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Docket No. PL21-3-000

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Thank you for the opportunity to respond to the questions posed by the Federal Energy Regulatory Commission (“FERC,” “Commission”) regarding its November 19, 2021 Technical Conference on Greenhouse Gas Mitigation under Sections 3 and 7 of the Natural Gas Act (NGA).²

We concentrate on questions 1.b: *What is the appropriate level of mitigation associated with GHG emissions for a particular project?* and 2.e: *What factors should the Commission consider in evaluating the sufficiency of a mitigation proposal?*

Our answers may be concisely stated:

- The Commission should not mandate any mitigation of project-related GHG emissions.
- The social cost of carbon (SCC) is not a factor the Commission should consider in public convenience and necessity determinations.

Section 1: Summary of Argument

In public convenience and necessity determinations, the Commission weighs the projected economic benefits of new natural gas infrastructure against the social and environmental costs. If the negative externalities are significant, the Commission may condition project approval on the adoption of mitigation measures. If significant mitigation is infeasible, the Commission may disapprove the project.

That decision framework has no rational application to natural gas infrastructure GHG emissions. The GHG emissions of even the largest natural gas infrastructure project have no

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² FERC, Technical Conference on Greenhouse Gas Mitigation: Natural Gas Act Sections 3 and 7 Authorizations; Notice Inviting Technical Conference Comments, 86 FR 66293, November 22, 2021, <https://www.govinfo.gov/content/pkg/FR-2021-11-22/pdf/2021-25403.pdf>.

discernible, traceable, or verifiable impacts on global average temperature, weather patterns, crop yields, polar bear populations, or any other environmental condition people care about. The undetectably small climate impacts of project-specific emissions are, for all practical purposes, nil. Consequently, the climate protection benefits of mitigating such emissions are illusory.

If an infrastructure project is commercially viable and helps ensure adequate supplies of electricity and natural gas at reasonable prices (the NGA's principal purpose), the Commission knows in advance that the project's economic benefits far exceed its climate-related externalities. Therefore, no further investigation of the project's GHG emissions is required, nor does it make sense to condition the certificate of public convenience and necessity on the project's adoption of mitigation measures.

The standard rebuttal to the foregoing may be summarized as follows. Social cost of carbon (SCC) analysis enables the Commission to estimate the climate damages attributable to individual projects. The SCC is an estimate in dollars of the cumulative damages from one ton of carbon dioxide-equivalent (CO₂e) GHG emitted in a given year. The Commission should estimate the project's direct and indirect lifetime GHG emissions, and multiply those emissions by their associated SCC values. The project's SCC-estimated climate cost may be large enough to warrant mitigation measures or even denying the project's certification.

There are two main problems with that rebuttal. First, the seeming objectivity and good-enough-for-government-work reliability of SCC estimation are illusory. SCC estimates are highly sensitive to the modeler's choice of inputs and assumptions. For example, when a leading integrated assessment model is updated with empirical information regarding climate sensitivity and CO₂ fertilization, the SCC drops to very low numbers with substantial probabilities of being negative through 2050. A negative SCC is another way of saying a net benefit.

Second, due to their intractably speculative character, SCC estimates are easily manipulated for political purposes. The technical support documents (TSDs) produced by the Obama and Biden administration Social Cost of Greenhouse Gases Interagency Working Group (IWG) are a prime case in point. The IWG's methodological decisions continually err on the side of climate alarm and regulatory ambition. Such egregiously-biased social cost estimates have no legitimate role in regulatory or permitting decisions.

In the course of developing those points, we also briefly explain why aligning the NGA with the Biden administration's NetZero agenda would be unlawful.

Section 2: Project-Related Emissions Do Not Significantly Affect the Human Environment

The NGA directs the Commission to follow National Environmental Policy Act (NEPA) procedures when reviewing proposed natural gas infrastructure projects. Some stakeholders claim this authorizes or requires the Commission to weigh potential climate change damages when determining whether a project serves the public convenience and necessity. Not so.

NEPA is centrally concerned with “major” federal actions that “significantly affect [] the quality of the human environment.”³ The GHG emissions of even the largest infrastructure project have no discernible, traceable, or verifiable impacts on the quality of the human environment. Project-related GHG emissions are not “significant” environmental effects for NEPA purposes. Consequently, NEPA does not require the Commission to weigh or balance such emissions against the economic benefits of natural gas infrastructure.

Those who view climate change as an existential threat may find it hard to believe that NEPA, the nation’s foundational environmental law, does not require GHG mitigation measures in project authorizations. The Obama administration Council on Environmental Quality (CEQ) clearly wanted to use NEPA as a climate policy tool. Over the course of six years and three comment periods, CEQ tried but could not coherently explain why project applicants and permitting agencies should mitigate or even review emissions known in advance to be climatically-insignificant. A brief review of that history follows.

Illusory Thresholds of “Meaningful” Climate Action

FERC’s Question 1.b asks: *What is the appropriate level of mitigation associated with GHG emissions for a particular project?* That question skips over the logically prior question: *What quantity of emissions is large enough to warrant scrutiny and mitigation?*

Climate change science predicts that cumulative global GHG emissions over decades to centuries will have detectable impacts on average global temperatures and other climate variables. It does not postulate that incremental emissions from individual sources have identifiable climate impacts, or any actual economic damages. Incremental emissions attributable to specific projects are nowhere near large enough to have foreseeable, traceable, or verifiable physical effects. And those microscopic perturbations are even less likely to decide the fate or fortunes of any business enterprise, community, or human being anywhere in the world. In short, even the GHG emissions of the largest project cannot “significantly affect [] the human environment.”

Consequently, NGA review of individual project-related GHG emissions serves no bona fide environmental, scientific, or economic purpose. Absent express directives in other statutes, GHG emissions have no proper role in NGA project reviews and permitting decisions.

Although some stakeholders may balk at those conclusions, CEQ, the expert agency tasked by Congress to administer NEPA, has long acknowledged their premise—the climatological insignificance of project-related GHG emissions.

In its 2010 Draft NEPA Guidance on Greenhouse Gas Emissions and Climate Change Effects, CEQ attempted to determine which among the myriad potential projects applying for federal permits should be vetted for greenhouse gases. The answer was not obvious. “From a

³ 42 U.S.C. § 4332.

quantitative perspective,” CEQ explained, “there are no dominating sources and fewer sources that would even be close to dominating total GHG emissions.”⁴

The 2010 Draft GHG Guidance proposed that 25,000 tons or more of annual carbon dioxide-equivalent (CO₂e) emissions could provide “an indicator that a quantitative and qualitative assessment may be meaningful to decision makers and the public.”⁵ However, CEQ immediately clarified that it was not making a claim about climatic impact: “CEQ does not propose this as an indicator of a threshold of significant effects, but rather as an indicator of a minimum level of GHG emissions that may warrant some description in the appropriate NEPA analysis for agency actions involving direct emissions of GHGs.”⁶

The 2010 Draft Guidance further stated: “CEQ does not propose this [25,000 ton] reference point as an indicator of a level of GHG emissions that may significantly affect the quality of the human environment.” Lest anyone mistakenly infer climatological significance, CEQ reiterated: “However, it is not currently useful for the NEPA analysis to attempt to link [proposed projects to] specific climatological changes, *as such direct linkage is difficult to isolate and to understand.*”⁷

Stakeholders were confused. How can NEPA analysis of a project emitting 25,000 tons of greenhouse gases per year be “meaningful” if that quantity of emissions does not significantly affect the quality of the human environment?⁸

CEQ’s 2014 Draft GHG Guidance devoted several pages to the issue without resolving it. CEQ again proposed a 25,000 metric ton reference point while disclaiming an intent to make a “determination of significance.”⁹ Rather, the significance of an agency action depends on multiple factors, such as “the degree to which the proposal affects public health or safety, the degree to which its effects on the quality of the human environment are likely to be highly controversial, and the degree to which its possible effects on the human environment are highly uncertain or involve unique unknown risks.”¹⁰

However, that restates rather than removes the perplexity. The degree to which GHG emissions from an individual project affect public health and safety is for all practical purposes zero. The climatic insignificance of individual projects is non-controversial and highly certain. Greenhouse gas emissions from individual projects are not suspected of posing unique unknown risks.

⁴ CEQ, Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions February 18, 2010, p. 2, <https://obamawhitehouse.archives.gov/sites/default/files/microsites/ceq/20100218-nepa-consideration-effects-ghg-draft-guidance.pdf> (hereafter 2010 Draft GHG Guidance)

⁵ 2010 Draft GHG Guidance, p. 2.

⁶ 2010 Draft GHG Guidance, p. 2.

⁷ 2010 Draft GHG Guidance, p. 3 (italics added).

⁸ CEQ, Revised Draft Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA Reviews, 79 FR 77825, December 24, 2014, <https://www.govinfo.gov/content/pkg/FR-2014-12-24/pdf/2014-30035.pdf>.

⁹ 79 FR 77810.

¹⁰ 79 FR 77810.

After reviewing comments ranging from ‘no project-level emissions are big enough to quantify’ to ‘no project-level emissions are too small to quantify,’ CEQ judged that a 25,000-ton disclosure threshold is “1) low enough to pull in the majority of large stationary sources of greenhouse gas emissions, but also 2) high enough to limit the number of sources covered that state and local air pollution permitting agencies could feasibly handle.”¹¹ In other words, administrative convenience rather than climatic significance would determine the cutoff.

Then, two years later, the final 2016 GHG guidance silently dropped the 25,000-ton threshold. In fact, the whole topic disappeared without a word of explanation or comment. Perhaps CEQ just gave up trying to explain how quantifying emissions that are not climatically “significant” could still be “meaningful.”¹²

False “Proxies” for Climate Effects

Although the climatic insignificance of project-related emissions has been Council’s consistent view since 2010, CEQ in 2014 continued to propose and in 2016 required agencies to quantify facility-level GHG emissions, and use that information to evaluate proposed actions, alternatives, and mitigation measures.

Based on what scientific rationale? CEQ argued that “projection of a proposed action’s direct and reasonably foreseeable indirect GHG emissions may be used as a proxy for assessing potential climate effects.”¹³ However, that is tantamount to saying, ‘Let’s pretend we know what we don’t know and regulate anyway.’

A proxy voter can cast a real, countable, ballot for an absentee voter. Data from tree rings, ice cores, fossil pollen, ocean sediments, and corals can be calibrated to instrumental data and then serve (albeit imperfectly) as proxies for climatic conditions in pre-industrial times. In contrast, no testable, measurable, or otherwise observable relationship exists between project-level greenhouse gas emissions and climate change effects. To call the former a “proxy” for the latter in an ostensibly scientific context is inaccurate and misleading.

The Obama CEQ’s actual rationale for treating project-related emissions as climate effects for regulatory purposes appears to be political. Requiring agencies (hence also project applicants) to quantify the “direct and indirect” GHG emissions of proposed projects injects climate concerns into the daily routines of myriad public and private actors involved in building, upgrading, and reviewing energy infrastructure. It is a “consciousness raising” exercise, forcing business leaders and agency heads to “think globally” whenever they “act locally” on infrastructure. GHG project review also helps mobilize activists, promote fear and loathing of “dirty” fuels, and multiply arenas of conflict over the “climate crisis.” Advancing such political objectives is not the Commission’s proper business.

¹¹ 79 FR 77818.

¹² CEQ, Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews, August 1, 2016, https://ceq.doe.gov/docs/ceq-regulations-and-guidance/nepa_final_ghg_guidance.pdf.

¹³ CEQ, 2010 Draft GHG Guidance, p. 3; 79 FR 77825; CEQ, 2016 Final GHG Guidance, pp. 4, 10.

Fool's Errand: Saving the Planet One Project at a Time

While abandoning a numerical “reference point” for “meaningful” GHG analysis, CEQ’s 2016 GHG Guidance nonetheless insists that NEPA is an appropriate framework for analyzing climate effects:

Climate change results from the incremental addition of GHG emissions from millions of individual sources, which collectively have a large impact on a global scale. CEQ recognizes that the totality of climate change impacts is not attributable to any single action, but are exacerbated by a series of actions including actions taken pursuant to decisions of the Federal Government. Therefore, a statement that emissions from a proposed Federal action represent only a small fraction of global emissions is essentially a statement about the nature of the climate change challenge, and is not an appropriate basis for deciding whether or to what extent to consider climate change impacts under NEPA.¹⁴

CEQ ignored the obvious. The “nature of the climate challenge” is what renders project-level GHG scrutiny a colossal waste of time and effort—perhaps the biggest make-work project ever conceived by the bureaucratic imagination.

