COMPETITIVE ENTERPRISE INSTITUTE

October 26, 2021

National Highway Traffic Safety Administration, Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks, Proposed Rule, 86 FR 49602 (September 3, 2021)

Docket No. NHTSA-2021-0053

Comments submitted by Patrick J. Michaels, Kevin Dayaratna, and Marlo Lewis.[1]

Thank you for the opportunity to comment on the National Highway Traffic Safety Administration's (NHTSA) proposed corporate average fuel economy (CAFE) standards for model years (MYs) 2024-2026 light duty vehicles.[2]

NHTSA invites comment on three alternatives to the Trump administration's Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule. Under the SAFE Rule, CAFE standards increase in stringency beyond MY 2020 levels by 1.5 percent annually during MYs 2021-2026.[3] Table IV-1 compares NHTSA's three proposed alternatives to the SAFE Rule. Alternative 2—an 8 percent annual increase in regulatory stringency during MYs 2024-2026—is NHTSA's "preferred" alternative.[4]

Table IV-1 – Regulatory Alternatives Considered in this Proposal

Regulatory Alternative	Year-Over-Year Stringency Increases (Passenger Cars)			Year-Over-Year Stringency Increases (Light Trucks)		
	2024	2025	2026	2024	2025	2026
Alternative 0 (No Action)	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Alternative 1	9.14%	3.26%	3.26%	11.02%	3.26%	3.26%
Alternative 2 (Preferred)	8%	8%	8%	8%	8%	8%
Alternative 3	10%	10%	10%	10%	10%	10%

[1] Patrick Michaels (pat.michaels@cei.org) and Marlo Lewis (marlo.lewis@cei.org) are Senior Fellows in Energy and Environmental Policy at the Competitive Enterprise Institute. Kevin Dayaratna (kevin.dayaratna@heritage.org) is Principal Statistician, Data Scientist and Research Fellow at the Heritage Foundation. He is commenting as an independent scholar and not on behalf of any organization. Please direct any questions about these comments to Marlo Lewis (marlo.lewis@cei.org).

[2] NHTSA, Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks, Proposed Rule, 86 FR 49602-49883, September 3, 2021, https://www.govinfo.gov/content/pkg/FR-2021-09-03/pdf/2021-17496.pdf.

[3] Environmental Protection Agency and National Highway Traffic Safety Administration, The Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule for Model Years 2021–2026 Passenger Cars and Light Trucks, 85 FR 24174-25278, April 30, 2020, https://www.govinfo.gov/content/pkg/FR-2020-04-30/pdf/2020-06967.pdf.

[4] 86 FR 49745.

We oppose replacing the SAFE Rule with more stringent regulatory requirements. Fuel economy standards have three unavoidable downsides. Such policies (1) increase vehicle ownership costs,[5] (2) restrict consumer choice,[6] and (3) make the average vehicle less crashworthy than it otherwise could be.[7] The more stringent the standards, the more severe those adverse effects are likely to be.

We expect other commenters to discuss CAFE's inherent drawbacks in greater detail, and so will not say more about that here. Our focus is on the proposed rule's putative climate benefits and the social cost of carbon (SCC) methodology on which NHTSA relies. We show that the rulemaking's projected climate benefit estimates are artifacts of bias and speculation. By necessary implication, our critique calls in question the proposal's total benefit and net-benefit estimates.

Section 1: Total Benefits, Climate Benefits

NHTSA calculates the proposed CAFE standards' costs and benefits under two "perspectives"—model year (MY) and calendar year (CY). The MY perspective "considers the *lifetime* impacts attributable to all vehicles produced prior to model year 2030, accounting for the operation of these vehicles over their entire useful lives (with some model year 2029 vehicles estimated to be in service as late as 2068)." The CY perspective "includes the *annual* impacts attributable to all vehicles estimated to be in service in each calendar year" during 2021-2050.[8] The costs and benefits are larger in the CY perspective because it "emphasizes longer-term impacts that could accrue if standards were to continue without change."[9]

For example, assuming a 3 percent discount rate, the costs, benefits, and net benefits of NHTSA's preferred alternative are $121.1 billion, $121.4 billion, and $0.3 billion, respectively,

[5] Manufacturers spend tens of billions of dollars annually on technology to comply with CAFE standards. That increases the average cost of new vehicles, which in turn can price middle-income households out of the new-car market. "The Average New Car Price Is Now Over $40,000," Autotrader reported in February, https://www.autotrader.com/car-news/the-average-new-car-price-is-now-over-40000. The proposed standards are projected to increase average vehicle cost by about $960 relative to the no-action (SAFE Rule) scenario (86 FR 49605, 49620).

[6] Regulatory agencies have different priorities than consumers. If that were not so, consumers would demand the same average fuel economy NHTSA deems optimal, competition would drive automakers to satisfy consumers (85 FR 24612), and CAFE standards would not be "needed." Fuel economy standards unavoidably shift capital and engineering talent from consumer priorities to bureaucratic priorities.

[7] Other things being equal, heavier vehicles consume more fuel per mile than lighter vehicles. Consequently, fuel economy standards put pressure on automakers to limit average vehicle weight. Lighter vehicles have less mass to absorb collision forces, so they tend to provide less protection in crashes. Under the SAFE Rule, automakers are already projected to reduce average vehicle weight by 4.2-4.7 percent during model years 2023-2026. EPA, Draft Regulatory Impact Analysis, Revised Model Year 2023 and Later Light Duty Vehicle GHG Emission Standards, August 2021, p. 4-19, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1012ONB.pdf. Fuel economy standards also divert automaker R&D spending from safety to fuel efficiency, for the simple reason that automakers do not have unlimited budgets. 85 FR 24174, 25136.

[8] 86 FR 49606 (emphasis added).

