits that will have important net present values at the discount rate. Therefore, a 3% or lower discount rate for climate change implies the need for a 300-year horizon to capture all significant values. NAS reviewed the best available, peer-reviewed scientific literature and concluded that the effects of greenhouse gas emissions over a 300-year period are sufficiently well established and reliable as to merit consideration in estimates of the social cost of greenhouse gases.[112]

Didn't the noted economist Robert Pindyck say the SCC numbers were flawed?

Not really, because he actually wants higher numbers. Robert Pindyck wrote a brief article[113] and released a working paper[114] shortly after the 2013 update to the IWG's SCC estimates, in which he criticizes the SCC. However, Pindyck actually advocates for an even higher SCC. He says: "My criticism of IAMs should not be taken to imply that because we know so little, nothing should be done about climate change right now, and instead we should wait until we learn more. Quite the contrary." He goes on to explain that being proactive will benefit society in the longterm. "One can think of a GHG abatement policy as a form of insurance: society would be paying for a guarantee that a low-probability catastrophe will not occur (or is less likely)."[115] Pindyck actually enforces the idea we discussed above, namely that the uncertainty underlying the SCC is no reason to not use the IWG estimates, but rather that decisionmakers who are interested in taking into account the climate effects of particular options should use the SCC as a starting point. In fact, Pindyck's own best estimate of the SCC is between $80 to $100, and goes up to $200.[116] Many groups cite Pindyck when criticizing the SCC, but fail to mention that his conclusion actually supports a robust accounting of climate damage externalities in decisionmaking.

Technical guidance: how do we apply the SCC in our analyses?

What should we choose as our central estimate?

The IWG SCC estimates are not a single number, but instead a range of four estimates, based on three discount rates, plus a 95th percentile estimate that represents catastrophic, low-probability outcomes.[117] Discount rates allow economists to measure the value of money over time—the tradeoff between what a dollar is worth today and what a dollar would be worth in the future.[118] Higher discount rates result in a lower SCC; if future climate damages are discounted at a high rate,

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[112] NAS Second Report, *supra* note 76.

[113] Robert S. Pindyck, *Pricing Carbon When We Don't Know the Right Price*, Regulation (Summer 2013). *Available at* https://object.cato.org/sites/cato.org/files/serials/files/cato-video/2013/6/regulation-v36n2-1-2.pdf.

[114] Robert Pindyck, "Climate Change Policy: What do the Models Tell Us?" Working Paper 19244. National Bureau of Economic Research (July 2013), *available at* http://www.nber.org/papers/w19244.pdf.

[115] *Id.* at 16.

[116] *Id.*

[117] TSD 2010, *supra* note 3; TSD 2013, *supra* note 62; Interagency Working Group on the Social Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2015); TSD 2016, *supra* note 2.

[118] If offered $1 now or $1 in a year, almost everyone would choose to receive the $1 now. Most individuals would only wait until next year if they were offered more money in the future. The discount rate is how much more you would have to receive to wait until next year.

we would be placing less value on avoiding those damages today. The IWG uses discount rates of 5, 3, and 2.5 percent.[119] The fourth value is taken from the 95th percentile of the SCC estimates corresponding to the 3-percent discount rate, which represents catastrophic but unlikely situations.[120] Note that application of the 95th percentile value was not part of an effort to show the probability distribution around the 3-percent discount rate; rather, the 95th percentile value serves as a methodological shortcut to approximate the uncertainties around low-probability but high-damage, catastrophic, or irreversible outcomes that are currently omitted or undercounted in the economic models.

Frequently, agencies will conduct their economic analyses using a range of SCC values.[121] Often, other analyses focus on a "central" estimate of the SCC.[122] The IWG recommends using a 3% discount rate. However, Washington State, for example, selected the 2.5% discount rate as its "central" estimate, for reasons discussed above.

Choosing the most appropriate discount rate is crucial to obtaining the best SCC estimate. A policymaker might decide that the uncertainty associated with climate damages warrants using a discount rate that declines over time, leading to a higher SCC. A consensus has emerged among leading climate economists that a declining discount rate should be used for climate damages, to reflect long-term uncertainty in interest rates.[123] The National Academy of Sciences January 2017 recommendations to the IWG support this approach.[124] Furthermore, as noted above, **the federal SCC estimate associated with a 3-percent discount rate should be interpreted as a lower bound**.[125]

Can we just calculate damages from a single year of emissions?