If climate change results from the “incremental addition of GHG emissions from millions of individual sources,” and “emissions from a proposed federal action represent only a small fraction of global emissions” (perhaps no more than a few hundred thousandths of 1 percent),¹⁵ then the GHG emissions from any individual action are climatically inconsequential. Attempting to solve the “climate change challenge” one project at a time is like trying to drain a swimming pool one thimbleful at a time. It is a fool’s errand. An individual project’s GHG emissions is an inappropriate basis for approving or rejecting the project, especially in the absence of a clear congressional directive to do so.

Keeping It Legal

The rejoinder, conveniently furnished by CEQ’s rescinded Final 2016 GHG Guidance, is that although “individual sources of emissions each make relatively small additions to global atmospheric GHG concentrations,” the myriad diverse sources “collectively have large impact.”¹⁶ The political implication is obvious: To mitigate “large impact,” permission should be denied to as many sources as possible—ideally to all.

The chief problem with that policy—aside from the enormous economic losses and suffering it would entail—is that Congress has not authorized it. The NGA has been amended several times since enactment in 1938. Yet the Act contains none of the terms suggestive of a statute intended to address climate change. The NGA never mentions “climate,” “impact,” “global,” “warming,”

¹⁴ CEQ, 2016 Final GHG Guidance, p. 10.

¹⁵ 79 FR 77810.

¹⁶ 2016 Final GHG Guidance, p. 10

“carbon,” “greenhouse,” “mitigation,” or their cognates.¹⁷ And as the Supreme Court has said, an agency action is arbitrary and capricious under Sec. 706 of the Administrative Procedure Act if, among other things, “the agency has relied on factors which Congress has not intended it to consider....”¹⁸

Congress made extensive revisions to the Commission’s powers and responsibilities in the 2005 Energy Policy Act. Section 368 (§15926 of the U.S. Code) remains in effect today. It clearly directs the Commission, as part of its “ongoing responsibilities,” to facilitate the planning and “construction” of natural gas infrastructure on federal lands.¹⁹ Using the NGA to tilt the energy marketplace against natural gas would be contrary to the statute’s “principal purpose” of “ensuring plentiful supplies of natural gas at reasonable prices.”²⁰

Numerous bills have been introduced in Congress since the early 1990s to establish economy-wide or sectoral GHG reduction targets and timetables, or to tax the carbon content of fuels or emissions. None has ever been enacted.²¹ To our knowledge, Congress has never even voted on legislation expressly requiring or authorizing the Commission to regulate natural gas infrastructure for climate change purposes.

Even in the 117th Congress, despite strong pressure from the President, the Speaker of the House, and the Senate Majority Leader, legislation requiring the rapid phaseout of gas-fired generation, whether via regulatory mandates or fiscal subsidies and penalties, seems unlikely to pass.²²

The Commission should take care not to do piecemeal what it clearly lacks authority to do at the pace and scale desired by activist groups. Those who wish to make climate policy should do so through new legislation specifically addressing the subject rather than by reinterpreting the 84-year-old NGA or 52-year-old NEPA—statutes never intended and completely inappropriate for the purpose.

Section 3: Social Cost of Carbon Basics

In the past, the Commission has taken the same position we do: “Currently, there is no standard methodology to determine how a [natural gas infrastructure] project’s relatively small incremental contribution to GHGs would translate into physical effects on the global

¹⁷ Natural Gas Act [The Act of June 21, 1938, Chapter 556, as Amended through P.L. 109-58, Enacted August 8, 2005], https://www.ferc.gov/sites/default/files/2021-04/natural_gas_act.pdf.

¹⁸ *Motor Veh. Mfrs. Ass’n v. State Farm Ins.*, 463 U.S. 29, 43 (1983).

¹⁹ U.S.C. §15926(c).

²⁰ *NAACP v. Fed. Power Comm’n*, 425 U.S. 662, 669 (1976).

²¹ Arnold W. Reitze Jr., “Global Warming,” *Environmental Law Reporter News & Analysis* 31, no. 3 (March 2001): 10253-10269, www.HeinOnline.org; Arnold W. Reitze, Jr., “Federal Control of Carbon Dioxide Emissions: What Are the Options?” *Boston College Environmental Law Review*, Vol. 36, Issue No. 1, 2009, <https://lawdigitalcommons.bc.edu/ealr/vol36/iss1/1/>; Patrick J. Michaels, “The IPCC Political Suicide Pill,” *National Review*, September 26, 2013, <https://www.nationalreview.com/2013/09/ipcc-political-suicide-pill-patrick-j-michaels/>.

²² Josh Lederman, Sahil Kapur and Leigh Ann Caldwell, “Clean energy program likely to be dropped because of Manchin’s objections,” NBC News, October 16, 2021, <https://www.nbcnews.com/politics/politics-news/clean-energy-program-likely-be-dropped-because-manchin-s-objections-n1281698>.

environment.”²³ Columbia Law School Research Scholar Romany M. Webb objects that social cost of carbon (SCC) analysis is the methodology that can quantify climate damages from project-level emissions:

The SCC reflects the cost, expressed in dollars per ton, of current and future damage caused by carbon dioxide emissions. It is widely considered the best available estimate of the costs imposed by climate damage, having been developed by an interagency working group, comprising experts from twelve federal bodies, based on the latest scientific and economic modeling.²⁴

Similarly, at the Commission’s November 19, 2021 Technical Conference, Analysis Group, Inc. Senior Advisor Dr. Susan Tierney, EarthJustice Senior Attorney Moneen Nasmith, and Environmental Protection Agency Deputy General Counsel Melissa Hoffer argued that SCC analysis is fit for purpose. In Dr. Tierney’s words:

And the social cost of carbon is a highly credible peer reviewed analysis that looks at the cost of impacts of greenhouse gas emissions across the economy . . . one can kick the tires and see transparently what are the economic studies that are associated with the number that has been determined as the social cost of carbon in any year associated with the next greenhouse gas emitted.²⁵

In the sections below, we explain how the SCC is highly sensitive to user manipulation and can therefore be easily misused to guide policy. Before doing so, we summarize in this section the basics of SCC analysis, particularly as performed by the IWG.

The SCC is an estimate in dollars of the cumulative long-term damage caused by one ton of CO₂ emitted in a specific year. That number also represents an estimate of the benefit of avoiding or reducing one ton of CO₂ emissions.

The computer models used to project SCC values are called integrated assessment models (IAMs) because they combine aspects of a climate model, which estimates the physical impacts of CO₂ emissions, with an economic model, which estimates the dollar value of climate change effects on agricultural productivity, property values, and other economic variables. The IWG uses three IAMs—abbreviated DICE, FUND, and PAGE—to estimate SCC values.²⁶

²³ FED. ENERGY REGULATORY COMM’N, NO. CP18-18-000, TRANSCONTINENTAL GAS PIPE LINE COMPANY, L.L.C. GATEWAY EXPANSION PROJECT: ENVIRONMENTAL ASSESSMENT, 2018, p. 55, <https://perma.cc/DRW7-C29C>.

²⁴ Romany M. Webb, “Climate Change, FERC, and Natural Gas Pipelines: The Legal Basis for Considering Greenhouse Gas Emissions Under section 7 of the Natural Gas Act,” *N.Y.U. Environmental Law Journal*, 2020, Vol. 28, p. 214, https://www.nyuelj.org/wp-content/uploads/2020/05/Webb_Climate-Change-FERC-Natural-Gas-Pipelines.pdf.

²⁵ FERC, Transcript, Greenhouse Gas Mitigation Meeting, December 22, 2021, p. 52, <https://www.ferc.gov/media/transcript-greenhouse-gas-mitigation-meeting>.

²⁶ For the DICE (Dynamic Integrated Climate and Economy) model, see William D. Nordhaus, “DICE/RICE Models,” <https://williamnordhaus.com/dicerice-models> (accessed September 15, 2021). For the FUND (Framework for Uncertainty, Negotiation, and Distribution) model, see “FUND Model,” <http://fund-model.org> (accessed September 15, 2021). For the PAGE (Policy Analysis for the Greenhouse Effect) model, see Climate CoLab, “PAGE,” <https://www.climatecolab.org/wiki/PAGE> (accessed September 15, 2021).

SCC estimates are highly sensitive to:

- The discount rates chosen to calculate the present value of future emissions and reductions.
- The calculated climate sensitivities chosen to estimate the warming impact of projected increases in atmospheric GHG concentration.
- The timespan chosen to estimate cumulative damages from rising GHG concentration.
- The extent to which the SCC reflects empirical information about the agricultural and ecological benefits of carbon dioxide fertilization.
- The assumptions chosen regarding the potential for adaptation to decrease the cost of future climate change impacts.
- The choice of socioeconomic pathways used to project future GHG emissions and concentrations.

In addition, from a political perspective, it matters a great deal whether the net benefits of climate policy proposals are calculated by comparing the domestic costs of GHG-reduction policies to the IAM-estimated global climate benefits or to the much smaller domestic benefits.

What this all means is that, if SCC analysts intend to make climate change look economically catastrophic and build a case for aggressive regulation, they:

- Run the IAMs with below-market discount rates.
- Use IAMs with high climate sensitivity.
- Calculate cumulative damages over a 300-year period—i.e., well beyond the limits of informed speculation about future economic vulnerabilities and adaptive technologies.
- Minimize the agricultural benefits of atmospheric CO₂ fertilization by, for example, averaging the results of three IAMs, two of which effectively assign a dollar value of zero to carbon dioxide's positive externalities.
- Include at least one IAM that assumes adaptation cannot mitigate the cost of climate change impacts once warming and sea-level rise exceed low-end climate model projections.
- Run the models with implausible emission scenarios that assume the world repeatedly burns through all economically-recoverable fossil fuel reserves.
- Calculate climate policy net benefits by comparing apples (domestic costs) to oranges (global benefits).

In other words, the analysts do exactly what the Obama IWG did in its 2010, 2013, and 2016 TSDs, and what the Biden IWG proposes to do in its 2021 interim TSD.²⁷

²⁷ Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990, February 2021, https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf (hereafter IWG, TSD 2021).

Section 4: How Discount Rate Affect the SCC²⁸

Models used to estimate the SCC rely on the specification of a discount rate. Discounting is essential in benefit-cost analysis because compliance costs are best viewed as investments intended to yield benefits in the future. Applying discount rates enables agencies to compare the projected rate of return from CO₂-reduction expenditures to the rates of return from other potential investments in the economy.

Office of Management and Budget (OMB) guidance in Circular A-4 specifically stipulates that agencies discount the future costs and benefits of regulations using both 3.0 percent and 7.0 percent discount rates.²⁹ The IWG suggests that a 7 percent discount rate is an affront to intergenerational equity, apparently on the theory that discount rates higher than 1-2 percent imply that people living today are more valuable than people living decades or centuries from now.³⁰

We respectfully disagree. The point of discounting is not to rank the worth of different generations but to have a consistent basis for comparing alternate investments. Only then can policymakers determine which investments are most likely to transmit the most valuable capital stock to future generations. In other words, discounting clarifies the *opportunity cost* of investing in climate mitigation, for example, rather than medical research, national defense, or trade liberalization.

Not only is it reasonable to include a 7 percent discount rate in SCC estimation, it is arguably the best option because 7 percent is the rate of return of the New York Stock Exchange over the last hundred and twenty-five years.³¹ Only by using a 7 percent discount rate can policymakers assess the wealth foregone when government invests in GHG reduction rather than other policy objectives or simply allows companies and households to invest more of their dollars as they see fit.

Institute for Energy Research economist David Kreutzer illustrates the point as follows. Suppose reducing one ton of CO₂ emissions produces \$100 in benefits by 2171 (150 years from now). That is equivalent to investing \$5.13 today with a 2 percent annual ROI. But if the same \$5.13 is invested in stock that appreciates at 7 percent annually, the investment yields \$131,081 in 2171. Clearly, that is a much larger bequest to future generations. How does that negatively affect

²⁸ Sections 4-7 draw upon Kevin Dayaratna's testimony on "Climate Change, Part IV: Moving Toward a Sustainable Future," before the House Oversight and Reform Subcommittee on the Environment, September 24, 2020, <https://oversight.house.gov/sites/democrats.oversight.house.gov/files/Dayaratna%20Testimony%2C%20Updated%20for%20Sept%2024%20hearing.pdf>.

²⁹ Office of Management and Budget, "Circular A-4," Obama White House, February 22, 2017, https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/ (accessed September 27, 2021).