[9] 86 FR 49620.

in the MY perspective, but $333.6 billion, $433.6 billion, and $100 billion, respectively, in the CY perspective. See Tables I-5 and I-8 below:

Table I-5 – Estimated Costs, Benefits, and Net Benefits Across MYs 1981-2029 (billions of dollars), Total Fleet for Alternative 2

	Totals		Annualized	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Costs	121.1	90.7	4.75	6.59
Benefits	121.4	75.6	4.76	5.49
Net Benefits	0.3	-15.1	0.01	-1.10

Table I-8 – Estimated Costs, Benefits, and Net Benefits Across Calendar Years 2021-2050 (billions of dollars), Total Fleet for Alternative 2

	Totals		Annualized	
	3% Discount Rate	7% Discount Rate	3% Discount Rate	7% Discount Rate
Costs	333.6	198.9	17.02	16.03
Benefits	433.6	236.0	22.12	19.02
Net Benefits	100.0	37.1	5.10	2.99

Using a 3 percent discount rate, NHTSA estimates alternatives 1, 2, and 3 will reduce climate damages by $20.3 billion, $32 billion, and $45.6 billion, respectively, in the MY perspective,[10] and $71.6 billion, $118.2 billion, and $161.4 billion, respectively, in the CY perspective.[11]

One implication of the numbers and tables above is that the proposal's climate benefits are critical to achieving positive net benefits—a rule in which total benefits exceed costs. For example, assuming a 3 percent discount rate, if climate benefits are $0.00, Alternative 2 produces net benefits of -$31.7 billion in the MY perspective and -$18.2 billion in the CY perspective.

Section 2: Summary of Argument

The proposal's projected climate benefits are phantasms. Those benefits derive from the Biden administration Interagency Working Group's (IWG) social cost of carbon (SCC) estimates.[12]

[10] 86 FR 49720.

[11] NHTSA, Appendix II, CAFE Analysis Data Book Analysis for Draft Supplemental Environmental Impact Statement, Table B-7-25 - Incremental Benefits and Costs for Calendar Years 2021-2050 for Total Fleet Produced Through MY2050 (2018$ Billions), 3% Percent Discount Rate, by Alternative, p. 199, August 2021, https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/CAFE-NHTSA-2127-AM34-PRIA-Appendix-II-tag.pdf. (hereafter NHTSA, CAFE Analysis Data Book, 2021)

[12] 86 FR 49627; see also NHTSA, Technical Support Document: Proposed Rulemaking for Model Years 2024-2026 Light-Duty Vehicle Corporate Average Fuel Economy Standards, Sections 6.2.1.1-6.2.1.2, August 2021, https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/CAFE-NHTSA-2127-AM34-TSD-Complete-web-tag.pdf. Technically, NHTSA bases its climate benefit estimates on the IWG's social cost of greenhouse gases (SC-GHG) estimates. Our comments retain the term "social cost of carbon" because it is more familiar to non-specialists and because the vast majority of the proposal's estimated climate benefits—roughly 98 percent—are attributed to CO_2 reductions. See NHTSA, Preliminary Regulatory Impact Analysis: Proposed Rulemaking for Model Years 2024-2026 Light-Duty Vehicle Corporate Average Fuel Economy Standards, August 2021, Figure 6-27, p. 173,

Whatever its value as an academic research tool, SCC estimation is too speculative and assumption-driven to inform policy decisions. The seeming objectivity and precision of official SCC estimates are illusory.

Unsurprisingly, SCC estimates are easily manipulated for political purposes. The IWG process is a prime case in point. All of the IWG's methodological decisions err on the side of alarm and regulatory ambition.

Those dubious decisions include the use of below-market discount rates, an analysis period extending far beyond the limits of informed speculation, outdated climate sensitivity assumptions, unscientific depreciation of carbon dioxide fertilization benefits, unjustified pessimism regarding human adaptive capabilities, implausible "return to coal" baseline emission scenarios, and net-benefit calculations that misleadingly compare domestic costs to global benefits. Absent those biases, the IWG's SCC estimates could fall to zero dollars or below during 2021-2050 and beyond.

Even if the IWG's methodology were not biased in multiple ways, NHTSA's claim that its preferred alternative would deliver $118.2 billion in climate benefits in 2050 would still defy common sense. In the agency's own analysis, the preferred alternative reduces global average temperature by less than 0.0013°C in 2050.[13] That hypothetical change would be far too small for scientists to detect. It would make no discernible difference to weather patterns, crop yields, polar bear populations, or any other environmental condition people care about. Benefits no one can experience are "benefits" in name only.

Section 3: Social Cost of Carbon Basics

The SCC is an estimate in dollars of the cumulative long-term damage caused by one ton of carbon dioxide (CO_2) emitted in a specific year. That number also represents an estimate of the benefit of avoiding or reducing one ton of CO_2 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 CO_2 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.[14]

https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/CAFE-NHTSA-2127-AM34-PRIA-Complete-web-8-6-21-tag.pdf (hereafter NHTSA, PRIA 2021).

[13] NHTSA, Corporate Average Fuel Economy Standards, Model Years 2024-2026, Draft Supplemental Environmental Impact Statement, Figure 8.6.4-4. Reductions in Global Mean Surface Temperature Compared to the No Action Alternative, p. 8-24, August 2021, https://www.nhtsa.gov/sites/nhtsa.gov/files/2021-08/02_SEIS_CAFE_MY_2024-2026_web-tag.pdf (hereafter NHTSA, DSEIS 2021).

[14] 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 climate sensitivity assumptions 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 choice of socioeconomic pathways used to project future GHG emissions and concentrations.
- 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.

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 a modeler intends to make climate change look economically catastrophic and build a case for aggressive regulation, the modeler:

- Runs the IAMs with below-market discount rates.
- Uses IAMs that assume high climate sensitivity.
- Calculates cumulative damages over a 300-year period—i.e., well beyond the limits of informed speculation about future economic vulnerabilities and adaptive technologies.
- Runs the models with implausible emission scenarios that assume the world repeatedly burns through all economically-recoverable fossil fuel reserves.
- Minimizes the immense agricultural benefits of atmospheric CO_2 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.
- Includes at least one IAM that assumes adaptation cannot mitigate the cost of climate change impacts once relatively modest levels of global warming and sea-level rise are exceeded.
- Calculates climate policy net benefits by comparing apples (domestic costs) to oranges (global benefits).

In other words, the modeler does exactly what the Obama IWG did in its 2010, 2013, and 2016 technical support documents (TSDs), and what the Biden IWG proposes to do in its 2021 interim TSD.[15]

Section 4: Artifactual Benefits No One Will Ever Experience

---

[15] 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).

What will be the proposed CAFE standards' measurable effects on global average surface temperature, compared to the existing SAFE Rule standards, and what benefits can be expected to accrue from the proposed changes?

In a word, the answer to both is simple: None.

NHTSA uses the Model for the Assessment of Greenhouse Gas-Induced Climate Change (MAGICC),[16] developed by the National Center for Atmospheric Research, to estimate the proposed CAFE standards' greenhouse gas emission reductions and associated climate effects. Table 5.4.2-2 of NHTSA's Draft Supplemental Environmental Impact Statement presents the overall results.