No. The values of the SCC in the IWG analysis are calculated by adding up the streams of future effects from a ton of emissions in the year of anticipated release, with discount rates reflecting the passage of time between the anticipated release and the future effects. It is necessary to include in the analysis emissions for each year that a plan, action or project is in place, because the SCC increases over time.

How does discounting work?

The IWG's SCC values represent the damages associated with each additional ton of carbon dioxide emissions released *from the perspective of the year of emission*. It is necessary when conducting a policy analysis *at the present time* about policies that affect greenhouse gas releases *in the future* to make sure that the SCC values are translated into the *perspective*

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[119] The IWG correctly excluded a 7% discount rate, a standard private sector rate of return on capital, in its SCC calculations for two main reasons. First, typical financial decisions, such as how much to save in a bank account, focus on private decisions and use private rates of return. However, in the context of climate change, analysts are concerned with social discount rates because emissions mitigation is a public good, where individual emissions choices affect public well-being broadly. Second, climate change is expected to primarily affect consumption, not traditional capital investments.

[120] *See* Environmental Defense Fund, Institute for Policy Integrity at New York University School of Law, Natural Resources Defense Council, and Union of Concerned Scientists. Comments on Proposed Exception to the Colorado Roadless Rule (RIN 0596-AD26) and Supplemental Draft Environmental Impact Statement (November 2015) to Forest Service; Council on Environmental Quality; Office of Information and Regulatory Affairs to describe importance of 95th percentile value.

[121] *See, e.g.,* Energy Conservation Program: Energy Conservation Standards for Miscellaneous Refrigeration Products, 81 Fed. Reg. 75,194 (Oct. 26, 2016); Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS, 81 Fed. Reg. 74,504 (Oct. 26, 2016).

[122] *See, e.g.,* Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Establishing the Benefit Cost Analysis Framework, New York Public Service Comm'n Case No. 14-M-0101 (Jan. 21, 2016) ["BCA Order"].

[123] *See* Weitzman 2001, *supra* note 90; Kenneth J. Arrow *et al.* 2013, *supra* note 92; Kenneth J. Arrow *et al.*, 2014, *supra* note 92; Maureen L. Cropper *et al.* 2014, *supra* note 92; Christian Gollier & Martin L. Weitzman 2010, *supra* note 92. Policy Integrity comments to NAS, *supra* note 68.

[124] NAS Second Report, *supra* note 76.

[125] *See* Omitted Damages, *supra* note 6; Richard L. Revesz *et al.* 2014, *supra* note 74.

of the year of the policy decision. The proper way to accomplish this translation is by using the discount rate to convert the effects of emissions from the year of release into the present value.

Imagine a policy has costs today and would decrease emissions in the year 2025. The IWG estimates for 2025 are how much those reductions are worth to people in year 2025, looking at cumulative effects over a 300-year period and discounting back to the year 2025. But because we prefer present consumption over future consumption, how we'd value that today isn't the same as how people in year 2025 would value it. Still, we need to discount from year 2025 back to today.

What about inflation?

Separate from the discounting considerations, which reflect the resource tradeoffs facing the actors in the relevant year of action, currency tends to inflate over time. The IWG's calculations for the SCC are based upon 2007 dollars, but the purchasing power of the dollar has gone down since then, meaning that $1 in 2007 is worth $1.20 in 2017.[126] It is important to ensure that the analysis is consistent across time frames and makes sense to decisionmakers. Thus, before any calculations are done, the analysts should account for inflation by converting all of the SCC values from 2007 dollars into dollars for the year the analysis is taking place (currently, 2017).

So once we multiply emissions by the SCC and discount back, are we done?

Not quite. It is still best to include a qualitative description of omitted damages. Best practices for regulatory analysis require including all costs and benefits, even the hard-to-monetize ones. Include a qualitative description to emphasize that the SCC is a lower bound on damages.

And what are all of the steps put together?

To make the calculation, the SCC figure should be multiplied by the projected avoided emissions to provide a figure for the monetized benefits of an action's or project's avoided greenhouse gas emissions. Specifically, you should:

1. Convert the SCC values from 2007 dollars to the year of analysis, using a consumer price index inflation calculator[127] (if the values have not yet been converted);
2. Determine the avoided emissions for each Year X between the effective date and the end date of 2030;
3. Multiply the quantity of avoided emissions in Year X by the corresponding SCC in Year X,[128] to calculate the monetary value of damages avoided by avoiding emissions in Year X;[129]
4. Apply the same discount rate used to calculate the SCC to calculate the present value of future effects of emissions from Year X;[130]

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[126] *See* CPI Inflation Calculator, http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=1&year1=2007&year2=2017.