³⁰ IWG, TSD 2021, pp. 17-19.

³¹ D. W. Kreutzer, "Discounting Climate Costs," Heritage Foundation *Issue Brief* No. 4575, June 16, 2016, <https://www.heritage.org/environment/report/discounting-climate-costs>; Kevin Dayaratna, Rachel Greszler and Patrick Tyrrell, "Is Social Security Worth Its Cost?" Heritage Foundation Backgrounder No. 3324, July 10, 2018, <https://www.heritage.org/budget-and-spending/report/social-security-worth-its-cost>.

“intergenerational equity”? It would confer much greater wealth on posterity, endowing them with far more productive capital stock.

Kreutzer also notes that all baseline scenarios assume future generations are richer than current generations. He comments:

It is a terrible policy to make investments that return \$100 instead of \$131,081, but it is virtually brain-dead to argue the bad return is justified on equity grounds. Those alive centuries from now are almost certain to be much wealthier, healthier, and possessed of technology to better overcome any adversity—including climate change.³²

It is hard to shake the suspicion that the IWG declines to use a 7 percent discount rate, even as a sensitivity-case analysis, because doing so would spotlight the comparatively low rates of return of GHG-reduction policies.

The IWG hints that its final TSD, to be published in 2022, may use discount rates as low as 1 percent.³³ However, as in the IWG’s 2010, 2013, and 2016 TSDs, the February 2021 interim TSD uses discount rates of 2.5 percent, 3.0 percent, and 5.0 percent. Accordingly, the remainder of this section examines how those rates affect SCC values.

At the Heritage Foundation, Dayaratna and colleagues ran DICE and FUND using a 7.0 percent discount rate to quantify how much the IWG’s lower discount rates increases SCC estimates. Below is the 2016 TSD’s SCC estimates³⁴ followed by the Heritage analysts’ results published in the peer-reviewed journal *Climate Change Economics*:³⁵

Table ES-1: Social Cost of CO₂, 2010 – 2050 (in 2007 dollars per metric ton of CO₂)

Year	5% Average	3% Average	2.5% Average	High Impact (95 th Pct at 3%)
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

³² David Kreutzer, IER Comments on Social Cost of Greenhouse Gas Estimates, Docket No. OMB-2021-0006, June 24, 2021, <https://www.instituteforenergyresearch.org/climate-change/ier-comments-on-social-cost-of-carbon-estimates/>.

³³ IWG, TSD 2021, pp. 21, 35.

³⁴ IWG, Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, August 2016, p. 4, https://www.epa.gov/sites/default/files/2016-12/documents/sc_co2_tsd_august_2016.pdf (hereafter IWG, TSD 2016).

³⁵ K. Dayaratna, R. McKittrick, and D. Kreutzer, “Empirically Constrained Climate Sensitivity and the Social Cost of Carbon,” *Climate Change Economics*, Vol. 8, No. 2 (2017), p. 1750006-1-1750006-12, <https://www.worldscientific.com/doi/abs/10.1142/S2010007817500063> (hereafter Dayaratna et al. (2017)).

DICE Model Average SCC – Baseline, End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	\$56.92	\$37.79	\$12.10	\$5.87
2030	\$66.53	\$45.15	\$15.33	\$7.70
2040	\$76.96	\$53.26	\$19.02	\$9.85
2050	\$87.70	\$61.72	\$23.06	\$12.25

FUND Model Average SCC – Baseline, End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	\$32.90	\$19.33	\$2.54	-\$0.37
2030	\$36.16	\$21.78	\$3.31	-\$0.13
2040	\$39.53	\$24.36	\$4.21	\$0.19
2050	\$42.98	\$27.06	\$5.25	\$0.63

If any agency, including the Commission, is going to use SCC analysis, it should include SCC discounted at 7 percent as part of its benefit-cost analysis, because only on that basis can the public compare climate policy “investments” to other capital expenditures. And only through such comparisons can policymakers reasonably assess which investments will best position future generations to inherit the most productive capital stock.

Section 5: How the Time Horizon Affects the SCC

Human beings use technology to adapt to environmental conditions. Consequently, the loss functions in IAMs depend on assumptions about how adaptive technologies will be developed and deployed as the world warms. It is essentially impossible to forecast technological change decades, let alone centuries, into the future.

Consider U.S. natural gas as an example. Around the turn of this century, it was accepted wisdom that our supplies were running so low that large net imports would be required. A mere ten years later, thanks to the widespread use of hydraulic fracturing of shale, it was apparent there are literally hundreds of years of supply within rock layers under vast areas of the lower-48 states (as well as in Europe and China, as later discovered).

Substitution of gas-fired combustion for coal firing reduces net greenhouse gas emissions by nearly 60 percent. Supercritical natural-gas fired turbine technology can actually reduce net

emissions to zero in an experimental plant,³⁶ though a much-anticipated commercial-grade upscaling has yet to be achieved. These developments only serve to emphasize how foolhardy it is to use, as the IWG does, a 300-year period (2000-2300). Dayaratna and his former Heritage Foundation colleague David Kreutzer ran the DICE model with a significantly shorter, albeit still unrealistic, time horizon of 150 years into the future.³⁷

Here are the DICE-estimated SCC values with a baseline ending in 2300:

TABLE 1

Average SCC Baseline, End Year 2300

Year	Discount Rate: 2.5%	Discount Rate: 3%	Discount Rate: 5%	Discount Rate: 7%
2010	\$46.57	\$30.04	\$8.81	\$4.02
2015	\$52.35	\$34.32	\$10.61	\$5.03
2020	\$56.92	\$37.79	\$12.10	\$5.87
2025	\$61.48	\$41.26	\$13.60	\$6.70
2030	\$66.52	\$45.14	\$15.33	\$7.70
2035	\$71.57	\$49.03	\$17.06	\$8.70
2040	\$76.95	\$53.25	\$19.02	\$9.85
2045	\$82.34	\$57.48	\$20.97	\$11.00
2050	\$87.69	\$61.72	\$23.06	\$12.25

Source: Calculations based on Heritage Foundation Monte Carlo simulation results using the DICE model.

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Here are the results with a baseline ending in 2150:

TABLE 3

Average SCC, End Year 2150

Year	Discount Rate: 2.5%	Discount Rate: 3%	Discount Rate: 5%	Discount Rate: 7%
2010	\$36.78	\$26.01	\$8.66	\$4.01
2015	\$41.24	\$29.65	\$10.42	\$5.02
2020	\$44.41	\$32.38	\$11.85	\$5.85
2025	\$47.57	\$35.11	\$13.28	\$6.68
2030	\$50.82	\$38.00	\$14.92	\$7.67
2035	\$54.07	\$40.89	\$16.56	\$8.66
2040	\$57.17	\$43.79	\$18.36	\$9.79
2045	\$60.27	\$46.68	\$20.16	\$10.92
2050	\$62.81	\$49.20	\$22.00	\$12.13

Source: Calculations based on Heritage Foundation Monte Carlo simulation results using the DICE model.

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The SCC estimates drop substantially—in some cases by more than 25 percent—as a result of ending the SCC estimation period in 2150.

³⁶ See <https://www.powermag.com/breakthrough-net-powers-all-am-cycle-test-facility-delivers-first-power-to-ercot-grid/>.

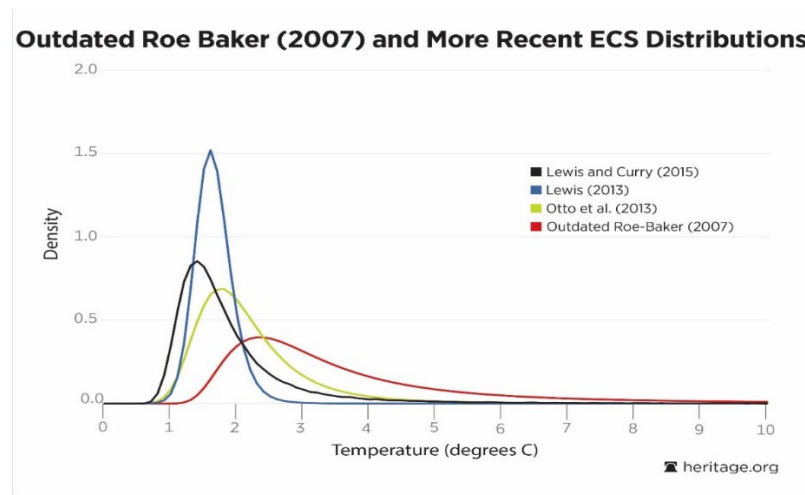
³⁷ Dayaratna and Kreutzer, *Loaded DICE: An EPA Model Not Ready for the Big Game*, Backgrounder No. 2860, The Heritage Foundation, November 21, 2013, <https://www.heritage.org/environment/report/loaded-dice-epa-model-not-ready-the-big-game>.

Section 6: How the Equilibrium Climate Sensitivity (ECS) Distribution Affects the SCC

The key climate specification used in estimating the SCC is the equilibrium climate sensitivity (ECS) distribution. Such distributions probabilistically quantify the earth's temperature response to a doubling of CO₂ concentrations.

ECS distributions are derived from general circulation models (GCMs) or more comprehensive earth system models (ESMs), which attempt to represent physical processes in the atmosphere, ocean, cryosphere and land surface. The IWG uses the ECS distribution from a study by Gerard Roe and Marcia Baker published 15 years ago in the journal *Science*.³⁸ This non-empirical distribution, calibrated by the IWG based on assumptions it selected in conjunction with IPCC recommendations,³⁹ is no longer scientifically defensible.⁴⁰

Since 2011, a variety of newer and empirically-constrained distributions have been published in the peer-reviewed literature. Many of those distributions suggest lower probabilities of extreme global warming in response to CO₂ concentrations. Below are three such distributions:⁴¹



³⁸ Gerard H. Roe and Marcia B. Baker. 2007. Why Is Climate Sensitivity So Unpredictable? *Science*, Vol. 318, No. 5850, pp. 629–632, <https://science.sciencemag.org/content/318/5850/629>.

³⁹ IWG, Technical Support Document: - Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866, February 2010, pp. 13-14, https://www.epa.gov/sites/default/files/2016-12/documents/scc_tsd_2010.pdf (hereafter IWG, TSD 2010).

⁴⁰ Patrick J. Michaels, "An Analysis of the Obama Administration's Social Cost of Carbon," testimony before the Committee on Natural Resources, U.S. House of Representatives, July 22, 2015, <https://www.cato.org/publications/testimony/analysis-obama-administrations-social-cost-carbon>.

⁴¹ Nicholas Lewis, "An Objective Bayesian Improved Approach for Applying Optimal Fingerprint Techniques to Estimate Climate Sensitivity," *Journal of Climate*, Vol. 26, No. 19 (October 2013), pp. 7414–7429, <https://journals.ametsoc.org/view/journals/clim/26/19/jcli-d-12-00473.1.xml>; Alexander Otto et al., "Energy Budget Constraints on Climate Response," *Nature Geoscience*, Vol. 6, No. 6 (June 2013), pp. 415–416, <https://www.nature.com/articles/ngeo1836>; Nicholas Lewis and Judith A. Curry, "The Implications for Climate Sensitivity of AR5 Forcing and Heat Uptake Estimates," *Climate Dynamics*, Vol. 45, No. 3, pp. 1009–1923, <http://link.springer.com/article/10.1007/s00382-014-2342-y>.

The areas under the curves between two temperature points represent the probability that the earth's temperature will increase between those amounts in response to a doubling of CO₂ concentration. For example, the area under the curve from 4°C onwards (known as right-hand "tail probability") represents the probability that the earth's temperature will warm by more than 4°C in response to a doubling of CO₂ concentrations. Note that the more up-to-date ECS distributions (Otto et al., 2013; Lewis, 2013; Lewis and Curry, 2015) have significantly lower tail probabilities than the outdated Roe-Baker (2007) distribution used by the IWG.

Here, again, is the IWG's 2016 SCC estimates for 2020-2050:

Table ES-1: Social Cost of CO₂, 2010 – 2050 (in 2007 dollars per metric ton of CO₂)

Year	5% Average	3% Average	2.5% Average	High Impact (95 th Pct at 3%)
2010	10	31	50	86
2015	11	36	56	105
2020	12	42	62	123
2025	14	46	68	138
2030	16	50	73	152
2035	18	55	78	168
2040	21	60	84	183
2045	23	64	89	197
2050	26	69	95	212

In *Climate Change Economics*, Dayaratna and colleagues re-estimated the DICE and FUND models' SCC values using the more up-to-date ECS distributions and obtained the following results:⁴²

DICE Model Average SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	\$28.92	\$19.66	\$6.86	\$3.57
2030	\$33.95	\$23.56	\$8.67	\$4.65
2040	\$39.47	\$27.88	\$10.74	\$5.91
2050	\$45.34	\$32.51	\$13.03	\$7.32

⁴²Dayaratna et al. (2017).