Table 5.4.2-2. Carbon Dioxide Concentrations, Global Mean Surface Temperature Increase, Sea-Level Rise, and Ocean pH (GCAM Reference) by Alternative [a]

	CO_2 Concentration (ppm)			Global Mean Surface Temperature Increase (°C) [b, c]			Sea-Level Rise (cm) [b, d]			Ocean pH [e]		
	2040	2060	2100	2040	2060	2100	2040	2060	2100	2040	2060	2100
Totals by Alternative												
Alt. 0 (No Action)	479.04	565.44	789.11	1.287	2.008	3.484	22.87	36.56	76.28	8.4099	8.3476	8.2176
Alt. 1	478.99	565.29	788.74	1.287	2.007	3.483	22.87	36.56	76.25	8.4099	8.3477	8.2178
Alt. 2	478.96	565.19	788.52	1.287	2.007	3.482	22.87	36.55	76.23	8.4100	8.3478	8.2179
Alt. 3	478.93	565.11	788.33	1.287	2.007	3.481	22.87	36.55	76.22	8.4100	8.3478	8.2180

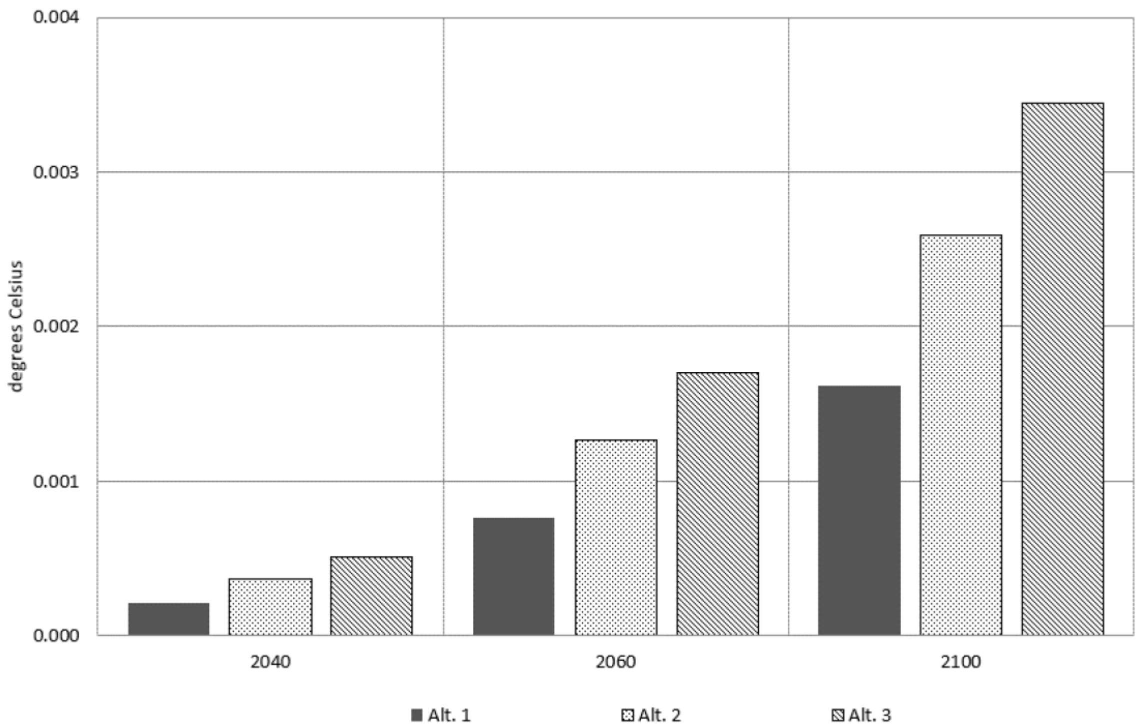
As can be seen above, in 2060, NHTSA's preferred alternative reduces CO_2 concentrations in 2060 by 0.25 parts per million, avoids 0.001°C of global warming, and averts 0.01cm of sea-level rise.[17] More precisely, NHTSA projects a 0.0013°C reduction in global mean surface temperature from Alt. 2 in 2060 (see Figure 8.6.6-4, below).[18]

So, we may reasonably infer Alt. 2 produces about 0.001°C of warming mitigation by 2050. For perspective, that is about one-third the average temperature difference between the air surrounding your knees and the air surrounding your midsection.

More importantly, according to the National Oceanic and Atmospheric Administration, the inherent error in current calculations of annual global average surface air temperature is 0.08°C, which is roughly 80 *times* the calculated effect of the new standards in 2050.[19] Yet when NHTSA multiplies the projected emission reductions by the IWG's SCC estimates, it comes up with $118.2 billion in climate benefits by 2050.

[16] MAGICC, The Climate System in a Nutshell, http://www.magicc.org/ (accessed September 16, 2021).
[17] NHTSA, DSEIS 2021, Table 5.4.2-2, p. 5-42. Calculations in Table 5.4.2-2 assume an equilibrium climate sensitivity of 3°C for a doubling of atmospheric CO_2 concentration (DSEIS, p. 5-32, fn. 35).
[18] NHTSA, DSEIS 2021, Figure 8.6.4-4, p. 8-26.
[19] NOAA National Centers for Environmental Information, Global Temperature Uncertainty, https://www.ncdc.noaa.gov/monitoring-references/faq/global-precision.php (accessed September 16, 2021).

Figure 8.6.4-4. Reductions in Global Mean Surface Temperature Compared to the No Action Alternative



It simply defies logic to calculate the benefits of a regulation that will have impossible-to-detect effects on surface temperature, because it is those same temperature changes that drive cost estimates.

In short, the proposed vehicle standards will have an undetectable effect on surface temperature, which means the standards will produce undetectable climate "benefits." Benefits no one can experience exist only in the virtual world SCC modeling. The proposal's climate benefits are not real enough to be netted against the hundreds of billions of dollars in costs the proposal will impose on automakers and consumers.

Section 5: How the Discount Rate Affects the SCC[20]

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

[20] Sections 5-8 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.

projected rate of return from CO_2-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.[21] 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.[22]

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.[23] 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 an emission-reduction investment 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.

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

[21] 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).

[22] IWG, TSD 2021, pp. 17-19.

[23] 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.

> centuries from now are almost certain to be much wealthier, healthier, and possessed of technology to better overcome any adversity—including climate change.[24]

It is hard to shake the suspicion that the IWG has never used 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.

