Testimony of Marlo Lewis, Ph.D., Senior Fellow in Energy and Environmental Policy, Competitive Enterprise Institute

Senate Budget Committee Hearing "Rising Seas, Rising Costs: Climate Change and the Economic Risks to Coastal Communities"

March 1, 2023

Chairman Whitehouse, Ranking Member Grassley, and honorable members of this Committee, thank you for the opportunity to present testimony on behalf of the Competitive Enterprise Institute (CEI) on the topic of today's hearing, "Rising Seas, Rising Costs: Climate Change and the Economic Risks to Coastal Communities." CEI is a non-profit public policy research organization dedicated to advancing individual liberty and free enterprise with an emphasis on regulatory policy.

My testimony develops three main points. First, we should be skeptical about worst-case sea-level rise projections. Second, emission reduction policies can provide no discernible protection from rising seas. Third, the best defense against damages from sea-level rise is sustained investment in adaptation, which is more likely to occur where governments prioritize economic growth rather than emission reduction.

Reasons for Skepticism about Worst-Case Projections

Implausible Emission Baselines

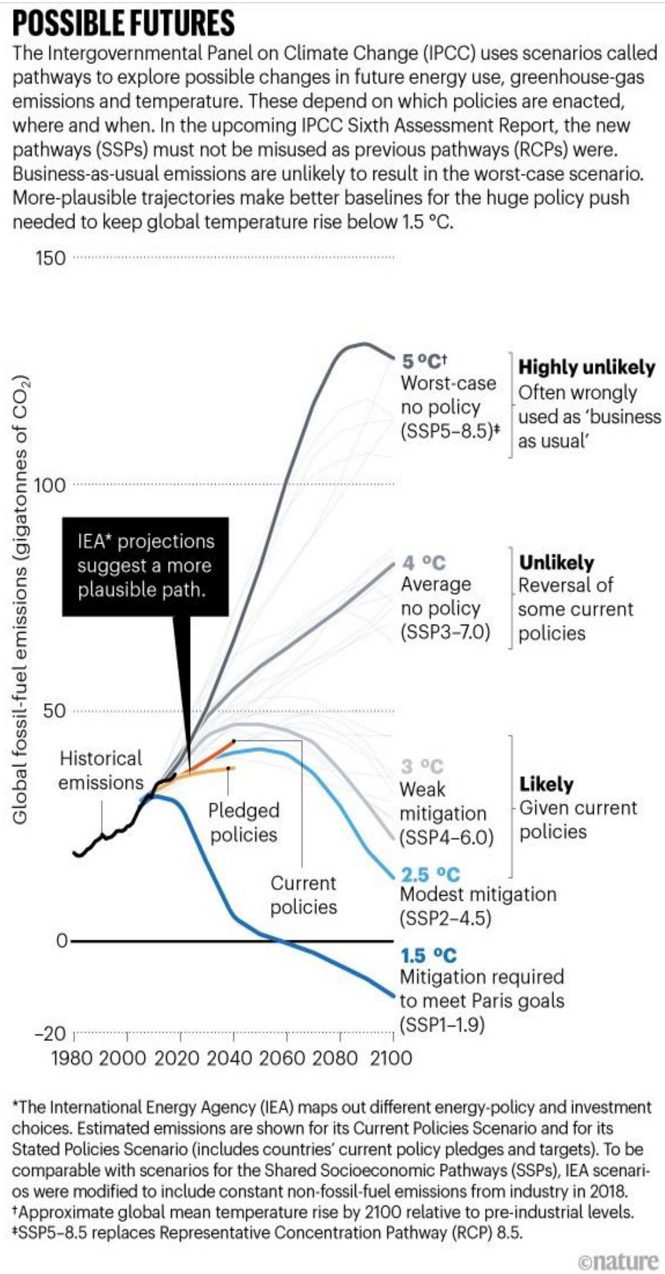
In February of last year, the National Oceanic and Atmospheric Administration (NOAA) published a major report on sea-level rise.[1] The report was a media splash. Headlines in the *Washington Post*, *New York Times*, and NBC News all had the same message point—sea levels along U.S. coastlines will rise one foot by 2050.[2]

If we examine NOAA's report, however, we immediately find reasons for skepticism. One foot of sea-level rise by 2050—or, as in NOAA's chart, 0.31 meters (i.e., 31 centimeters)—is the high end of a projected range of sea-level rise in SSP5-8.5, the IPCC Sixth Assessment Report's high-end emissions scenario. The scenario's mid-range projection for 2050 is 25 centimeters.

For those unfamiliar with this jargon, SSP stands for socioeconomic pathway. The number 8.5 stands for 8.5 watts per square meter—the radiative forcing (warming pressure) exerted by the projected rise in atmospheric carbon dioxide concentration by the year 2100.

Global Mean Surface Air Temperature 2081–2100	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	Unknown Likelihood, High Impact – Low Emissions	Unknown Likelihood, High Impact – Very High Emissions
Closest Emissions Scenario–Based GMSL Projection	Low (SSP1-2.6)	Low (SSP1-2.6) to Intermediate (SSP2-4.5)	Intermediate (SSP2-4.5) to High (SSP3-7.0)	High (SSP3-7.0)	Very High (SSP5-8.5)	Low (SSP1-2.6), *Low Confidence* processes	Very High (SSP5-8.5), *Low Confidence* processes
Total (2050)	0.18 (0.16–0.24)	0.20 (0.17–0.26)	0.21 (0.18–0.27)	0.22 (0.19–0.28)	0.25 (0.22–0.31)	0.20 (0.16–0.31)	0.24 (0.20–0.40)
Total (2100)	0.44 (0.34–0.59)	0.51 (0.40–0.69)	0.61 (0.50–0.81)	0.70 (0.58–0.92)	0.81 (0.69–1.05)	0.45 (0.32–0.79)	0.88 (0.63–1.60)