FUND Model Average SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	\$5.86	\$3.33	–\$0.47	–\$1.10
2030	\$6.45	\$3.90	–\$0.19	–\$1.01
2040	\$7.02	\$4.49	–\$0.18	–\$0.82
2050	\$7.53	\$5.09	\$0.64	–\$0.53

Using the more up-to-date ECS distributions dramatically lowers SCC estimates. The IWG’s outdated assumptions overstate the probabilities of extreme global warming, which artificially inflates their SCC estimates. The Commission should not use SCC estimation for policymaking, as it is highly susceptible to user manipulation. However, if it must be used, the Commission should utilize the more realistic estimates of climate sensitivity.

Lest the Commission assume we prefer the empirically-constrained ECS estimates just because they are lower, we would note that so-called state-of-the-art GCMs repeatedly overshoot observed tropical warming at altitude—a clear indication the models overestimate climate sensitivity.

In its Fifth Assessment Report (AR5), the IPCC used the Coupled Model Intercomparison Project Phase 5 (CMIP5) models to project future warming and the associated climate impacts.⁴³ The figure below compares predicted and observed average tropospheric temperature over the tropics.⁴⁴ The observations come from satellites, weather balloons, and reanalyses.⁴⁵

A careful look at the figure reveals that only one of the 102 model runs correctly simulates what has been observed. This is the Russian climate model INM-CM4, which also has the least prospective warming of all of them, with an ECS of 2.05°C, compared to the CMIP5 average of 3.2°C.

⁴³ Program for Climate Model Diagnosis and Intercomparison, CMIP5 – Coupled Model Intercomparison Project Phase 5 – Overview, <https://pcmdi.llnl.gov/mips/cmip5/>.

⁴⁴ The CMIP5 predictions are available at <https://climexp.knmi.nl/start.cgi>.

⁴⁵ Climate reanalyses produces synthetic histories of recent climate and weather using all available observations, a consistent data assimilation system, and mathematical modeling to fill in data gaps. See National Center for Atmospheric Research, Atmospheric Reanalysis: Overview & Comparison, <https://climatedataguide.ucar.edu/climate-data/atmospheric-reanalysis-overview-comparison-tables> and ECMWF, Climate Reanalysis, <https://www.ecmwf.int/en/research/climate-reanalysis>

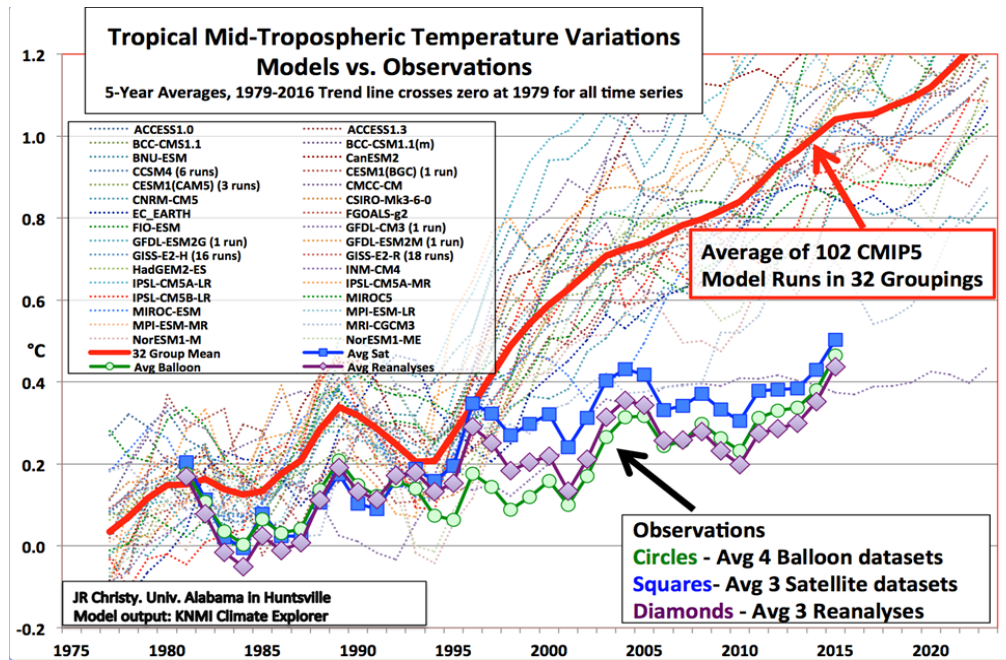


Figure 1. Solid red line—average of all the CMIP-5 climate models; Thin colored lines—individual CMIP-5 models; solid figures—weather balloon, satellite, and reanalysis data for the tropical troposphere. ⁴⁶

Best scientific practice uses models that work and does not seriously consider those that do not. This is standard when formulating the daily weather forecast, and should be the standard with regard to climate forecasts. In assessing the efficacy of mitigation measures, the Commission should pay attention to best practice, which may mean that regulation of carbon dioxide at this time or in proximate decades is simply senseless.

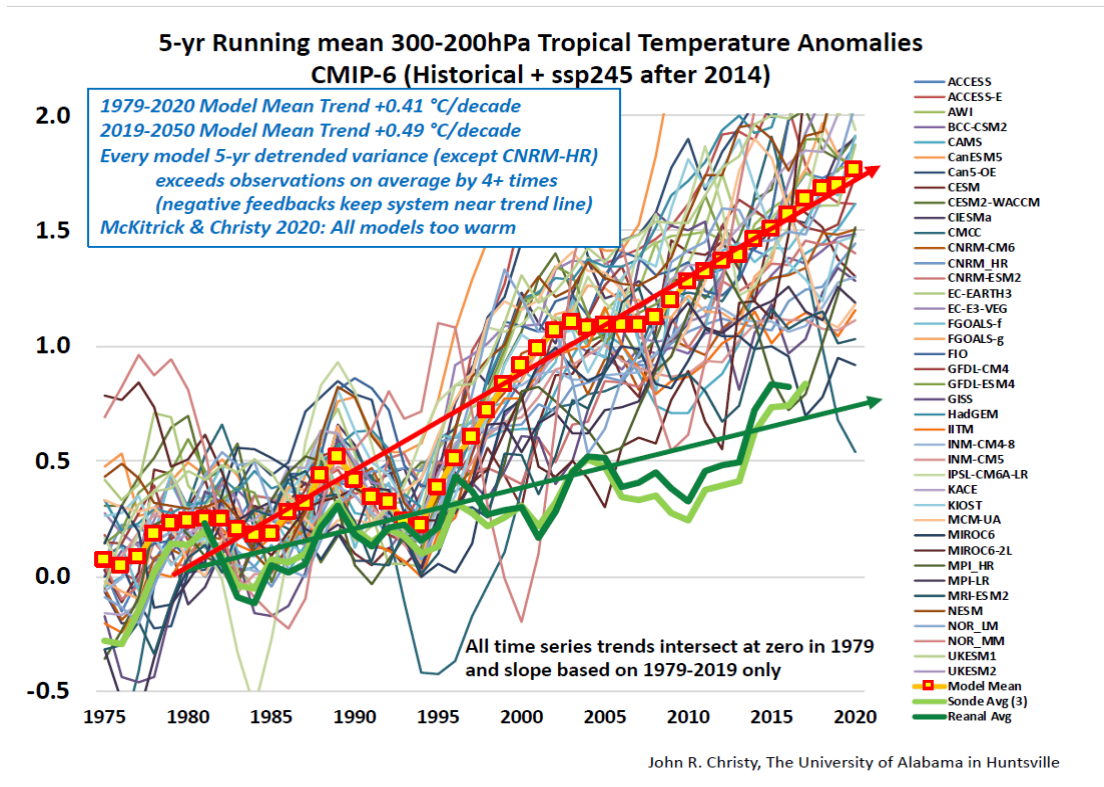
The IPCC's recently released Sixth Assessment Report (AR6) uses a new suite of models, designated CMIP6. Is this an improvement?

No. As shown by McKittrick and Christy (2020), the CMIP6 models are even worse.⁴⁷ Of the two models that work, the Russian INM-CM4.8, has even less warming than its predecessor, with an ECS of 1.8°C, compared to the CMIP6 community value of around four degrees.⁴⁸ The other one is also a very low ECS model from the same, group, INM-CM5. The model mean warming rate exceeds observation by more than two times at altitude in the tropics.

⁴⁶ Christy, J.R.: 2017, [in "State of the Climate in 2016"], *Bull. Amer. Meteor. Soc.* 98, (8), S16-S17, <https://journals.ametsoc.org/view/journals/bams/98/8/2017bamsstateoftheclimate.1.xml>.

⁴⁷ R. McKittrick and J. Christy. 2020. Pervasive Warming Bias in CMIP6 Tropospheric Layers. *Earth and Space Science* Volume 7, Issue 9, <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EA001281>.

⁴⁸ Most (not all) of the CMIP-6 models were available for McKittrick and Christy (2020); this figure is the mean ECS of what was released through late 2020.



Quoting from McKittrick and Christy's conclusion:

The literature drawing attention to an upward bias in climate model warming responses in the tropical troposphere extends back at least 15 years now ... Rather than being resolved, the problem has become worse, since now every member of the CMIP6 generation of climate models exhibits an upward bias in the entire global troposphere as well as in the tropics.

Zeke Hausfather, hardly a climate skeptic, has noted that while the CMIP6 models are warmer than the previous generation, the warmer they are, the more they over-forecast warming in recent decades, confirming what McKittrick and Christy found.⁴⁹

Zhu, Poulsen, and Otto-Bliesner (2020) used a CMIP6 model called CESM2 to project warming from an emission scenario that reaches 855 parts per million by 2100—roughly three times the pre-industrial concentration. Despite being tuned to match the behavior of 20th century climate, CESM2 produced a global mean temperature “5.5°C greater than the upper end of proxy temperature estimates for the Early Eocene Climate Optimum.” That was a period when CO₂ concentrations of about 1,000 ppm persisted for millions of years.⁵⁰ Moreover, the modeled tropical land temperature exceeded 55°C, “which is much higher than the temperature tolerance

⁴⁹ Zeke Hausfather, “Cold Water on Hot Models,” The Breakthrough Institute, February 11, 2020, <https://thebreakthrough.org/issues/energy/cold-water-hot-models>.

⁵⁰ NOAA National Centers for Environmental Information, Early Eocene Period, 54 to 48 Million Years Ago, <https://www.ncdc.noaa.gov/global-warming/early-eocene-period>.

of plant photosynthesis and is inconsistent with fossil evidence of an Eocene Neotropical rainforest.”⁵¹

The bottom line is that the Roe-Baker ECS distribution inflates the IWG’s SCC estimates, which will become even more unrealistic if updated with CMIP6.

Section 7: Negative SCC Values

Policymakers and the media often assume carbon dioxide emissions have only harmful impacts on society. However, CO₂ emissions have enormous direct agricultural⁵² and ecological benefits,⁵³ global warming lengthens growing seasons,⁵⁴ and warming potentially also alleviates cold-related mortality, which may exceed heat-related mortality by 20 to 1.⁵⁵

Of the three IAMs used by the IWG, only the FUND model estimates CO₂ fertilization benefits. Dayaratna and colleagues investigated whether a model with CO₂ fertilization benefits could produce negative SCC estimates. A negative SCC means that each incremental ton of CO₂ emissions produces a net benefit.

The researchers calculated the probability of a negative SCC under a variety of assumptions. Below are some of the results published both at the Heritage Foundation as well as in the peer-reviewed journal *Climate Change Economics*:⁵⁶

FUND Model Probability of Negative SCC – ECS Distribution Based on Outdated Roe–Baker (2007) Distribution, End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	0.084	0.115	0.344	0.601

⁵¹ Jiang Zhu, Christopher J. Poulsen & Bette L. Otto-Bliesner. 2020. High climate sensitivity in CMIP6 model not supported by paleoclimate. *Nature Climate Change* volume 10, pages 378–379, <https://www.nature.com/articles/s41558-020-0764-6>.