To its credit, NHTSA discounts climate damages avoided using both 3 percent and 7 percent discount rates. In the MY perspective, reduced climate damages of alternatives 1, 2, and 3 are estimated at $13.3 billion, $21.0 billion, and $29.9 billion, when discounted at 7 percent versus $20.3 billion, $32.0 billion, and $45.6 billion, when discounted at 3 percent.[25] Similarly, in the CY perspective, reduced climate damages of alternatives 1, 2, and 3 are estimated at $46.5 billion, $76.9 billion, and $104.9 billion, respectively, when discounted at 7 percent versus $71.6 billion, $118.2 billion, and $161.4 billion, respectively, when discounted at 3 percent.[26]

The IWG hints that its final TSD, to be published in 2022, may use discount rates as low as 1 percent.[27] 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 estimates[28] followed by the Heritage analysts' results published in the peer-reviewed journal *Climate Change Economics*:[29]

Table ES-1: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Year	5% Average	**3% Average**	2.5% Average	High Impact (95th 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

[24] 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/.

[25] Compare Table III-38 at 86 FR 49721 with Table III-37 at 86 FR 49720.

[26] Compare NHTSA, Appendix II, Table B-7-28, p. 202 with Table B-7-25, p. 199.

[27] IWG, TSD 2021, pp. 21, 35.

[28] 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).

[29] K. Dayaratna, R. McKitrick, 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

As the above tables illustrate, the SCC estimates are drastically reduced when the models are run with a 7.0 percent discount rate. In fact, under the FUND model, the estimates are negative. Using a 7.0 percent discount rate can cause the SCC to drop by as much as 80 percent or more.

NHTSA should not use SCC analysis for policymaking, as it depends on too many unknowns. However, if the agency is going to use SCC analysis, it should continue to 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 6: 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. Regardless, the IWG bases its SCC estimates on projections of climate change damages over 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.[30]

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. B 2860 heritage.org

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. B 2860 heritage.org

The SCC estimates drop substantially—in some cases by more than 25 percent—as a result of ending the SCC estimation period in 2150. If NHTSA is going to use the SCC in policymaking, it should underscore the highly-speculative nature of long-term economic and technology forecasting. In addition, NHTSA should include sensitivity case analyses using timespans shorter than 300 years.

Section 7: How the Equilibrium Climate Sensitivity (ECS) Distribution Affects the SCC

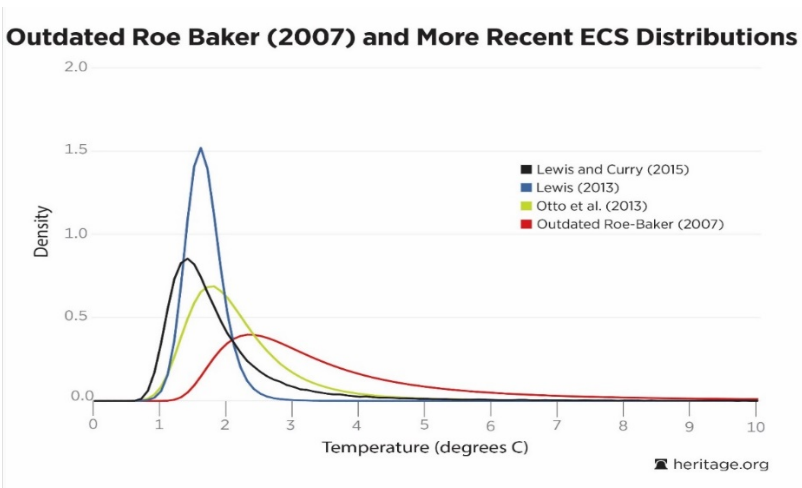
---

[30] 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.

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 CO_2 concentrations.

ECS distributions are derived from general circulation models (GCMs), 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 14 years ago in the journal *Science*.[31] This non-empirical distribution, calibrated by the IWG based on assumptions it selected in conjunction with IPCC recommendations,[32] is no longer scientifically defensible.[33]

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 CO_2 concentrations. Below are three such distributions:[34]



[31] 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.

[32] 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).

[33] 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.

[34] 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 CO_2 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 CO_2 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 CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Year	5% Average	**3% Average**	2.5% Average	High Impact (95th 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:[35]

	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

[35]Dayaratna, McKitrick, and Kreutzer, "Empirically Constrained Climate Sensitivity and the Social Cost of Carbon."

	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. NHTSA should not use SCC estimation for policymaking, as it is highly susceptible to user manipulation. However, if it must be used, the agency should utilize realistic estimates of climate sensitivity.

Lest NHTSA 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 warming—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.[36] The figure below compares predicted and observed average tropospheric temperature over the tropics.[37] The observations come from satellites, weather balloons, and reanalyses.[38]

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.

---

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

[37] The CMIP5 predictions are available at https://climexp.knmi.nl/start.cgi.

[38] 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

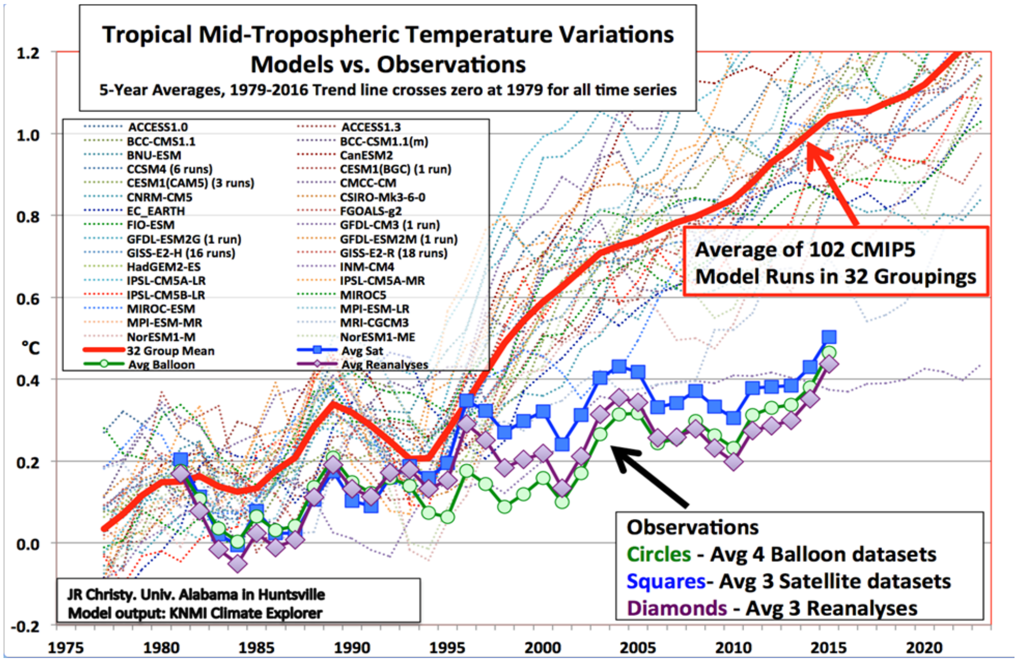


Figure 1. Solid red line—average of all the CMIP-5 climate models; Thin colored lines—individual CMIP-5 models; solid figures—weather balloon, satellite, and reanalysis data for the tropical troposphere. [39]

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 standard with regard to climate forecasts.