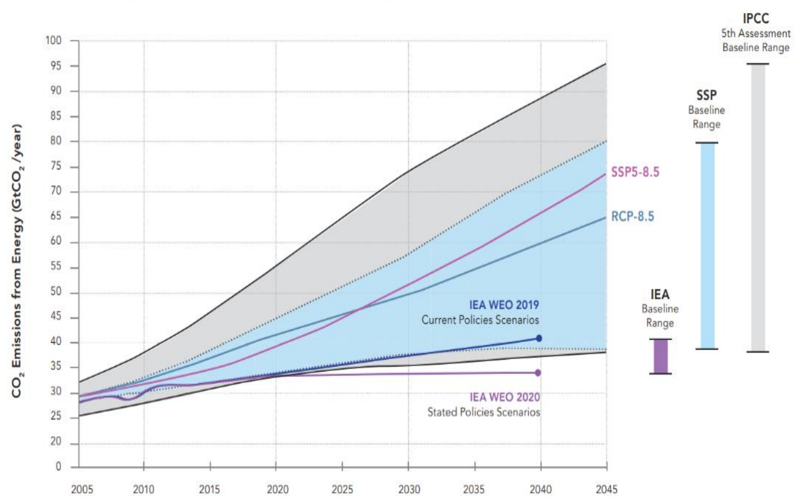
Like its counterpart scenario RCP8.5 in the IPCC's Fifth Assessment Report, SSP5-8.5 is a worst-case scenario. Both are implausible. As shown in this chart by Zeke Hausfather of the Breakthrough Institute and Glenn Peters of the CICERO Center for International Climate Research, midcentury carbon dioxide emissions in SSP5-8.5 are more than double those projected by the International Energy Agency (IEA) in its baseline emission scenarios ("current policies" and "pledged policies").



Source: *Hausfather and Peters (2020)*[3]

The next chart is by University of Colorado professor Roger Pielke, Jr. and University of British Columbia professor Justin Ritchie. It shows that the potential range of emissions in SSP5-8.5 and RCP8.5 lie almost entirely outside the range of the IEA's emission baselines.

Figure 2. **IPCC BASELINE EMISSIONS SCENARIOS FROM 2005 TO 2040**

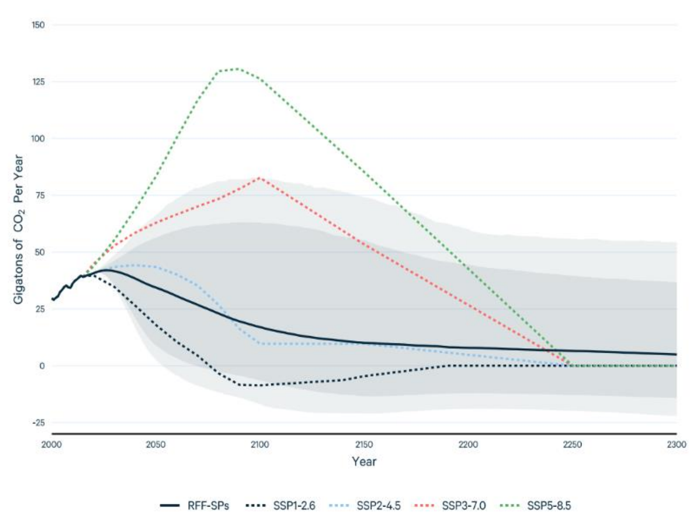


The range of fossil fuel baseline emissions projected by the International Energy Agency in 2019 and 2020 lie almost entirely outside the full range of baseline scenarios for the IPCC Fifth Assessment Report and the SSP scenarios shaping the IPCC Sixth Assessment Report.

Source: *Pielke Jr. and Ritchie (2021)*[4]

The next chart is by Kevin Rennert and his team at Resources for the Future (RFF). Annual carbon dioxide emissions in the new RFF baselines are less than half those projected by SSP5-8.5 in 2050 and less than one-fifth those projected by SSP5-8.5 in 2100.

Figure 8. Net Annual Emissions of CO_2 from RFF-SPs and SSPs



Notes. Lines represent median values, and dark and light shading represent the 5th to 95th (darker) and 1st to 99th (lighter) percentile ranges of the RFF-SPs.

Source: *Rennert et al. (2021)*[5]

Ever since 2010, the U.S. government's Interagency Working Group (IWG) has used the average of five emission baselines from a 2009 Stanford Energy Modeling Forum study[6] to estimate the social cost of carbon dioxide. The average of the five baselines over the 300-year 2000-2300 analysis period is 17,195 gigatons of carbon dioxide. The average of the new RFF baselines is 5,000 $GtCO_2$—less than one-third of the old baselines.