⁵² Literally hundreds of peer-reviewed studies document significant percentage increases in food crop photosynthesis, dry-weight biomass, and water-use efficiency due to elevated CO₂ concentrations. See the Center for the Study of Carbon Dioxide and Global Change’s Plant-Growth Database: http://co2science.org/data/plant_growth/plantgrowth.php

⁵³ See, for example, Randall J. Donahue et al. 2013. Impact of CO₂ fertilization on maximum foliage cover across the globe’s warm, arid environments. *Geophysical Research Letters* Vol. 40, 1–5, https://friendsofscience.org/assets/documents/CO2_Fertilization_grl_Donohue.pdf; Zaichun Zhu et al. The Greening of the Earth and Its Drivers. 2016. *Nature Climate Change* 6, 791-795, <https://www.nature.com/articles/nclimate3004>; and J.E. Campbell et al. 2017. Large historical growth in global gross primary production. *Nature* 544, 84-87, <https://www.nature.com/articles/nature22030>.

⁵⁴ EPA, Climate Change Indicators: Length of Growing Season, <https://www.epa.gov/climate-indicators/climate-change-indicators-length-growing-season>.

⁵⁵ Antonio Gasparrini et al. 2015. Mortality risk attributable to high and low ambient temperature: a multicountry observational study, *The Lancet*, Volume 386, Issue 9991, [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(14\)62114-0/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)62114-0/fulltext).

⁵⁶ Dayaratna and Kreutzer, “Unfounded FUND: Yet Another EPA Model Not Ready for the Big Game,” Backgrounder No. 2897, April 29, 2014, http://thf_media.s3.amazonaws.com/2014/pdf/BG2897.pdf; and Dayaratna et al. (2017).

2030	0.080	0.108	0.312	0.555
2040	0.075	0.101	0.282	0.507
2050	0.071	0.093	0.251	0.455

FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Otto et al. (2013), End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	0.268	0.306	0.496	0.661
2030	0.255	0.291	0.461	0.619
2040	0.244	0.274	0.425	0.571
2050	0.228	0.256	0.386	0.517

FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Lewis (2013), End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	0.375	0.411	0.565	0.685
2030	0.361	0.392	0.530	0.645
2040	0.344	0.371	0.491	0.598
2050	0.326	0.349	0.449	0.545

FUND Model Probability of Negative SCC – ECS Distribution Updated in Accordance with Lewis and Curry (2015), End Year 2300				
Year	Discount Rate - 2.5%	Discount Rate – 3.0%	Discount Rate – 5.0%	Discount Rate – 7.0%
2020	0.402	0.432	0.570	0.690
2030	0.388	0.414	0.536	0.646
2040	0.371	0.394	0.496	0.597
2050	0.354	0.372	0.456	0.542

As the above statistics illustrate, under a variety of reasonable assumptions, the SCC has a substantial probability of being negative. In fact, in some cases, the SCC is more likely to be

negative than positive, which implies—if one adopts the perspective of a central planner—that the Commission should, in fact, subsidize (not limit) CO₂ emissions. We, of course, oppose such interventionism.

Our purpose here is to illustrate the extreme sensitivity of these models to reasonable changes in assumptions. We advise the Commission not to use SCC analysis as a policymaking tool. However, if it does so, it should also present the probabilities of negative SCC values—i.e., the chance that the direct benefits of CO₂ emissions will exceed climate-related damages.

Section 8: Updated Agricultural Benefits and Benefit-Cost Analysis

It is a well-established fact that increases in CO₂ concentration enhance plant growth by increasing their internal water use efficiency as well as raising the rate of net photosynthesis.⁵⁷ As discussed in the previous section, the FUND model attempts to incorporate those benefits; however, this aspect of the model is grounded on research that is one-to-two decades old. Even so, as discussed in the preceding section, Dayaratna et al. (2017) found substantial probabilities of negative SCC using the outdated assumptions in FUND.

Dayaratna et al. (2020) summarized more recent CO₂ fertilization research, updated the FUND model's CO₂ fertilization function, and re-estimated the model's SCC values.⁵⁸ To facilitate the Commission's review of that research, we excerpt several paragraphs from Dayaratna et al. (2020):

Three forms of evidence gained since then indicates that the CO₂ fertilization effects in FUND may be too low. First, rice yields have been shown to exhibit strong positive responses to enhanced ambient CO₂ levels. Kimball (2016) surveyed results from Free-Air CO₂ Enrichment (FACE) experiments, and drew particular attention to the large yield responses (about 34 percent) of hybrid rice in CO₂ doubling experiments, describing these as “the most exciting and important advances” in the field. FACE experiments in both Japan and China showed that available cultivars respond very favorably to elevated ambient CO₂. Furthermore, Challinor et al. (2014), Zhu et al. (2015) and Wu et al. (2018) all report evidence that hybrid rice varieties exist that are more heat-tolerant and therefore able to take advantage of CO₂ enrichment even under warming conditions. Collectively, this research thus indicates that the rice parameterization in FUND is overly pessimistic.

Second, satellite-based studies have yielded compelling evidence of stronger general growth effects than were anticipated in the 1990s. Zhu et al. (2016)

⁵⁷ K.E. Idso and S.B. Idso. 1994. Plant responses to atmospheric CO₂ enrichment in the face of environmental constraints: A review of the past 10 years' research. *Agricultural and Forest Meteorology*, 69, 153-203, <https://www.sciencedirect.com/science/article/abs/pii/0168192394900256>; Jennifer Cuniff et al. 2008. Response of wild C4 crop progenitors to subambient CO₂ highlights a possible role in the origin of agriculture. *Global Change Biology* 14: 576-587, <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2007.01515.x>.

⁵⁸ Kevin Dayaratna, Ross McKittrick, and Patrick Michaels. 2020. Climate sensitivity, agricultural productivity and the social cost of carbon in FUND. *Environmental Economics and Policy Studies* 22: 433-448, <https://link.springer.com/article/10.1007/s10018-020-00263-w>.

published a comprehensive study on greening and human activity from 1982 to 2009. The ratio of land areas that became greener, as opposed to browner, was approximately 9 to 1. The increase in atmospheric CO₂ was just under 15 percent over the interval but was found to be responsible for approximately 70 percent of the observed greening, followed by the deposition of airborne nitrogen compounds (9 percent) from the combustion of coal and deflation of nitrate-containing agricultural fertilizers, lengthening growing seasons (8 percent) and land cover changes (4 percent), mainly reforestation of regions such as southeastern North America ...

Munier et al. (2018) likewise found a remarkable increase in the yield of grasslands. In a 17-year (1999-2015) analysis of satellite-sensed LAI [leaf area index], during which time the atmospheric CO₂ level rose by about 10 percent, there was an average LAI increase of 85 percent. A full 31 percent of earth's continental land outside of Antarctica is covered by grassland, the largest of the three agricultural land types they classified. Also, for summer crops, such as maize (corn) and soybeans, greening increased an average of 52 percent, while for winter crops, whose area is relatively small compared to those for summer, the increase was 31 percent. If 70 percent of the yield gain is attributable to increased CO₂, the results from Zhu et al (2016) imply gains of 60 percent, 36 percent and 22 percent over the 17-year period for, respectively, grasslands, summer crops and winter crops, associated with only a 10 percent increase in CO₂, compared to parameterized yield gains in the range of 20 to 30 percent for CO₂ doubling in FUND.

Third, there has been an extensive amount of research since Tsingas et al. (1997) on adaptive agricultural practices under simultaneous warming and CO₂ enrichment. Challinor et al. (2014) surveyed a large number of studies that examined responses to combinations of increased temperature, CO₂ and precipitation, with and without adaptation. In their metaanalysis, average yield gains increased 0.06 percent per ppm increase in CO₂ and 0.5 percent per percentage point increase in precipitation, and adaptation added a further 7.2 percent yield gain, but warming decreased it by 4.9 percent per degree C. In FUND, 3°C warming negates the yield gains due to CO₂ enrichment. However, based on Challinor et al.'s (2014) regression analysis, doubling CO₂ from 400 to 800 pm, while allowing temperatures to rise by 3°C and precipitation to increase by 2 percent, would imply an average percent yield increase ranging from 2.1 to 12.1 percent increase, indicating the productivity increase in FUND is likely too small.

Based on that literature, Dayaratna et al. (2020) updated the FUND model's coefficients to increase its agricultural benefits by 15 percent and 30 percent. In addition, the authors

used an updated ECS distribution—that of Lewis and Curry (2018).⁵⁹ In the charts below, the last three columns show the mean SCC as well as the associated probability of negative SCC values under different discount rates.

FUND Model Average SCC, agricultural component updated - Discount Rate – 2.5%				
	Roe Baker (2007)	Lewis and Curry (2018)	Lewis and Curry (2018) + 15%	Lewis and Curry (2018) + 30%
2020	\$32.90	\$3.78 / 0.46	\$0.62 / 0.53	-\$1.53 / 0.59
2030	\$36.16	\$4.69 / 0.44	\$1.25 / 0.51	-\$1.02 / 0.57
2040	\$39.53	\$5.76 / 0.42	\$2.03 / 0.48	-\$0.33 / 0.54
2050	\$42.98	\$6.98 / 0.39	\$2.96 / 0.46	-\$0.55 / 0.51

FUND Model Average SCC, agricultural component updated - Discount Rate – 3%				
	Roe Baker (2007)	Lewis and Curry (2018)	Lewis and Curry (2018) + 15%	Lewis and Curry (2018) + 30%
2020	\$19.33	\$1.61 / 0.49	-\$0.82 / 0.57	-\$2.74 / 0.63
2030	\$21.78	\$2.32 / 0.47	-\$0.35 / 0.54	-\$2.39 / 0.61
2040	\$24.36	\$3.18 / 0.44	\$0.28 / 0.51	-\$1.85 / 0.57
2050	\$27.06	\$4.21 / 0.42	\$1.08 / 0.48	-\$1.12 / 0.54

FUND Model Average SCC, agricultural component updated - Discount Rate – 5%				
	Roe Baker (2007)	Lewis and Curry (2018)	Lewis and Curry (2018) + 15%	Lewis and Curry (2018) + 30%
2020	\$2.54	-\$1.02 / 0.62	-\$2.25 / 0.71	-\$3.41 / 0.78
2030	\$3.31	-\$0.77 / 0.58	-\$2.14 / 0.67	-\$3.41 / 0.74
2040	\$4.21	-\$0.39 / 0.54	-\$1.89 / 0.63	-\$3.24 / 0.70
2050	\$5.25	\$0.15 / 0.49	-\$1.47 / 0.58	-\$2.87 / 0.65

⁵⁹ Lewis and Curry. 2018. The impact of recent forcing and ocean heat uptake data on estimates of climate sensitivity. *Journal of Climate* Vol. 31: 6051-6071, <https://journals.ametsoc.org/view/journals/clim/31/15/jcli-d-17-0667.1.xml>.

	FUND Model Average SCC, agricultural component updated - Discount Rate – 7%			
	Roe Baker (2007)	Lewis and Curry (2018)	Lewis and Curry (2018) + 15%	Lewis and Curry (2018) + 30%
2020	-\$0.37	-\$1.25 / 0.71	-\$2.06 / 0.80	-\$2.84 / 0.85
2030	-\$0.13	-\$1.18 / 0.67	-\$2.08 / 0.76	-\$2.94 / 0.82
2040	\$0.19	-\$0.98 / 0.62	-\$1.98 / 0.71	-\$2.91 / 0.77
2050	\$0.63	-\$0.66 / 0.56	-\$1.74 / 0.65	-\$2.71 / 0.72

As the results illustrate, under more realistic assumptions regarding agricultural productivity and climate sensitivity, the mean SCC essentially drops to zero and in many cases has a substantial probability of being negative.

In light of Dayaratna et al. (2020), it is fair to say that the IWG’s SCC estimation process, which averages the results of three models, only one which includes CO₂ agricultural benefits, is structurally biased.

In this connection, we could not help noticing that CO₂ fertilization and global greening are not mentioned in the IWG’s February 2021 interim TSD. Similarly, although Dayaratna et al. (2020) was published in January 2020, neither that study nor Dayaratna et al. (2017) are included among the TSD’s 115 references.

Section 9: Unreasonable Pessimism Regarding Human Adaptive Capabilities

Other things being equal, the more pessimistic an IAM’s view of human adaptive capabilities, the higher the SCC estimates it will produce. Climate impact assessments often ignore, assume away, or depreciate mankind’s remarkable capacity for adaptation.⁶⁰ Prominent examples include:

- The 2018 Fourth National Climate Assessment, which estimates global warming could reach 8°C and reduce U.S. GDP by 10 percent in the 2090s.⁶¹ As revealed in the fine print, that estimate assumes no adaptive measures beyond those already deployed “in the historical period,” i.e., during 1980-2010.⁶²

⁶⁰ Oren Cass, *Overheated: How Flawed Analyses Overestimate the Costs of Climate Change*, Manhattan Institute, March 11, 2018, <https://www.manhattan-institute.org/html/overheated-how-flawed-analyses-overestimate-costs-climate-change-10986.html>.