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

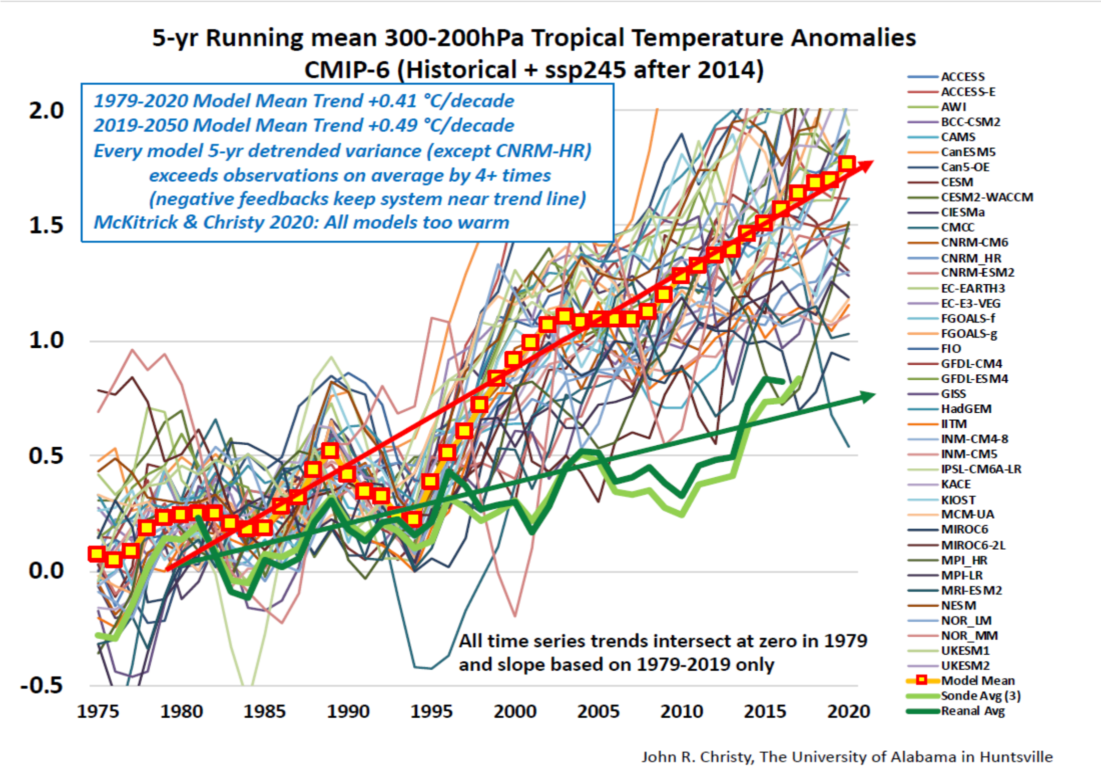
No. As shown by McKitrick and Christy (2020), the CMIP6 models are even worse.[40] Of the two models that work, the Russian INM-CM4.8, has even less warming than its predecessor, with an ECS of 1.8°C, compared to the CMIP6 community value of around four degrees.[41] The other one is also a very low ECS model from the same, group, INM-CM5. The model mean warming rate exceeds observation by more than four times at altitude in the tropics.

---

[39] 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.

[40] R. McKitrick 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.

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



Quoting from McKitrick 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 (Karl et al., 2006). 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 McKitrick and Christy found.[42]

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 CO_2 concentrations of about 1,000 ppm persisted for millions of years.[43] Moreover, the modeled tropical land temperature exceeded 55°C, "which is much higher than the temperature tolerance

[42] Zeke Hausfather, "Cold Water on Hot Models," The Breakthrough Institute, February 11, 2020, https://thebreakthrough.org/issues/energy/cold-water-hot-models.

[43] 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."[44]

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

Section 8: Negative SCC Values

Policymakers and the media often assume carbon dioxide emissions have only harmful impacts on society. However, CO_2 emissions have enormous direct agricultural[45] and ecological benefits,[46] global warming can lengthen growing seasons,[47] and warming potentially also alleviates cold-related mortality, which may exceed heat-related mortality by 20 to 1.[48]

Of the three IAMs used by the IWG, only the FUND model estimates CO_2 fertilization benefits. Dayaratna and colleagues investigated whether a model with CO_2 fertilization benefits could produce negative SCC estimates. A negative SCC means that each incremental ton of CO_2 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*:[49]

	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

[44] 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.

[45] Literally hundreds of peer-reviewed studies document significant percentage increases in food crop photosynthesis, dry-weight biomass, and water-use efficiency due to elevated CO_2 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

[46] 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.

[47] EPA, Climate Change Indicators: Length of Growing Season, https://www.epa.gov/climate-indicators/climate-change-indicators-length-growing-season.

[48] 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.

[49] 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 NHTSA should, in fact, subsidize (not limit) CO_2 emissions. We, of course, oppose such interventionism.

Our purpose here is to illustrate the extreme sensitivity of these models to reasonable changes in assumptions. Although we advise NHTSA not to use SCC analysis as a policymaking tool, if it does so, it should also present the probabilities of negative SCC values—i.e., the chance that the direct benefits of CO_2 emissions will exceed climate-related damages.

Section 9: Updated Agricultural Benefits and Benefit-Cost Analysis

It is a well-established fact that increases in CO_2 concentration enhance plant growth by increasing their internal water use efficiency as well as raising the rate of net photosynthesis.[50] 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 CO_2 fertilization research in a peer-reviewed study published in *Environmental Economics and Policy Studies* and re-estimated the FUND model's SCC values upon updating those assumptions.[51] To facilitate NHTSA's review of that research, we excerpt several paragraphs from Dayaratna et al. (2020):

> Three forms of evidence gained since then indicates that the CO_2 fertilization effects in FUND may be too low. First, rice yields have been shown to exhibit strong positive responses to enhanced ambient CO_2 levels. Kimball (2016) surveyed results from Free-Air CO_2 Enrichment (FACE) experiments, and drew particular attention to the large yield responses (about 34 percent) of hybrid rice in CO_2 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 CO_2. Furthermore, Challinor et al. (2014), Zhu et al. (2015) and Wu et al. (2018) all report evidence that hybrid rice varietals exist that are more heat-tolerant and therefore able to take advantage of CO_2 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)

---

[50] 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 CO_2 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.