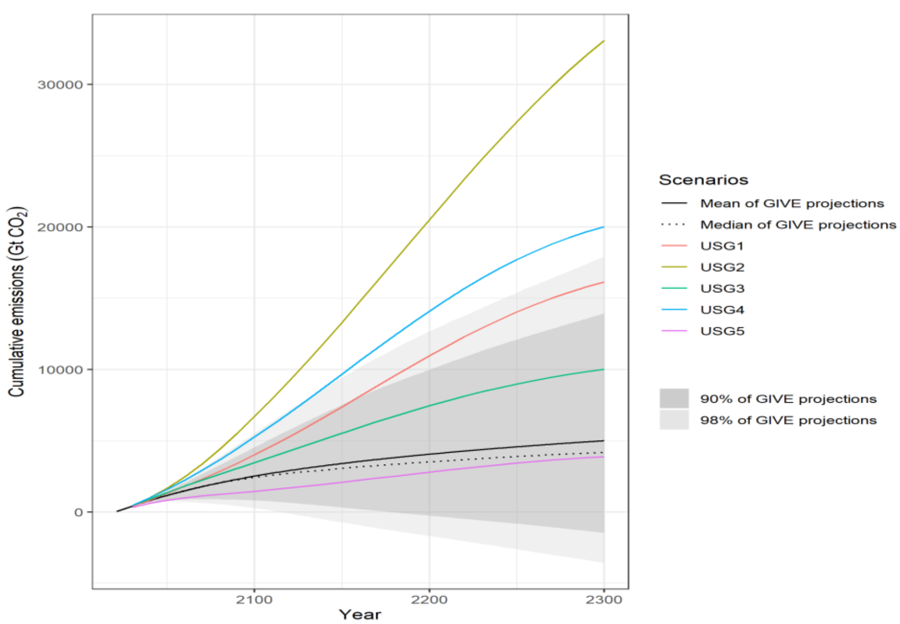
Here are the baselines underpinning the IWG's 2010, 2013, 2016, and 2021 technical support documents (TSDs) on the social cost of carbon/greenhouse gases:

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	

Source: *Electric Power Research Institute (2014)*[7]

Here is a chart comparing the new RFF mean emission baseline projection to the five scenarios used in U.S. Government social cost estimates.



Source: *Kevin Rennert (December 2, 2022)*

Significantly, the EPA's recent draft report on the social cost of greenhouse gases proposes to replace the older baselines with the RFF mean baseline.[8] In other words, the EPA implicitly acknowledges that SSP5-8.5 is a highly-inflated emissions scenario. It proposes to use the RFF mean baseline in social cost estimation. To reiterate, compared to SSP5-8.5, the RFF baseline projects less than half the carbon dioxide emissions in 2050 and less than one-fifth the emissions in 2100.

Of the IPCC's four main SSPs, the RFF's mean CO_2 baseline is most similar to SSP2-4.5. In NOAA's chart, the mean SSP2-4.5 sea-level rise projection for 2050 is 21 centimeters or 8.2 inches, not one foot.

Global Mean Surface Air Temperature 2081–2100	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	Unknown Likelihood, High Impact – Low Emissions	Unknown Likelihood, High Impact – Very High Emissions
Closest Emissions Scenario–Based GMSL Projection	Low (SSP1-2.6)	Low (SSP1-2.6) to Intermediate (SSP2-4.5)	Intermediate (SSP2-4.5) to High (SSP3-7.0)	High (SSP3-7.0)	Very High (SSP5-8.5)	Low (SSP1-2.6), *Low Confidence* processes	Very High (SSP5-8.5), *Low Confidence* processes
Total (2050)	0.18 (0.16–0.24)	0.20 (0.17–0.26)	0.21 (0.18–0.27)	0.22 (0.19–0.28)	0.25 (0.22–0.31)	0.20 (0.16–0.31)	0.24 (0.20–0.40)
Total (2100)	0.44 (0.34–0.59)	0.51 (0.40–0.69)	0.61 (0.50–0.81)	0.70 (0.58–0.92)	0.81 (0.69–1.05)	0.45 (0.32–0.79)	0.88 (0.63–1.60)

You may be wondering how the official emission baselines could be so far off, for so long. SSP5-8.5 was calibrated to match the forcing scenario of the high-end representative concentration pathway, RCP8.5, in the IPCC's 2013 Fifth Assessment Report. RCP8.5 itself derives from an earlier scenario (A2r) from the IPCC's 2007 Fourth Assessment Report. The A2r scenario assumes coal is the increasingly affordable backstop energy of the global economy throughout the 21st century.[9] Specifically, the socioeconomic projection underpinning RCP8.5 assumes global coal consumption increases almost ten-fold from 2000 to 2100.

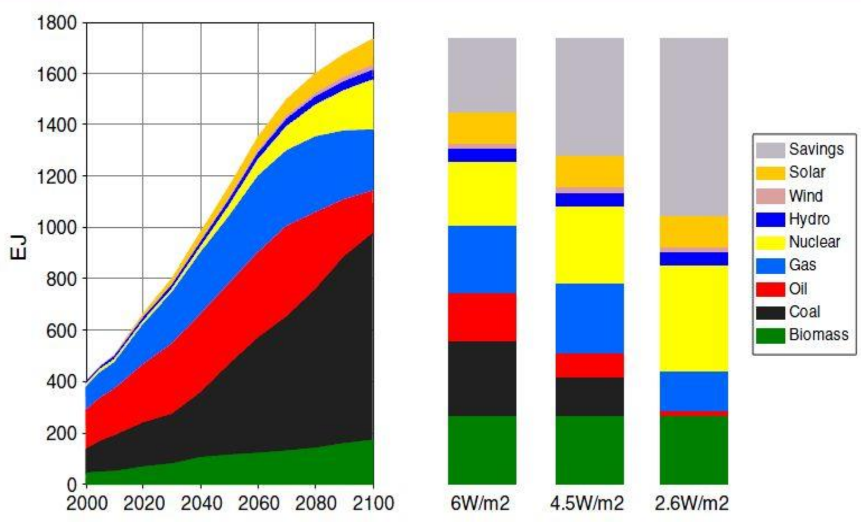


Fig. 5 Development of global primary energy supply in RCP8.5 (*left-hand panel*) and global primary energy supply in 2100 in the associated mitigation cases stabilizing radiative forcing at levels of 6, 4.5, and 2.6 W/m^2 (*right-hand bars*). Note that primary energy is accounted using the direct equivalent method