⁶¹ Coral Davenport and Kendra Pierre-Luis, “U.S. Climate Report Warns of Damaged Environment and Shrinking Economy,” *New York Times*, November 23, 2018, <https://www.nytimes.com/2018/11/23/climate/us-climate-report.html>.

⁶² U.S. Global Change Research Program, *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*, Chapter 29, “Reducing Risks Through Emissions Mitigation,” p. 1,360,

- The Assessment’s high-end \$505 billion estimate of sector-specific climate damages in 2090. That estimate similarly assumes “limited or no adaptation.”⁶³
- The EPA’s 2015 *Benefits of Global Action* report, which projects 12,000 annual heat-stress deaths and 57,000 annual air pollution deaths in 49 U.S. cities in 2100.⁶⁴ As revealed in the fine print, the heat mortality estimate assumes no further progress in adaptation after 2015. As revealed in a key underlying study,⁶⁵ the air pollution mortality estimate assumes no further reduction in air pollutant emissions after 2000, even though fine particle (PM_{2.5}) emissions and precursors in 2015 were already significantly lower than in 2000.⁶⁶

The 2021 TSD says little about adaptation other than to acknowledge the IAMs’ “incomplete treatment of adaptation and technological change” and “uncertainty” about adaptation costs.⁶⁷ The 2016 TSD has a subsection on the PAGE model’s treatment of adaptation. Here is the gist. In PAGE2002, “Beyond 2°C, no adaptation is assumed to be available to mitigate the impacts of climate change.” And in PAGE09, “adaptation is assumed to alleviate 25-50 percent of the damages from the first 0.20 to 0.25 meters of sea level rise but is assumed to be ineffective thereafter.”⁶⁸

Those assumptions are not reasonable. Industrial civilization’s virtuous circle of wealth creation and technological innovation endlessly updates mankind’s adaptive capabilities, including our ability to make earth’s naturally dangerous climate more livable.⁶⁹ Since the 1920s, global CO₂ concentrations increased from about 305 parts per million to more than 415 ppm, and average global temperatures increased by about 1°C.⁷⁰ Yet, globally, the number of people dying from storms, floods, droughts, wildfires, and extreme temperatures decreased from about 472,000 per year in the 1920s to a projected 6,600 in 2021. “That’s almost 99 percent less than the death toll a century ago,” statistician Bjorn Lomborg pointed out recently in the *Wall Street Journal*.

https://nca2018.globalchange.gov/downloads/NCA4_Ch29_Mitigation_Full.pdf (hereafter USGCRP, NCA 2018). Incidentally, the Assessment’s 8°C warming projection comes from a study ([Hsiang et al. 2017](https://doi.org/10.1016/j.gloenvcha.2017.05.001)) that ran the overheated CMIP5 models with an inflated emissions scenario (RCP8.5, discussed below). Even with that biased combo, warming hits 8°C in only 1 percent of model runs—a fact the Assessment did not see fit to mention. See Marlo Lewis, “As Election Nears, NYT Makes Another Push for Groupthink,” Open Market, October 31, 2020, <https://cei.org/blog/as-election-nears-nyt-makes-another-push-for-groupthink/>.

⁶³ USGCRP, NCA 2018, p. 1,358.

⁶⁴ Environmental Protection Agency, *Climate Change in the United States: Benefits of Global Action*, June 2015, <https://www.epa.gov/sites/production/files/2015-06/documents/cirareport.pdf>. Like the National Assessment, *Benefits of Global Action* runs the warm-biased CMIP5 models with a forcing trajectory comparable to RCP8.5.

⁶⁵ Fernando Garcia-Menendez et al. 2015. U.S. Air Quality and Health Benefits from Avoided Climate Change under Greenhouse Gas Mitigation. *Environmental Science and Technology* 49, 7580-7588, https://www.researchgate.net/publication/277893514_US_Air_Quality_and_Health_Benefits_from_Avoided_Climate_Change_under_Greenhouse_Gas_Mitigation.

⁶⁶ EPA, Our Nation’s Air, interactive chart on air pollution concentrations, <https://gispub.epa.gov/air/trendsreport/2020/#home>.

⁶⁷ IWG, TSD 2021, pp. 26, 30.

⁶⁸ IWG, TSD 2016, pp. 14-15.

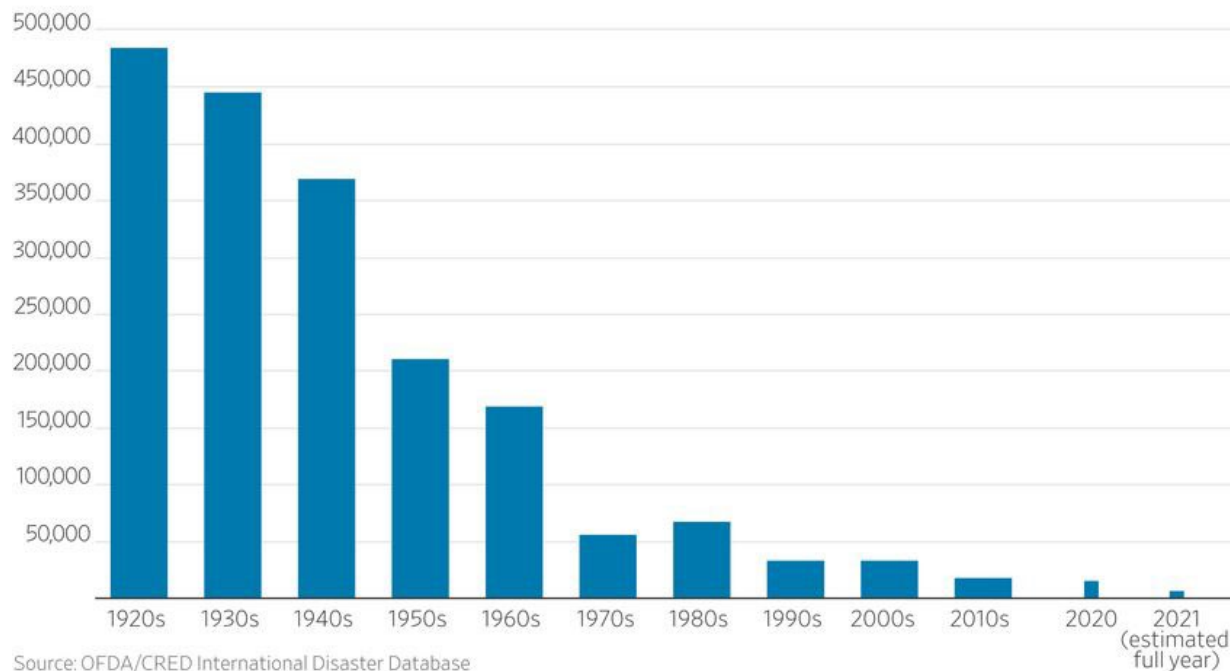
⁶⁹ Indur Goklany, *Humanity Unbound: How Fossil Fuels Save Humanity from Nature and Nature from Humanity*. Policy Analysis No. 715, Cato Institute, December 20, 2012, <https://www.cato.org/sites/cato.org/files/pubs/pdf/pa715.pdf>.

⁷⁰ NASA, Global CO₂ Mixing Ratios (ppm), <https://data.giss.nasa.gov/modelforce/ghgases/fig1A.ext.txt>

Weather-related mortality rates have dropped even more dramatically, as the global population has quadrupled over the past 100 years.⁷¹ If we are in a “climate crisis” today, what words can adequately describe the climate regime of the 1920s with so much more weather-related mortality?

Climate-Related Disasters Kill Ever Fewer

Global deaths from floods, droughts, storms, wildfire and extreme temperatures, annual average by decade 1920-2019, per year for 2020 and 2021



It is not possible to discern a social cost of carbon in those data. Nor is an SCC detectable in several other trends of fundamental relevance to human survival and flourishing. The past 70 years have been marked by unprecedented improvements in global life expectancy,⁷² per capita income,⁷³ food security,⁷⁴ and various health-related metrics.⁷⁵ Yields of all major food crops keep increasing, and production is increasing exponentially.⁷⁶ Nearly 3 billion people gained access to improved water sources since 1990,⁷⁷ and deaths from malaria (the most consequential climate-sensitive disease) declined by 52 percent during 2000-2015.⁷⁸

⁷¹ Bjorn Lomborg, “We’re Safer from Climate Disasters Than Ever Before,” *Wall Street Journal*, November 3, 2021, <https://www.wsj.com/articles/climate-activists-disasters-fire-storms-deaths-change-cop26-glasgow-global-warming-11635973538>.

⁷² Our World in Data, Life Expectancy, <https://ourworldindata.org/grapher/life-expectancy>.

⁷³ Our World in Data, Economic Growth, <https://ourworldindata.org/economic-growth>.

⁷⁴ Our World in Data, Food Supply, <https://ourworldindata.org/food-supply>.

⁷⁵ Our World in Data, Burden of Disease, <https://ourworldindata.org/health-meta#burden-of-disease>.

⁷⁶ Our World in Data, Crop Yields, <https://ourworldindata.org/crop-yields>. See also Figure 1 in Dayaratna et al. (2020), <https://link.springer.com/content/pdf/10.1007/s10018-020-00263-w.pdf>.

⁷⁷ Our World in Data, Access to Improved Water Sources, <https://ourworldindata.org/water-access#what-share-of-people-have-access-to-an-improved-water-source>.

⁷⁸ Our World in Data, Malaria, <https://ourworldindata.org/malaria>.

Even in recent decades, the warmest in the instrumental record, mortality and economic loss data point to an increasingly sustainable civilization. A May 2019 peer-reviewed study by European scholars Giuseppe Formetta and Luc Feyen reports that climate-related hazards show a “clear decreasing trend in both human and economic vulnerability, with global average mortality and economic loss rates that have dropped by 6.5 and nearly 5 times, respectively, from 1980–1989 to 2007–2016.”⁷⁹ Similarly, data buried in the appendix of a 2019 study in the *Lancet* reveal that disaster losses as a percentage of GDP are declining, with the greatest declines occurring in low-income countries.⁸⁰

An important policy implication of those trends is often overlooked. Policies that help make the United States and other countries wealthier also make humanity better able to handle whatever climate-related hazards occur in the future. SCC-based regulations, on the other hand, are likely to impede economic growth, while providing negligible climate change mitigation.⁸¹

A useful counterpoint to the PAGE model’s pessimism about the futility of adaptation beyond 2°C of warming and 0.20-0.25 meters of sea-level rise is Hinkel et al. (2014), a study published in *Proceedings of the National Academy of Sciences*. The study includes an RCP8.5 warming scenario in which sea levels rise up to six feet and flood 350 million people every year by century’s end, with costs potentially reaching \$100 trillion or 11 percent of global GDP annually.⁸² However, as Lomborg points out in his book *False Alarm*, those extraordinary damages are projected to occur only if people do nothing more than maintain current sea walls.

The results are dramatically different if coastal communities deploy “enhanced” adaptive measures that keep pace with sea-level rise. Annual flood costs increase from \$11 billion in 2000 to \$38 billion in 2100. Similarly, annual dike costs increase from \$13 billion to \$48 billion. However, Lomborg notes, “the total cost to the economy will actually decline, from 0.05 percent of GDP to 0.008 percent.” Moreover, the number of people experiencing flood damages drops from 3.4 million in 2000 to 15,000 in 2100—a 99.6 percent reduction in flood victims. In other

⁷⁹ Giuseppe Formetta and Luc Feyen. 2019. Empirical Evidence of Declining Global Vulnerability to Climate-Related Hazards. *Global Environmental Change* 57, https://www.researchgate.net/publication/333507964_Empirical_evidence_of_declining_global_vulnerability_to_climate-related_hazards.

⁸⁰ Roger Pielke, Jr., “Why Climate Advocates Need To Stop Hying Extreme Weather” *Forbes*, December 14, 2019, <https://www.forbes.com/sites/rogerpielke/2019/12/14/why-climate-advocates-need-to-stop-hying-extreme-weather/?sh=77801a227f0a> (accessed June 18, 2021); Nick Watts et al, “The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate,” *The Lancet* Vol 394, Issue 10211, pp. 1836-1867 (November 2019), [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(19\)32596-6/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(19)32596-6/fulltext) (accessed June 18, 2021).