[51] Kevin Dayaratna, Ross McKitrick, 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 CO_2 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, during which time the atmospheric CO_2 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 CO_2, 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 CO_2, compared to parameterized yield gains in the range of 20 to 30 percent for CO_2 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 CO_2 enrichment. Challinor et al. (2014) surveyed a large number of studies that examined responses to combinations of increased temperature, CO_2 and precipitation, with and without adaptation. In their metanalysis, average yield gains increased 0.06 percent per ppm increase in CO_2 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 CO_2 enrichment. However, based on Challinor et al.'s (2014) regression analysis, doubling CO_2 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).[52] 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

[52] 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. At a minimum, Dayaratna et al. (2020) further demonstrates that the SCC is highly sensitive to very reasonable changes in assumptions and thus is readily prone to user manipulation.

Indeed, we could not help noticing that the concepts of CO_2 fertilization and global greening do not occur in the IWG's February 2021 interim TSD. Similarly, although Dayaratna et al. (2020) was published in January 2020, the IWG does not include it among the TSD's 115 references. Nor does the IWG reference Dayaratna et al. (2017).

Section 10: 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.[53] Prominent examples include:

- The 2018 Fourth National Climate Assessment, which estimates that global warming could reach 8°C and reduce U.S. GDP by 10 percent in the 2090s.[54] As revealed in the fine print, the estimate assumes no adaptive measures beyond those already deployed "in the historical period," i.e., during 1980-2010.[55]

---

[53] 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.

[54] 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.

[55] 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, 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) that ran the

- The Assessment's high-end estimate of $505 billion in climate damages in 2090. That estimate similarly assumes "limited or no adaptation."[56]
- The EPA's 2015 *Benefits of Global Action* report, which projects 12,000 annual heat-stress deaths and 57,000 annual air pollution deaths in 49 U.S. cities in 2100.[57] As revealed in the fine print, the heat mortality estimate assumes no further progress in adaptation after 2015. As revealed in a key underlying study,[58] the air pollution mortality estimate assumes no further reduction in air pollutant emissions after 2000, even though fine particle ($PM_{2.5}$) emissions and precursors in 2015 were already significantly lower than in 2000.[59]

The 2021 TSD says little about adaptation other than to acknowledge the IAMs' "incomplete treatment of adaptation and technological change" and "uncertainty" about the adaptation costs.[60] 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."[61]

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.[62] Since the 1920s, global CO_2 concentrations increased from about 305 parts per million to more than 410 ppm, and average global temperatures increased by about 1°C.[63] Yet, globally, the individual risk of dying from weather-related disasters such as hurricanes, floods, and drought decreased by 99 percent.[64] If we

---

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/.

[56] USGCRP, NCA 2018, p. 1,358.

[57] 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.

[58] 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.

[59] EPA, Our Nation's Air, interactive chart on air pollution concentrations, https://gispub.epa.gov/air/trendsreport/2020/#home.

[60] IWG, TSD 2021, pp. 26, 30.

[61] IWG, TSD 2016, pp. 14-15.

[62] 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.

[63] NASA, Global CO2 Mixing Ratios (ppm), https://data.giss.nasa.gov/modelforce/ghgases/Fig1A.ext.txt

[64] 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), p. 73. Lomborg's calculation is based on the EM-DAT International Disaster Database maintained by the Center for Research on the Epidemiology of Disasters, https://www.emdat.be/database.

are in a "climate crisis" today, what words can adequately describe the climate regime of the 1920s?[65]

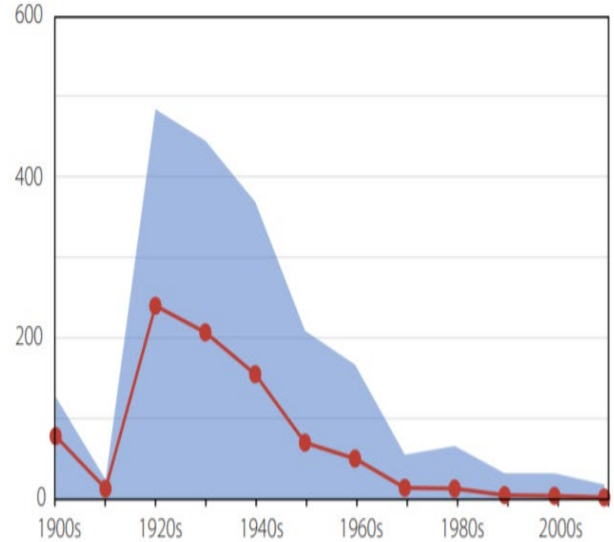


Figure 8: Average annual deaths and death rates from all EWEs, 1900–2018.

Source: Updated from Goklany (2009b), using WDI (2019) and EM-DAT (2019).

Deaths (thousands)

Death rate (per million)

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,[66] per capita income,[67] food security,[68] and various health-related metrics.[69] Yields of all major food crops keep increasing,[70] nearly 3 billion people gained access to improved water sources since 1990,[71] and deaths from malaria (the most consequential climate-sensitive disease) declined by 52 percent during 2000-2015.[72]

Even in recent decades, the warmest in the instrumental record, mortality and economic loss data point to an increasingly sustainable civilization. A recent peer-reviewed study finds 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."[73] Similarly, data buried in the appendix of a 2019

---

[65] Indur M. Goklany, Impacts of Climate Change: Perception and Reality, Global Warming Policy Foundation, Report 46, 2021, https://www.thegwpf.org/content/uploads/2021/02/Goklany-EmpiricalTrends.pdf.
[66] Our World in Data, Life Expectancy, https://ourworldindata.org/grapher/life-expectancy.
[67] Our World in Data, Economic Growth, https://ourworldindata.org/economic-growth.
[68] Our World in Data, Food Supply, https://ourworldindata.org/food-supply.
[69] Our World in Data, Burden of Disease, https://ourworldindata.org/health-meta#burden-of-disease.
[70] Our World in Data, Crop Yields, https://ourworldindata.org/crop-yields.
[71] 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.
[72] Our World in Data, Malaria, https://ourworldindata.org/malaria.
[73] 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.

study in the *Lancet* reveal that disaster losses as a percentage of GDP are declining, with the greatest declines occurring in low-income countries.[74]

It is thus fundamentally important to pursue policies that will make the United States and other countries wealthier, which will make humanity better able to handle whatever climate-related hazards occur in the future. SCC-based regulations, on the other hand, are likely to make nations less wealthy, while providing negligible climate change mitigation.[75]

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* and reviewed by Bjorn Lomborg in his recent book *False Alarm*. 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 reaching $100 trillion or 11 percent of global GDP annually.[76] However, those extraordinary damages are projected to occur only if people do nothing more than maintain current sea walls.