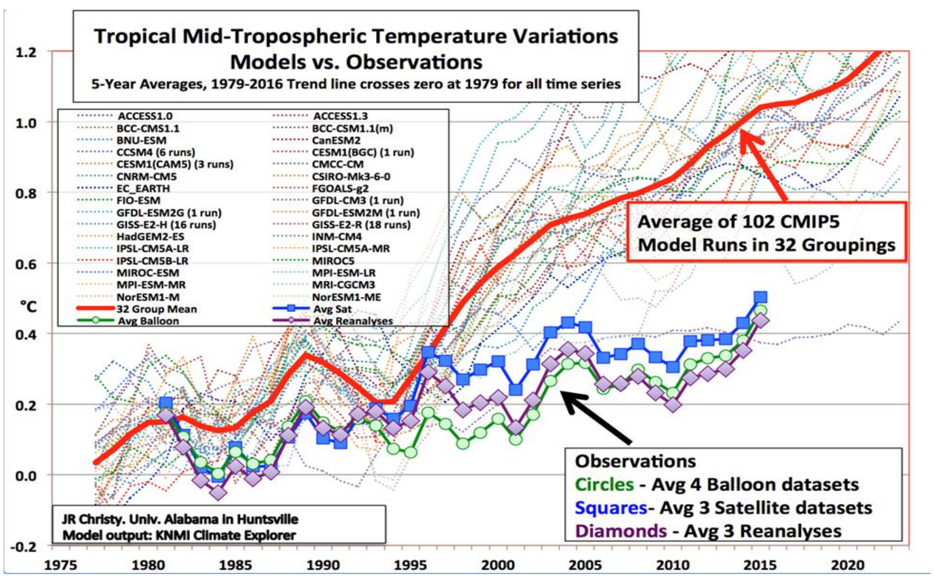
Source: *Riahi et al. 2011.*

There is no evidence anything like that is happening or will happen. The same governments that joined the Paris Agreement would have to collude to make burning coal a collective global priority.

Using Google Scholar, Pielke, Jr. and Ritchie find that from the beginning of 2020 through mid-June 2021, climate researchers published 7,200 papers using RCP8.5 and 1,500 using SSP5-8.5.[10] The academic consensus in favor of using those scenarios in climate research may well have been 97 percent! That consensus is crumbling, which is great news. Those scenarios have needlessly alarmed the public and distorted both climate science and policy deliberation.

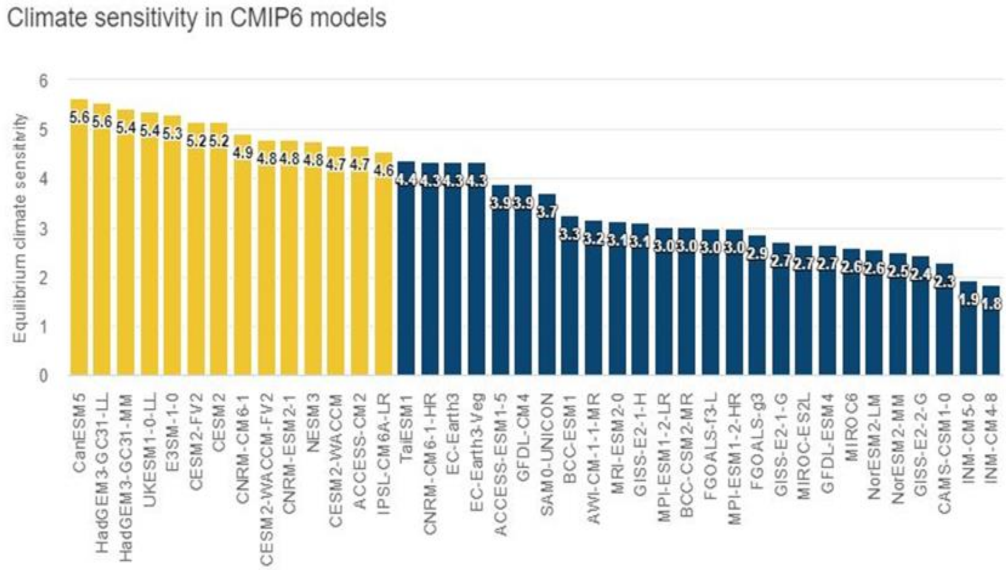
Hot Models

As mentioned, NOAA's mid-range SSP2-4.5 sea-level rise estimate is 8.2 inches by 2050. Even that may be an exaggeration. The IPCC's Sixth Assessment Report (AR6) uses the CMIP6 generation of climate models to project warming and sea levels from various SSPs.[11] The CMIP6 models on average are tuned hotter than the CMIP5 models used in the IPCC's Fifth Assessment Report (AR5). And the AR5 models already hindcast more than twice the observed warming in the tropical troposphere since 1979.[12]



Source: *Christy 2017. 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.*

About one-third of the AR6 models have higher equilibrium climate sensitivities than any model in the AR5 ensemble.[13] Equilibrium climate sensitivity (ECS) is the term used to describe how much warming will occur after the climate system has fully adjusted to a doubling of CO_2 concentrations.