⁸¹ Kevin D. Dayaratna and Nick Loris, “Assessing the Costs and Benefits of the Green New Deal,” Heritage Foundation Backgrounder No. 3427, July 24, 2019, <https://www.heritage.org/energy-economics/report/assessing-the-costs-and-benefits-the-green-new-deals-energy-policies>.

⁸² Jochen Hinkel et al. 2014. Coastal flood damage and adaptation cost under 21st century sea-level rise. *Proceedings of the National Academies of Sciences*, 111(9):3292-7, https://www.researchgate.net/publication/260528772_Coastal_flood_damage_and_adaptation_cost_under_21st_century_sea-level_rise.

words, with reasonable adaptation, people are projected to be much safer, and the global economy much less affected by sea-level rise in 2100, despite high-end warming.⁸³

If the Commission uses SCC estimates, it should eschew those produced by models that assume humanity is powerless to mitigate the costs of even modest levels of warming and sea-level rise.

Section 10: Implausible Emission Baselines

We have discussed several ways modelers can inflate SCC estimates: run the models with below-market discount rates, project social costs far beyond the limits of informed speculation, assume climate sensitivities derived from general circulation models that repeatedly overshoot observed warming, use models that depreciate (or simply ignore) CO₂ fertilization benefits, and use models that lowball human adaptive capabilities. Another way is to run the IAMs with implausibly high baseline emission scenarios. University of Colorado professor Roger Pielke, Jr. spotlighted this fatal flaw in the IWG exercise.⁸⁴

To estimate the incremental impact of one ton of CO₂ emissions, SCC modelers must first estimate how global emissions and concentrations will change over time. Such estimates are only as credible as the socio-economic development scenarios on which they are based. The IWG calculates SCC values with five emission trajectories. Four are no-climate-policy emission scenarios projected by four socio-economic models participating in a 2009 Stanford Energy Modeling Forum study known as EMF-22.⁸⁵ The fifth, a climate policy scenario, is the average trajectory produced by the same four models run with a CO₂ stabilization target of 550 parts per million. For more detail, see the Electric Power Research Institute's (EPRI) 2014 technical assessment report.⁸⁶

The EMF models estimated emissions growth through 2100. The IWG took those trajectories and extended them out to 2300. According to EPRI, "the extensions lack a coherent, viable, and intuitive storyline (or set of storylines)" that could explain the emission pathways after 2100. That is not surprising. As noted above, nobody can foresee how the global economy will evolve centuries into the future. The IWG did not even try to guess how economies would develop after 2100, yet nonetheless plotted emissions growth over the next 200 years. Based on what

⁸³ Bjorn Lomborg, *False Alarm: How Climate Change Panic Costs Us Trillions, Hurts the Poor, and Fails to Fix the Planet* (New York: Basic Books, 2020), pp. 29-34, 185-186. In their study, Hinkel et al. state that enhanced adaptation can reduce flood damages from an RCP8.5 warming by "2-3 orders of magnitude." Lomborg's numbers for costs and flood victims come from charts in the study's supplementary material. See Hinkel et al. Supporting Information,

<https://www.pnas.org/content/pnas/suppl/2014/01/29/1222469111.DCSupplemental/pnas.20122469SI.pdf>.

⁸⁴ Roger Pielke, Jr., "The Biden Administration Just Failed Its First Scientific Integrity Test," The Honest Broker Newsletter, February 28, 2021, <https://rogerpielkejr.substack.com/p/the-biden-administration-just-failed>.

⁸⁵ Leon Clarke et al. 2009. International climate policy architectures: Overview of the EMF 22 International Scenarios. *Energy Economics* Volume 31, Supplement 2, S64-S81, <https://www.sciencedirect.com/science/article/pii/S0140988309001960?via%3DiHub>.

⁸⁶ EPRI, *Understanding the Social Cost of Carbon: A Technical Assessment*, October 2014, Section 4, pp. 3-4, <https://www.epri.com/research/products/3002004657>.

assumptions? Apparently, the IWG assumed that, absent specific climate change mitigation policies, the global economy would burn through all fossil fuel reserves and do so repeatedly. As EPRI put it, all four “reference” (no-climate-policy) scenarios (USG1 – USG4) “result in post-2100 cumulative CO₂ emissions in excess of estimated fossil reserves.”

Table 4-6
Cumulative fossil and industrial CO₂ emissions in the USG assumptions and estimated fossil fuel reserves

	Cumulative CO ₂ emissions (GtCO ₂)	
	By 2200	By 2300
USG1	11,207	16,741
USG2	20,024	33,023
USG3	8,113	10,864
USG4	14,092	20,504
USG5	3,691	4,843
Estimated reserves (GtCO ₂)	3,674 - 7,113	

For example, in the USG2 scenario, cumulative CO₂ emissions reach 22,024 gigatons in 2200 and 33,023 gigatons in 2300—multiples of the estimated reserves (3,674 – 7,113 gigatons). The average of the five scenarios exceeds estimated reserves by factors of 2.5 to 4.7.

Thus, the IWG’s SCC estimates “envision cumulative carbon dioxide emissions that are far, far in excess of any plausible current expectation about the future,” Pielke, Jr. observes. “In fact,” he continues, “to even approach these massive amounts of cumulative emissions, the world would have to make it a policy goal to burn as much coal as possible over the coming centuries. That seems unlikely.”

The IWG’s 300-year emission baselines are even more implausible than RCP8.5,⁸⁷ the so-called business-as-usual (BAU) emission scenario used in the U.S. National Climate Assessment, IPCC AR5, AR6 (updated as SSP5-8.5), and literally thousands of other climate impact studies.⁸⁸ For RCP8.5 to be a realistic projection of future CO₂ emissions and concentrations, coal

⁸⁷ A representative concentration pathway (RCP) projects the growth in CO₂-equivalent GHG emissions, concentrations, and radiative forcing from 2000 to 2100. Radiative forcing is the net change in the Earth’s energy balance—the difference between incoming shortwave solar radiation and outgoing longwave infrared radiation. Forcing is measured in watts per square meter (W/m²). Thus, in RCP8.5, the rise in GHG concentration exerts a net warming pressure of 8.5W/m². An RCP is representative in the sense that at least some published socioeconomic development scenarios (called shared socioeconomic pathways or SSPs) produce the equivalent forcing during 2000-2100.

⁸⁸ Roger Pielke, Jr. and Justin Ritchie, “How Climate Scenarios Lost Touch with Reality,” *Issues in Science and Technology*, Summer 2021, [74-83 Pielke & Ritchie - How Climate Scenarios Lost Touch With Reality \(Summer 2021 ISSUES\).pdf - Google Drive](#); Roger Pielke, Jr. and Justin Ritchie. 2021. Distorting our view of the climate future: The misuse and abuse of climate pathways and scenarios. *Energy Research & Social Science*, Vol. 72, [Distorting the view of our climate future: The misuse and abuse of climate pathways and scenarios - ScienceDirect](#).

consumption would have to increase ten-fold during 2000-2100,⁸⁹ achieving market shares not seen since the 1940s.⁹⁰

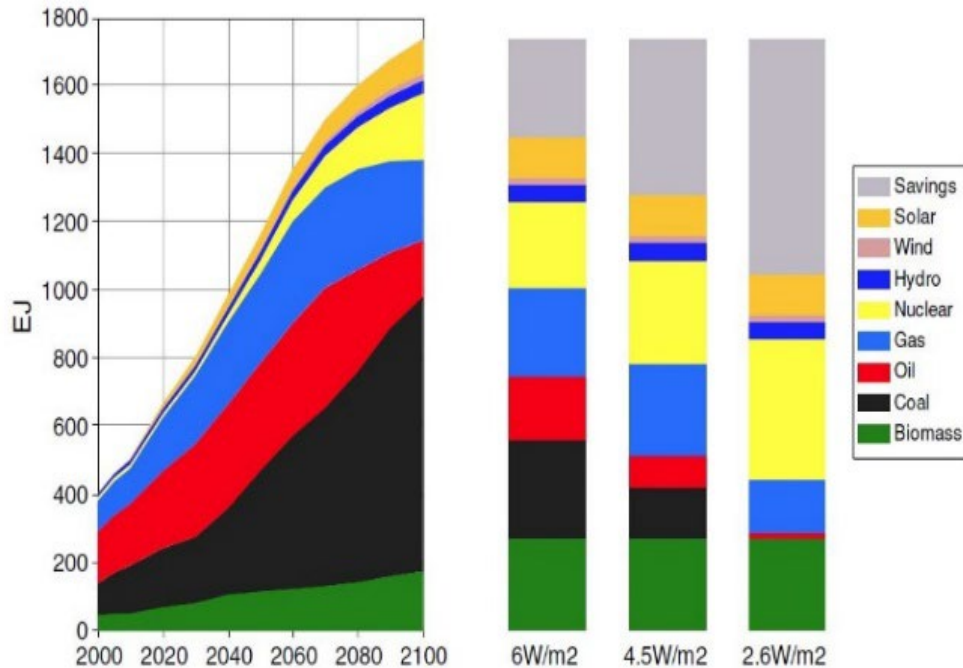


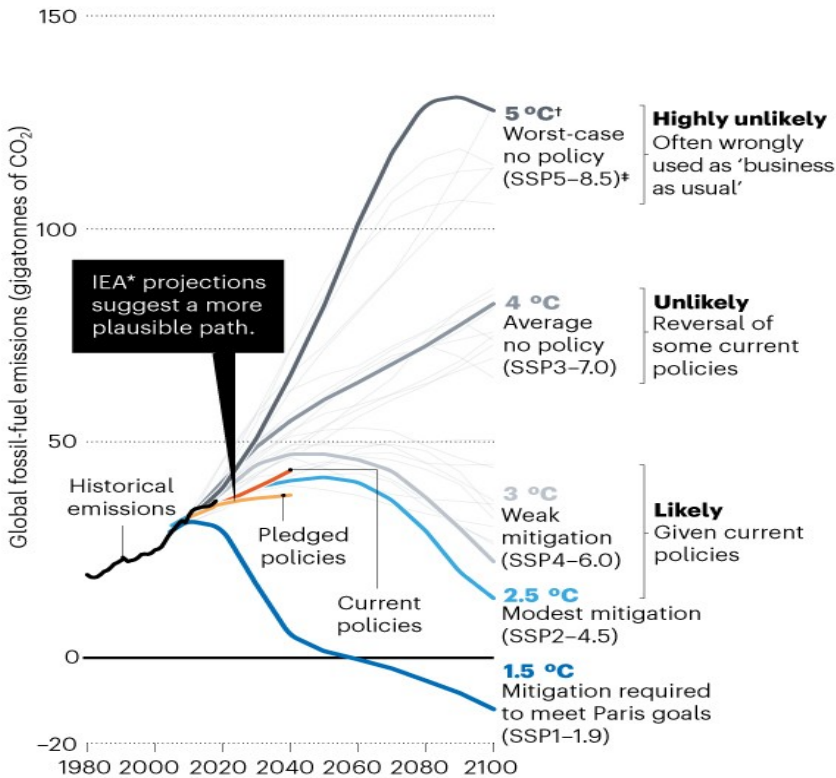
Fig. 5 Development of global primary energy supply in RCP8.5 (*left-hand panel*) and global primary energy supply in 2100 in the associated mitigation cases stabilizing radiative forcing at levels of 6, 4.5, and 2.6 W/m² (*right-hand bars*). Note that primary energy is accounted using the direct equivalent method

That is not happening, and emission trends increasingly diverge from those projected in RCP8.5. See the chart below by Zeke Hausfather and Glenn Peters. The chart shows that RCP8.5-projected CO₂ emissions in 2050 are more than double those projected by the International Energy Agency in its baseline (current and pledged policies) emission scenarios.⁹¹

⁸⁹ The figure is from Riahi et al. 2011. RCP 8.5—A scenario of comparatively high greenhouse gas emissions. *Climatic Change* 109, article 33, <https://link.springer.com/article/10.1007/s10584-011-0149-y>.

⁹⁰ Our World in Data, "Global primary energy consumption by fuel source," <https://ourworldindata.org/energy-production-consumption#how-much-energy-does-the-world-consume>.

⁹¹ Zeke Hausfather and Glenn P. Peters, "Emissions – the 'business as usual' story is misleading," *Nature*, January 29, 2020, <https://www.nature.com/articles/d41586-020-00177-3>.