[127] *See* CPI Inflation Calculator, http://data.bls.gov/cgi-bin/cpicalc.pl.

[128] In general, the SCC goes up over time because greenhouse gases accumulate, exacerbating the effects of climate change—and therefore the harm from each additional unit of emissions—over time. TSD 2010, *supra* note 3, at 28.

[129] The SCC for a given year encompasses the effects that a ton of carbon dioxide, once emitted in that year, will have stretching into the future over a 300-year time frame. TSD 2010, *supra* note 3, at 25.

[130] Using a consistent discount rate for both the SCC (assessed from the perspective of the actors in the year of emission) and the net present value calculation (assessed from the perspective of the decisionmaker) is important to ensure that the decisionmaker is treating emissions in each time frame similarly. The decisionmaker should not be overvaluing or undervaluing emissions in the present as compared to emissions in the future. NAS First Report, *supra* note 66.

5. Sum these values for all relevant years between the effective date and the end date to arrive at the total monetized climate benefits of the plan's avoided emissions;[131] and
6. Qualitatively describe in the final discussion of the climate benefits all of the other damages that have been omitted from the SCC.

State agencies could conduct these calculations with a single, central discount rate for the SCC, or the agency could conduct the analysis several times, using a range of discount rates for the SCC, being sure to use the selected discount rate in step 4 for each different iteration.

Because the SCC has been used in a number of federal regulatory impact analyses and environmental impact statements, there are a number of examples from which states can learn how to conduct their own SCC analysis.[132]

How is the SCC used in an analysis with other discount rates?

In its Phase 1 report, NAS recommended that the SCC be used with a "consistent" discount rate in cost-benefit analysis.[133] "Consistent" should be interpreted to mean "compatible" and based on the same theoretically-sound methodology (i.e., theoretically consistent): for example, applying a higher discount rate (say 3%) to other costs and benefits may be "consistent" with a lower discount rate (say 2.5%) for the SCC, to account for the greater uncertainty with respect to climate change relative to more short-run benefits and costs. This approach is appropriate when climate uncertainty exceeds the short-run uncertainty captured by most benefit-cost analysis in which the SCC is applied.

What other resources exist?

- Omitted Damages: What's Missing from the Social Cost of Carbon (2014) by Peter Howard
- Think Global, International Reciprocity as Justification for a Global Social Cost of Carbon (2016) by Jason Schwartz and Peter Howard
- Best cost estimates of greenhouse gases (2017) by Richard Revesz, Michael Greenstone, Michael Hanemann, Thomas Sterner, Peter Howard, Jason Schwartz
- Global Warming: Improve Economic Models of Climate Change (2014) by Richard L. Revesz, Kenneth Arrow *et al.*
- The Social Cost of Carbon: A Global Imperative (2017) by Richard L. Revesz, Jason A. Schwartz, Peter H. Howard, Kenneth Arrow, Michael A. Livermore, Michael Oppenheimer, and Thomas Sterner
- Flammable Planet: Wildfires and the Social Cost of Carbon (2014), by Peter Howard
- Recent comments by Policy Integrity, EDF, NRDC, and Union of Concerned Scientists on the SCC
- Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update (2016), National Academies of Sciences

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[131] Steps 4 and 5 combined are equivalent to calculating the present value of the stream of future monetary values using the same discount rate as the SCC discount rate.

[132] *See, e.g.*, Energy Conservation Program: Energy Conservation Standards for Commercial Refrigeration Equipment 79 Fed. Reg. 17,726, at 17,728, 17,773, 17,779, 17,811 (Mar. 28, 2014); U.S. Department of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment 12-22, 13-4 to 13-5, 14-2 (2014).

[133] NAS First Report, *supra* note 66, at 49.

- Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide (2017), National Academies of Sciences
- Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2010), Interagency Working Group on the Social Cost of Greenhouse Gases
- Revised: Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2013), Interagency Working Group on the Social Cost of Greenhouse Gases
- Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis (2016), Interagency Working Group on the Social Cost of Greenhouse Gases Under Executive Order 12866 Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (2016), Interagency Working Group on the Social Cost of Greenhouse Gases

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