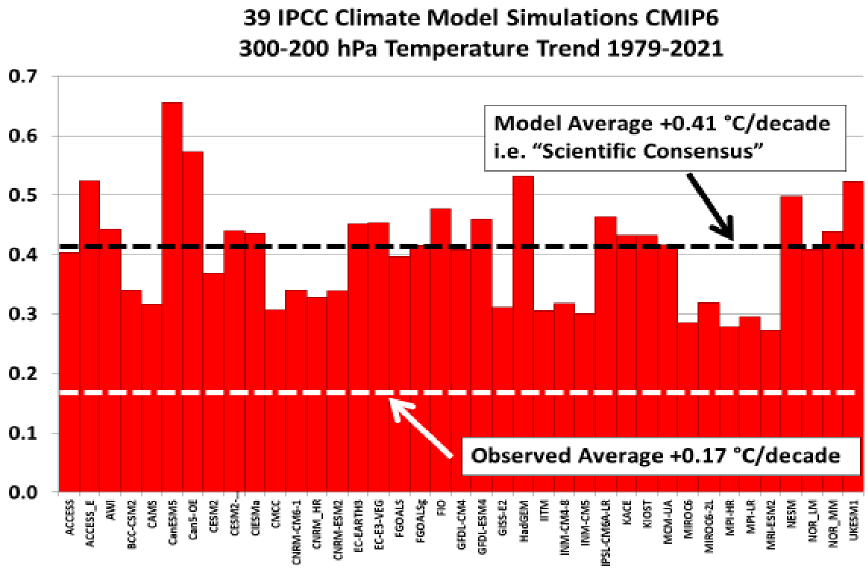
Source: *Hausfather 2020. The CMIP6 model suite. Models warmer than the warmest CMIP5 versions are in yellow.*

In a 2022 article in *Nature*, Zeke Hausfather and three co-authors caution that a subset of the CMIP6 models are "too hot" and produce warming projections "that might be larger than that supported by other evidence."[14]

For example, Zhu, Poulsen, and Otto-Bliesner (2020) ran the CESM2 model with an emission scenario in which CO_2 concentrations reach 855 parts per million (ppm) by 2100. The model produced a global mean temperature "5.5°C greater than the upper end of proxy temperature estimates for the Early Eocene Climate Optimum."[15] That was a period when CO_2 concentrations of about 1,000 ppm persisted for millions of years.[16] Moreover, the CESM2 tropical land temperature exceeds 55°C, "which is much higher than the temperature tolerance of plant photosynthesis and is inconsistent with fossil evidence of an Eocene Neotropical rainforest."[17]

In AR5 and previous IPCC reports, the IPCC "simply used the mean and spread of models to estimate impacts and their uncertainties"—a method dubbed "model democracy" because each model counts equally with every other. To address the "hot model" problem, AR6 authors decided to apply weights to the models before averaging them.[18]

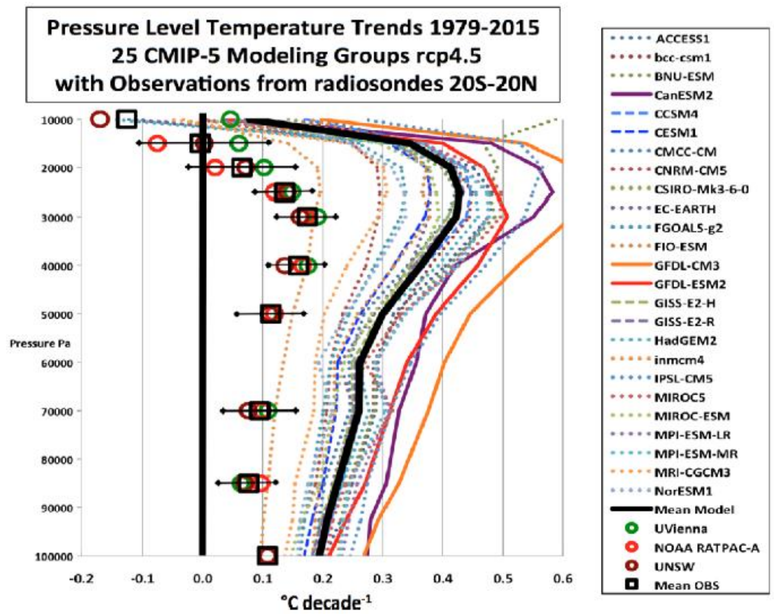
While "weighting" avoids the embarrassment of giving an equal vote to an outlandish model like CESM2, it does not correct the basic methodological flaw—the IPCC's reliance on errant models. All CMIP6 models overestimate observed warming in the troposphere, the atmospheric layer where the vast majority of the anthropogenic greenhouse effect occurs. More importantly, in the tropical mid-troposphere, the region best suited to measure anthropogenic changes in the greenhouse effect,[19] the CMIP6 models overshoot observed warming by more than a factor of more than two.[20]



Source: *John Christy. CMIP 6 models vs. observations.*

Accordingly, it is reasonable to surmise that global sea levels will rise less than 8.2 inches by 2050.

My late colleague Dr. Patrick Michaels often observed that when meteorologists forecast the weather, they use the model or models with proven skill, not the average of all models regardless of their track records. He therefore recommended that federal agencies take a reasonable emission scenario, such as SSP2-4.5, and run it with a model that accurately hindcasts warming in the tropical troposphere. As it happens, only one model has done so—the Russian INM-CM4, one of the CMIP5 models used in AR5.



Source: *Christy and McNider (2017). Pressure-level temperature trends (1979-2016) for the tropical atmosphere as measured by four radiosonde datasets (circles with square as average, UVienna is average of two datasets) and 25 modeling groups (dotted, dashed and solid lines, mean is black line) used in IPCC AR5. The temperature projection by INM-CM4 is the leftmost dotted line.*

I heartily encourage Chairman Whitehouse and Ranking Member Grassley to invite NOAA, the EPA, or another federal agency to conduct the experiment.

Emission Reduction Policies Won't Hold Back the Seas

It is ironic that sea-level rise projections like those NOAA's 2022 report are used to sell emission reduction policies. In the news cycle, NOAA oceanographer Harold Sweet told the *Post* that even if the world moves swiftly to curb emissions, the trajectory of sea-level rise "is more or less set over the next 30 years." Similarly, NOAA administrator Nick Spinrad told the *Times* that roughly the same amount of sea-level rise will occur "no matter what we do about emissions."