*The International Energy Agency (IEA) maps out different energy-policy and investment choices. Estimated emissions are shown for its Current Policies Scenario and for its Stated Policies Scenario (includes countries' current policy pledges and targets). To be comparable with scenarios for the Shared Socioeconomic Pathways (SSPs), IEA scenarios were modified to include constant non-fossil-fuel emissions from industry in 2018.
 †Approximate global mean temperature rise by 2100 relative to pre-industrial levels.
 ‡SSP5–8.5 replaces Representative Concentration Pathway (RCP) 8.5.

©nature

One point that should leap out at attentive readers is that *no-policy scenarios* such as RCP8.5 are no longer “reference case” or “business-as-usual” baselines. Climate policies have been proliferating since the IWG’s first SCC report in 2010. Yet the IWG continues to treat the obsolete EMF-22 “no policy” scenarios as BAU baselines.

More importantly, the EMF-22 no-policy scenarios and RCP8.5 would be unrealistic even if governments were not adopting climate policies. In “The 1000 GtC coal question: Are cases of vastly expanded future coal combustion still plausible?” Justin Ritchie and Hadi Dowlatabadi show that all of the IPCC’s five assessment reports “use business-as-usual (BAU) scenarios that combust most or all coal reserves before the year 2100.”⁹² The basic assumption is that coal is the inexpensive backstop energy source for the global economy, with reserve-to-production (R-P) ratios that increase over time as technological progress decreases extraction costs. Ritchie and Dowlatabadi further note that DICE, FUND, and PAGE “adopt similar reference case assumptions for coal,” as do the EMF baseline scenarios underpinning the IWG’s technical support documents.

⁹² Justin Ritchie and Hadi Dowlatabadi. 2017. The 1000 GtC coal question: Are cases of vastly expanded future coal combustion still plausible? *Energy Economics* 65, 16-31, <https://www.sciencedirect.com/science/article/pii/S0140988317301226>.

Such scenarios are no longer plausible projections for the 21st century. The current coal R-P ratio is about 100 years—an order of magnitude lower than 1960s vintage assessments (>900 years) and one-third the size of the 300-year R-P ratio estimated in 1990.

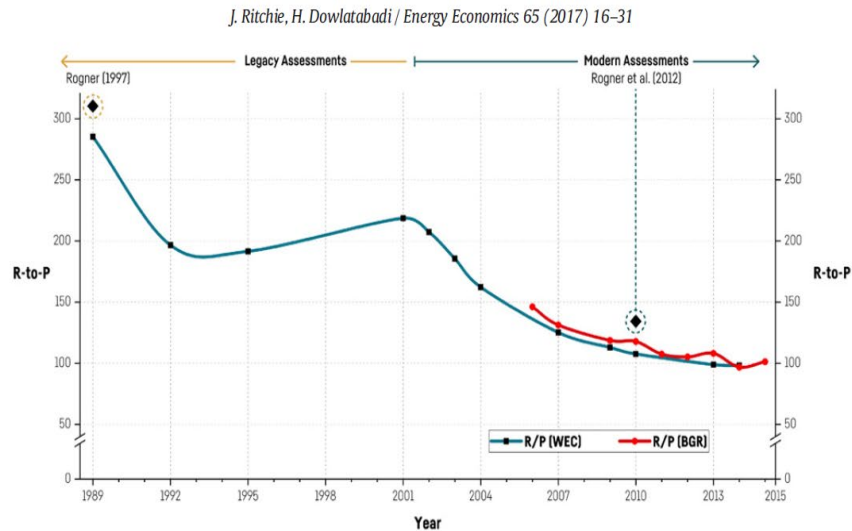


Fig. 1d. Reserve-to-production ratio for global coal [mass-basis] – Rogner (1997) and Rogner et al. (2012) illustrate the distinction between legacy and modern assessments; note y-axis break.

Moreover, instead of real coal prices falling, as assumed in the IPCC, IAM, and EMF reference scenarios, prices in 2016 were about the same as in 1990, and have risen since 2000. Coal prices today (\$171 per metric ton) are significantly higher than the average price of \$66/ton in 2016.⁹³

Ritchie and Dowlatabadi comment: “All else equal, conventional resource economists theorize that higher sustained commodity prices lead to a reclassification of marginal geologic deposits as economically recoverable reserves. Yet, since the doubling of coal prices and production in 2000, reserves declined by roughly 15 percent.”

⁹³ *Trading Economics*, <https://tradingeconomics.com/commodity/coal> (accessed January 3, 2021); Statista, Thermal coal prices from 2013 to 2020 (in U.S. dollars per metric ton), <https://www.statista.com/statistics/214236/thermal-coal-prices-since-2003/> (accessed January 3, 2021),

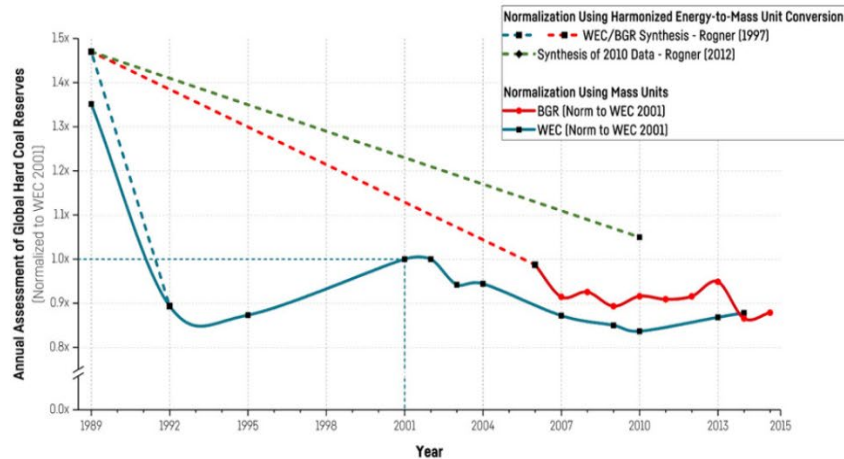


Fig. 1c. Coal reserves in mass units from successive WEC and BGR reports indexed to WEC (2001). The WEC-BGR synthesis reported by Rogner (1997), and the updated Rogner et al. (2012) normalized to WEC (2001) using harmonized energy-to-mass units; note y-axis break.

In short, “today’s [coal] reserves are now more costly and less abundant than assumed 30 years ago.” That is due to several factors besides climate policy. Those include constraints on extraction related to air and water quality regulations, declining social acceptance of mining operations near populated areas, the replacement of human labor with excavation machines too large to access smaller deposits, the absence (despite decades of R&D) of significant markets for coal-to-liquid motor fuel and coal syngas electricity fuel, and increased competition from unconventional oil and natural gas.

It is therefore no longer reasonable to view “all geologic coal resources as eventual reserves” that sooner or later will be combusted. That is akin to assuming that “all oceans should be on a supply curve for drinkable water” just because “the total quantity of ocean water is vast and existing technology could theoretically convert all saltwater to replace fresh water.”

Ritchie and Dowlatabadi acknowledge that “technological breakthroughs” may reverse the rise in coal prices and decline in coal R-P ratios. “However, to assume [such breakthroughs] as constituting a plausible reference case is a tall ask.” To sum up, there is no evidence that, absent stringent new climate policies, coal will dominate global energy for centuries to come.⁹⁴

Section 11: Comparing Apples and Oranges

In addition to stipulating that agencies should use both 3 percent and 7 percent discount rates in benefit-cost analysis, OMB Circular A-4 states:

The analysis should focus on benefits and costs that accrue to citizens and residents of the United States. Where the agency chooses to evaluate a regulation that is likely to have

⁹⁴ Justin Ritchie and Hadi Dowlatabadi. 2017. Why do climate scenarios return to coal? *Energy* 140, 1276-1291, <https://cedmcenter.org/wp-content/uploads/2017/08/Why-do-climate-change-scenarios-return-to-coal.pdf>.

effects beyond the borders of the United States, these effects should be reported separately.⁹⁵

Comparing domestic benefits to domestic costs makes obvious sense. It is Americans who chiefly bear the costs of domestic GHG regulations, so quantification of the associated U.S. climate benefits (to the extent that the SCC is quantifiable at all) is reasonable and appropriate.

Nonetheless, the IWG only estimates the global benefits of GHG emission reductions and suggests domestic benefit estimation is foolish or worse. We're admonished that GHG emissions are global externalities; that climate damages abroad have "spillover" effects in the United States; that there are relatively few region- or country-specific SCC estimates in the literature; that IAMs were not calibrated to estimate domestic climate damages; and that presenting global SCC estimates facilitates U.S.-led international policy coordination.⁹⁶

Whatever the merits of those points, they do not rebut the fact the agencies' current practice misleads the public by comparing apples to oranges. It encourages the public to mistakenly infer larger benefit-cost ratios for U.S. residents than domestic climate regulations would actually deliver. However valid it may be to present global SCC-based benefit estimates, those should be reported separately, as Circular A-4 directs. There is no scientific or ethical justification for hiding U.S. domestic SCC estimates from the public.

The IWG discussed domestic SCC estimation in its 2010 TSD.⁹⁷ The continuing dearth of country-specific SCC estimates and IAMs calibrated to estimate domestic SCC values strongly suggests agencies are not funding such research. Is that because domestic SCC estimates, even when inflated by all the methodological biases discussed above, are not large enough to support the "climate crisis" narrative?

According to the 2010 TSD, the FUND model indicates that the U.S. benefit of reducing CO₂ emissions is about 7-10 percent of the global benefit.⁹⁸ Based on such speculation (and, to repeat, all SCC estimation is speculation), the Trump administration estimated the domestic SCC in 2020 to be \$7 per ton—about 86 percent lower than the IWG's 2016 estimate.⁹⁹

⁹⁵ Office of Management and Budget, Regulatory Impact Analysis: A Primer, p. 5, [circular-a-4_regulatory-impact-analysis-a-primer.pdf](#).

⁹⁶ IWG, TSD 2021, pp. 14-16.

⁹⁷ IWG, TSD 2010, pp. 3, 10-11.

⁹⁸ IWG, TSD 2010, p. 11.

⁹⁹ Government Accountability Office, *Social Cost of Carbon: Identifying a Federal Entity to Address the National Academies' Recommendations Could Strengthen Regulatory Analysis*, June 2020, <https://www.gao.gov/assets/gao-20-254.pdf>.

Prior and Current Federal Estimates of the Social Cost of Carbon, per Metric Ton, at a 3 Percent Discount Rate in 2018 U.S. Dollars

Year of emissions	Prior estimates (based on global climate change damages)	Current estimates (based on domestic climate change damages)
2020	\$50	\$7
2030	\$60	\$8
2040	\$72	\$9
2050	\$82	\$11

Source: GAO analysis of data from the Interagency Working Group on Social Cost of Greenhouse Gases, EPA, and the United States Gross Domestic Product Price Index from the U.S. Department of Commerce, Bureau of Economic Analysis. | GAO-20-254

This much is clear. The IWG’s policy of comparing the domestic costs of GHG reductions to the purported global benefits injects a pro-regulatory bias into American politics. But then, so do all the IWG methodological decisions discussed above. As noted above, we believe the SCC is highly susceptible to user-manipulation and therefore should not be used in guiding regulatory policy. However, if the Commission decides otherwise, then we strongly encourage domestic and global SCC-estimated climate benefits to be presented separately.

Section 12: Conclusion

The GHG emissions of even the largest natural gas infrastructure project have no significant impact on the quality of the human environment. Neither the ostensible climate damages from those emissions nor the claimed climate benefits from mitigation measures are large enough to be verified scientifically or experienced by human beings.

SCC analysis purports to quantify what empirical investigation cannot confirm. However, SCC estimation depends on so many questionable and biased methodological choices there is no good reason to believe mitigation actions have any meaningful monetary value.

The studies by Dayaratna and colleagues reviewed above show that reasonable alternative assumptions substantially drive down SCC estimates, even pushing SCC values into negative territory. Replacing the IWG’s obsolete “return to coal” baselines with realistic emission scenarios would further decrease SCC values during 2021-2050 and beyond.

However small (or negative) the global SCC would be after all reasonable adjustments are made to assumptions regarding discount rates, time horizons, climate sensitivity, CO₂ fertilization, adaptive capabilities, and baseline emission trajectories, the SCC would be smaller still (or increasingly negative) if calculated on a domestic (U.S.-only) basis.

Finally, although NEPA’s application to GHG emissions is an issue of ongoing legal and political controversy, we are quite confident the NGA may not lawfully be used to attack the commercial viability of U.S. natural gas infrastructure.

Respectfully Submitted,

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