If "enhanced" adaptive measures are taken, 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 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.[77]

If NHTSA continues to use 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.

---

[74] Roger Pielke, Jr., "Why Climate Advocates Need To Stop Hyping Extreme Weather" *Forbes*, December 14, 2019, https://www.forbes.com/sites/rogerpielke/2019/12/14/why-climate-advocates-need-to-stop-hyping-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 (accessed June 18, 2021).

[75] 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.

[76] 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.

[77] 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.201222469SI.pdf.

Section 11: 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) CO_2 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. recently spotlighted this fatal flaw in the IWG exercise.[78]

To estimate the incremental impact of one ton of CO_2 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 trajectories projected by four socio-economic models participating in a 2009 Stanford Energy Modeling Forum study known as EMF-22.[79] The fifth, a climate policy scenario, is the average trajectory produced by the same four models run with a CO_2 stabilization target of 550 parts per million. For more detail, see the Electric Power Research Institute's (EPRI) 2014 technical assessment report.[80]

Here is the gist. 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 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 CO_2 emissions in excess of estimated fossil reserves."

---

[78] 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.

[79] 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.

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

Table 4-6
Cumulative fossil and industrial CO_2 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 CO_2 emissions reach 22,024 gigatons in 2200 and 33,023 gigatons in 2300—multiples of the estimated reserves (3,674 – 7,113 gigatons).

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,[81] 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.[82] For RCP8.5 to be a realistic projection of future CO_2 emissions and concentrations, coal consumption would have to increase ten-fold during 2000-2100,[83] achieving market shares not seen since the 1940s.[84]

---

[81] A representative concentration pathway (RCP) projects the growth in CO_2-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/m^2). Thus, in RCP8.5, the rise in GHG concentration exerts a net warming pressure of $8.5W/m^2$. 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.

[82] 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.

[83] 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.

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

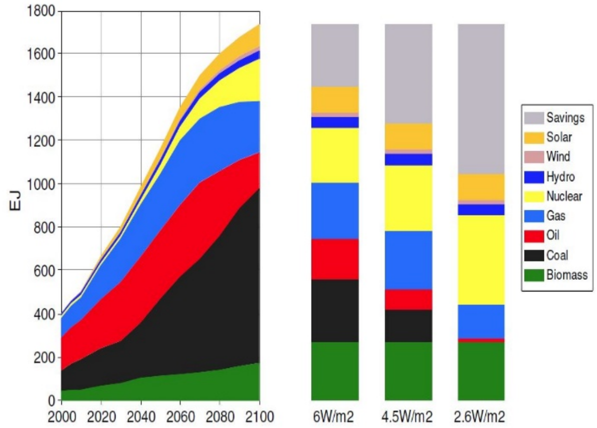
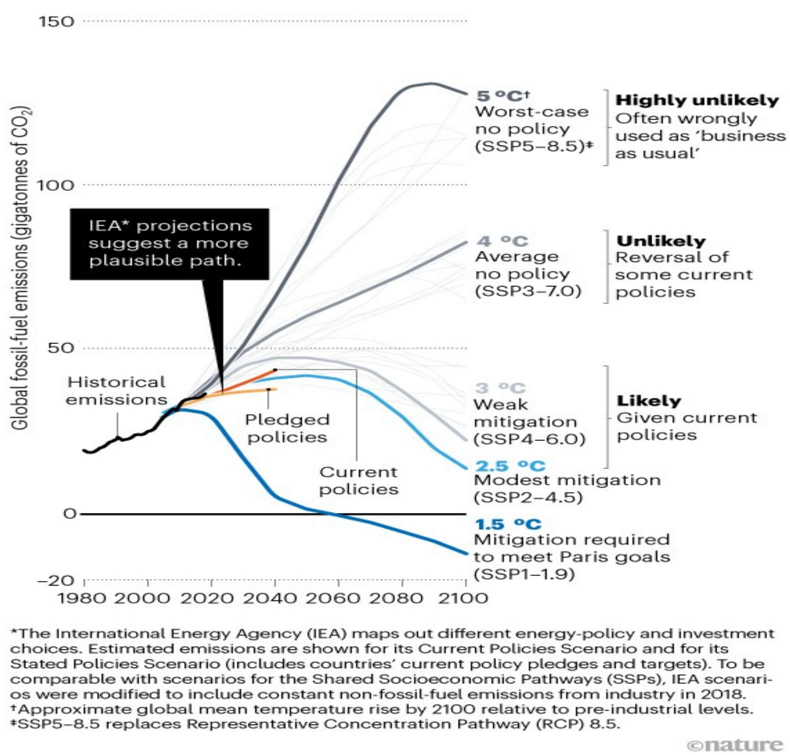


Fig. 5 Development of global primary energy supply in RCP8.5 (*left-hand panel*) and global primary energy supply in 2100 in the associated mitigation cases stabilizing radiative forcing at levels of 6, 4.5, and 2.6 W/m^2 (*right-hand bars*). Note that primary energy is accounted using the direct equivalent 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 CO_2 emissions in 2050 are more than double those projected by the International Energy Agency in its baseline (current and pledged policies) emission scenarios.[85]



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

---

[85] 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.

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 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?"[86] 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." The basic idea 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.

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 two-thirds lower than the 300-year R-P ratio estimated in 1990.