Let's break that down a bit. Here again are NOAA's warming and sea-level rise projections:

Global Mean Surface Air Temperature 2081–2100	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	Unknown Likelihood, High Impact – Low Emissions	Unknown Likelihood, High Impact – Very High Emissions
Closest Emissions Scenario–Based GMSL Projection	Low (SSP1-2.6)	Low (SSP1-2.6) to Intermediate (SSP2-4.5)	Intermediate (SSP2-4.5) to High (SSP3-7.0)	High (SSP3-7.0)	Very High (SSP5-8.5)	Low (SSP1-2.6), *Low Confidence* processes	Very High (SSP5-8.5), *Low Confidence* processes
Total (2050)	0.18 (0.16–0.24)	0.20 (0.17–0.26)	0.21 (0.18–0.27)	0.22 (0.19–0.28)	0.25 (0.22–0.31)	0.20 (0.16–0.31)	0.24 (0.20–0.40)
Total (2100)	0.44 (0.34–0.59)	0.51 (0.40–0.69)	0.61 (0.50–0.81)	0.70 (0.58–0.92)	0.81 (0.69–1.05)	0.45 (0.32–0.79)	0.88 (0.63–1.60)

According to the IPCC, limiting warming to 1.5°C would require the entire world to achieve NetZero emissions by 2050.[21] If SSP5-8.5 is the baseline trajectory, achieving global NetZero by 2050 would reduce sea-level rise in 2050 by 7 centimeters—2.8 inches. If SSP2-4.5 is the baseline, then achieving global NetZero would reduce sea-level rise by 3 centimeters or 1.1 inches.

Achieving global NetZero by 2050 is infeasible, as there are too many nations whose urgent energy priority is not emission reduction but gaining access to electricity and obtaining enough commercial energy to eradicate poverty and support development.[22]

The Paris Agreement's goal of global NetZero by the 2070s is only slightly less unrealistic. It assumes industrialized countries like the United States lead the way and achieve NetZero by 2050. However, the economic burdens would be crushing and, thus, politically unsustainable.

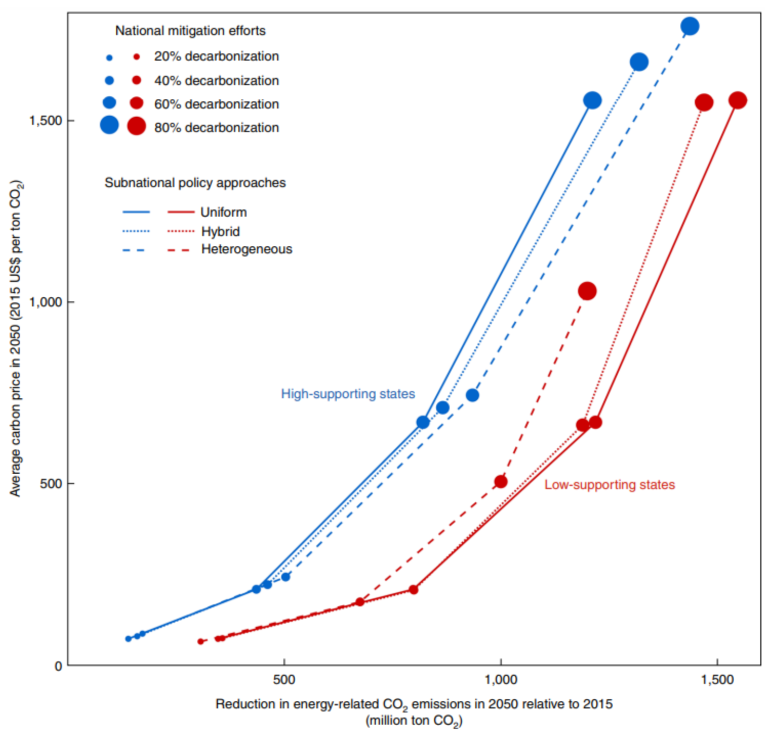
Most economists regard carbon taxes as a more economically-efficient emission-reduction tool than the usual potpourri of regulatory mandates, subsidies, and keep-it-in-the-ground restrictions on fossil-energy exploration, production, and transport. A recent Heritage Foundation study uses a clone of the U.S. Energy Information Administration's National Energy Modeling System (NEMS) to project the economic impacts and emission reductions from a revenue-neutral carbon tax, with per-ton prices ranging from $35 to $300.[23] Not even the $300 per ton carbon tax comes close to achieving NetZero emissions by 2050. Instead, it reduces emissions to 44 percent of 2005 levels in 2030 and 47 percent in 2040, with little if any additional reduction thereafter.

Nonetheless, the $300 per ton carbon tax has severe economic impacts, including:

- An overall average reduction of more than 1.2 million jobs per year.
- A peak employment reduction of more than 7.8 million jobs.
- An average annual income loss for a family of four of $5,100.
- A total income loss for a family of four exceeding $87,000 over the 18-year time horizon.
- An aggregate GDP loss of over $7.7 trillion over the 18-year time horizon.
- A rise in household electricity expenditures averaging 23 percent per year.

So, how high must a carbon tax be to achieve NetZero by 2050, and at what cost?

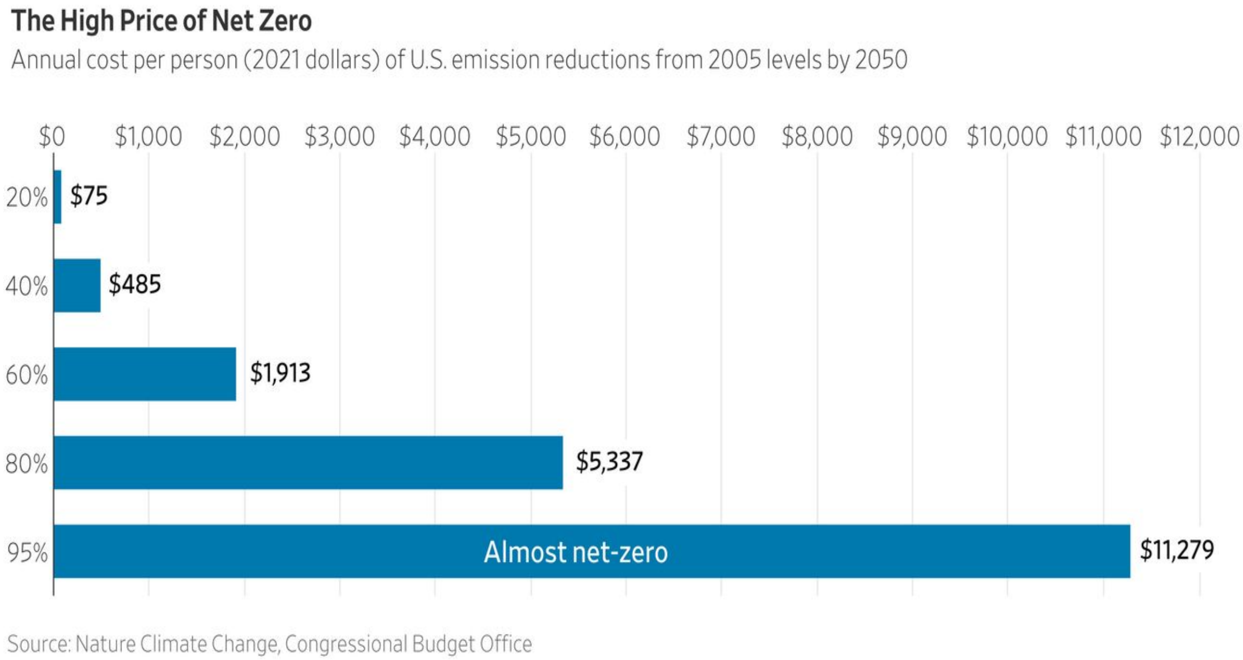
An August 2021 study in *Nature Climate Change* estimates that a carbon tax would have to reach $1,500 per-ton to achieve 80 percent decarbonization by 2050. An even higher tax would be needed to achieve 95 percent decarbonization.[24]



Source: *Peng et al. (2022). Per-ton price of 80% CO2 emission reduction, carbon tax vs. state policies.*

The 95-percent reduction in U.S. CO_2 emissions would cost a pretty penny: an estimated 11.9 percent of U.S. GDP in 2050. A *Wall Street Journal* article by Danish statistician Bjorn Lomborg puts it all in perspective:

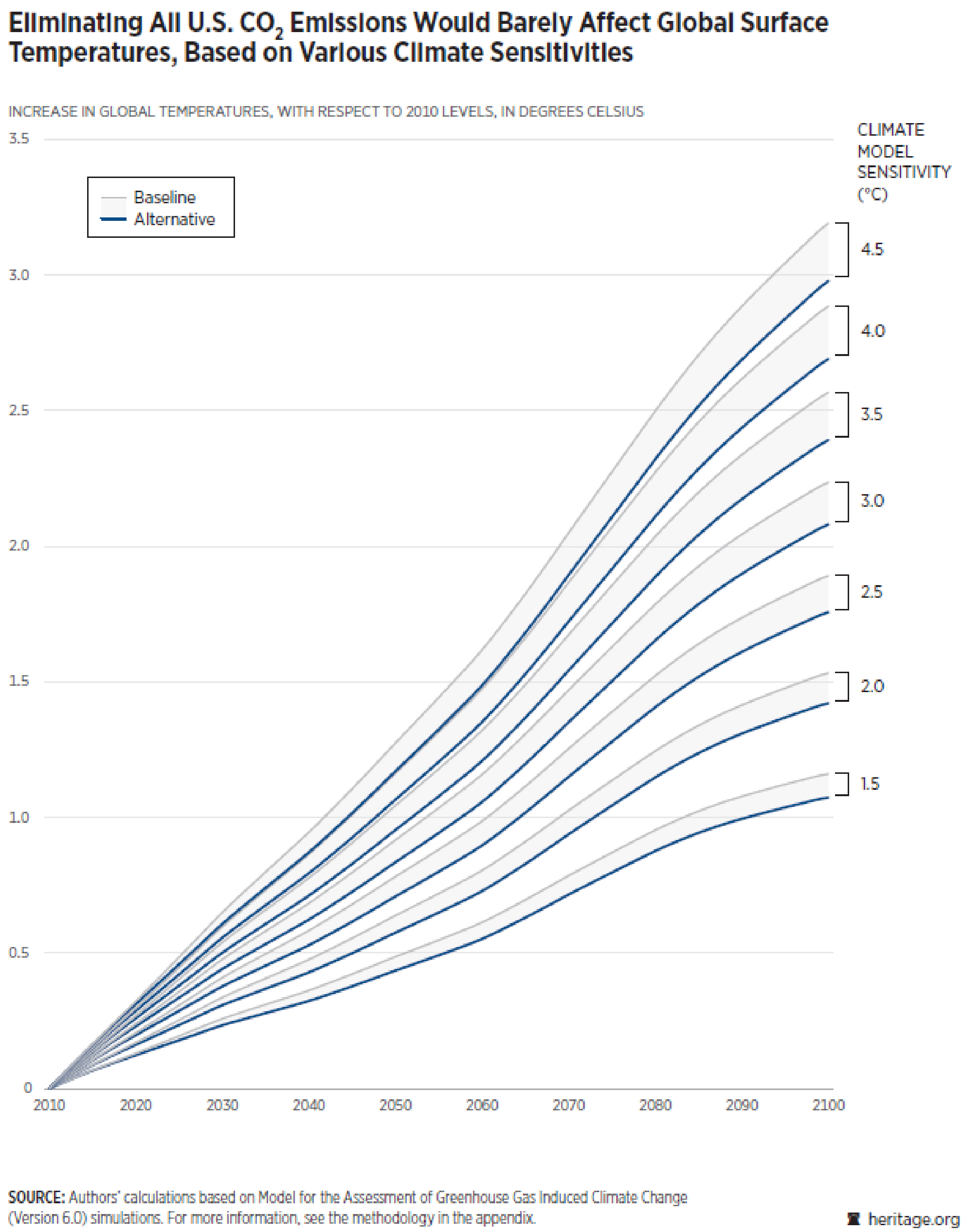
> Total expenditure on Social Security, Medicare, and Medicaid came to 11.6 percent of GDP in 2019. The annual cost of trying to hit Mr. Biden's target will rise to $4.4 trillion by 2050. That's more than everything the federal government is projected to take in this year in tax revenue. It breaks down to $11,300 per person per year, or almost 500 times more than the majority of Americans is willing to pay.[25]