J. Ritchie, H. Dowlatabadi / Energy Economics 65 (2017) 16–31 21

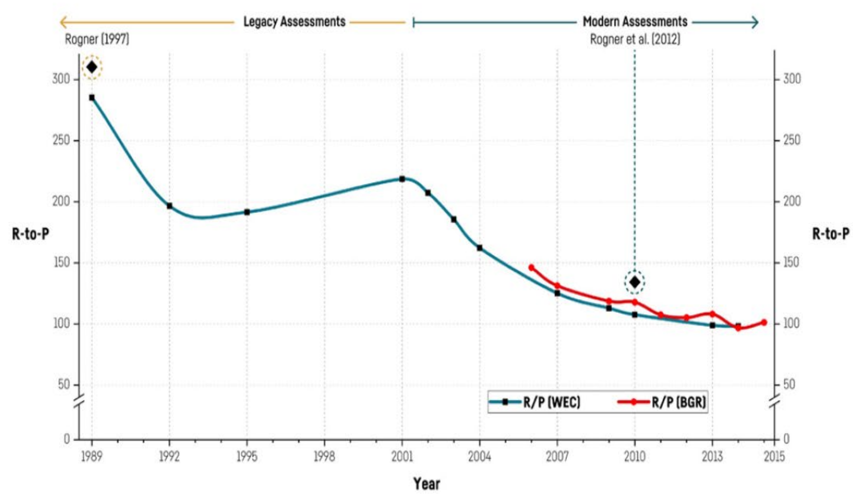


Fig. 1d. Reserve-to-production ratio for global coal [mass-basis] – Rogner (1997) and Rogner et al. (2012) illustrate the distinction between legacy and modern assessments; note y-axis break.

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. In fact, coal prices today ($226 per metric ton) are more than four times the average price in 2016.[87]

---

[86] 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.

[87] *Trading Economics*, https://tradingeconomics.com/commodity/coal (accessed October 26, 2021).

20 J. Ritchie, H. Dowlatabadi / Energy Economics 65 (2017) 16–31

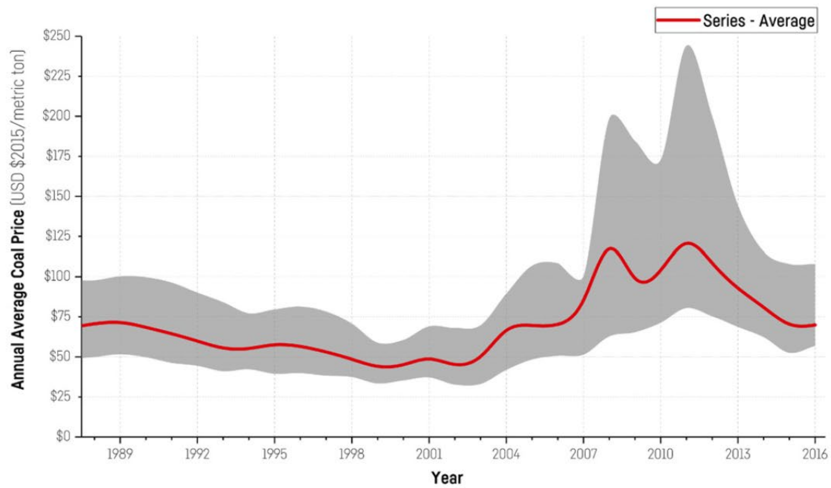


Fig. 1a. Trends in global coal market benchmark prices (BP, 2016; EIA, 2012, 2017; World Bank, 2017), minimum and maximum values indicated by gray range, while red line follows the average of benchmark prices.

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."

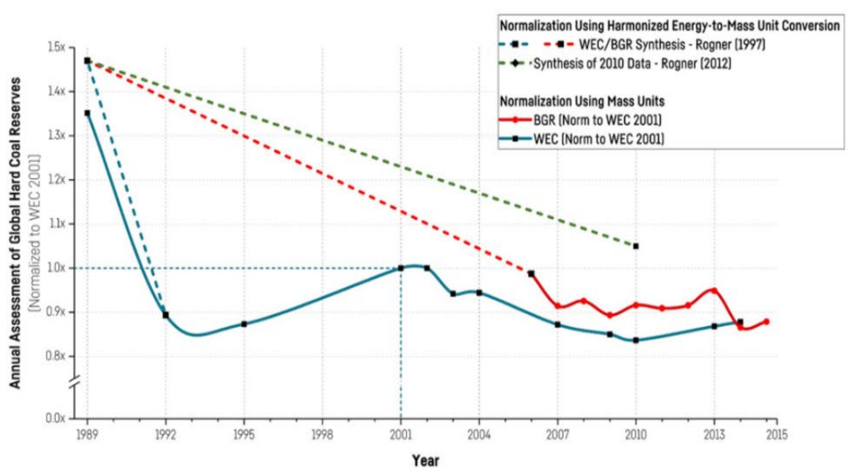


Fig. 1c. Coal reserves in mass units from successive WEC and BGR reports indexed to WEC (2001). The WEC-BGR synthesis reported by Rogner (1997), and the updated Rogner et al. (2012) normalized to WEC (2001) using harmonized energy-to-mass units; note y-axis break.

In short, "today's [coal] reserves are now more costly and less abundant than assumed 30 years ago." That is due to several factors including 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.[88]

Section 12: 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 effects beyond the borders of the United States, these effects should be reported separately.[89]

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.[90]

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 that it will reap most or all of the net benefits calculated by subtracting domestic regulatory costs from global climate change mitigation benefits. However valid it may be to present global SCC-based benefits, 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.[91] The continuing dearth of country-specific SCC estimates and IAMs calibrated to estimate domestic SCC values strongly

---

[88] 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.

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

[90] IWG, TSD 2021, pp. 14-16.

[91] IWG, TSD 2010, pp. 3, 10-11.

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 the U.S. benefit of reducing CO_2 emissions is about 7-10 percent of the global benefit.[92] 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.[93]

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. Failure to compare domestic climate policy costs and benefits injects a pro-regulatory bias into American politics. But then, so do all the IWG methodological decisions discussed above.

Section 13: Conclusion

NHTSA's estimates of either $32 billion or $118.2 billion in climate benefits from its preferred alternative do not withstand scrutiny. Those estimates depend on so many questionable and biased methodological choices there is no good reason to believe the projected emission reductions have any actual 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 obsolete EMF-22 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, CO_2 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, because the proposal's climate benefit estimates are an inference from undetectably small hypothetical changes in global temperature with no discernible or verifiable environmental

---

[92] IWG, TSD 2010, p. 11.

[93] 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.

impacts, those benefits are not real enough to be netted against the tens of billions of dollars in annual costs the proposal would indisputably impose on automakers and consumers.

Respectfully Submitted,

Patrick J. Michaels, Ph.D.
Senior Fellow
Competitive Enterprise Institute

Kevin Dayaratna, Ph.D.
Principal Statistician, Data Scientist and
Research Fellow
Heritage Foundation (for identification
purposes only)

Marlo Lewis, Ph.D.
Senior Fellow
Competitive Enterprise Institute