Source: *Lomborg, WSJ, October 14, 2021*

Relevance to today's hearing? U.S. CO_2 emissions in 2021 were approximately 13.5 percent of global emissions.[26] Achieving net-zero U.S. emissions by 2050 would reduce sea levels by less than global NetZero, which, even assuming the dubious CMIP6 climate sensitivity estimates, would avert only 1.1 inches of sea-level rise by 2050 under the reasonably realistic SSP2-4.5 emission scenario. Few Americans think it is worth spending up to $11,300 annually to avert less than one inch of sea-level rise 30 years from now.

Indeed, it is doubtful Americans would long tolerate the costs imposed by smaller carbon taxes, especially if they compare the costs to the potential climate-related benefits. Using the EPA's climate policy model known as MAGICC,[27] the aforementioned Heritage study estimates that even complete and instantaneous elimination of U.S. carbon dioxide emissions would avert only 0.2°C of warming by 2100 (assuming a mid-range—3°C—climate sensitivity). The reduction in global warming and sea levels from any U.S. emission reductions feasibly achieved by 2050 would likely be undetectable.

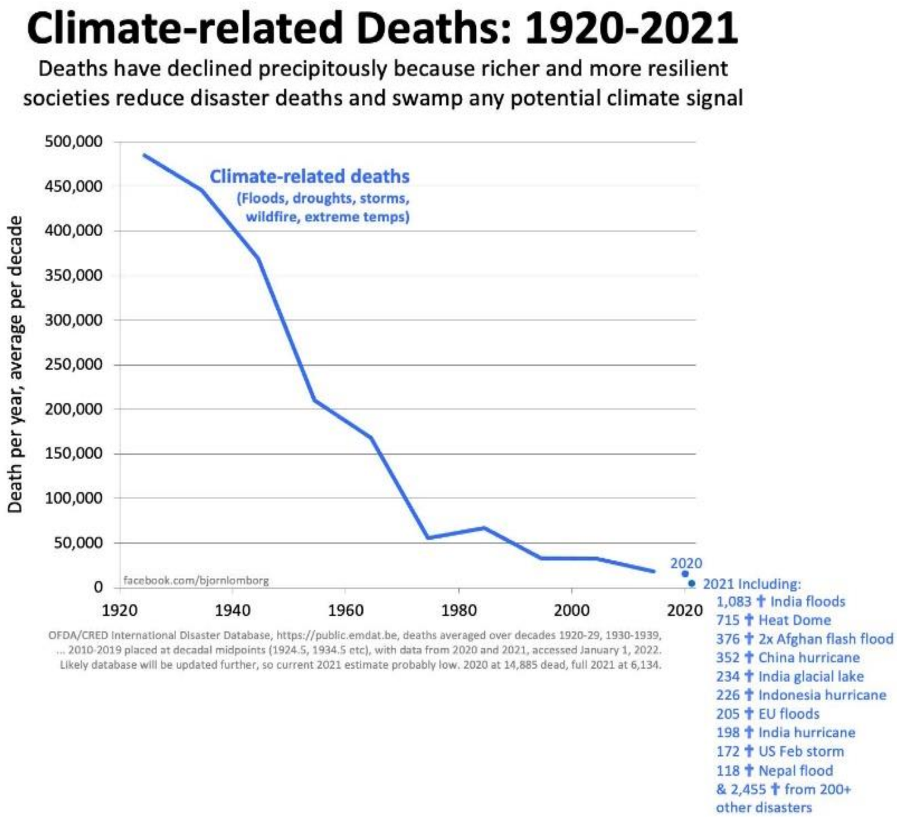


Source: Dayaratna et al. (2022). *The climate impact of eliminating CO2 emissions from fossil fuels completely under different climate sensitivity assumptions. If ECS is 3°C, global temperatures decrease 0.2°C by 2100.*

Economic Growth Is the Best Climate Policy

If climate change were a global ecological and economic crisis, we would expect to find evidence of declining health and well-being over the past 50 to 70 years. Instead, we find dramatic improvements in global life expectancy,[28] per capita income,[29] food security,[30] crop yields,[31] and various health-related metrics.[32] Recent years have seen a surge disease mortality and displaced persons, but the causes (COVID-19, the Ukraine War, dysfunctional statist economies) had nothing to do with climate change.

Of particular relevance, the average annual number of climate-related deaths per decade has declined by 96% since the 1920s.[33] This spectacular decrease in aggregate climate-related mortality occurred despite a fourfold increase in global population. The individual risk of dying from extreme weather events declined by 99.4% over the past 100 years.[34] That is an impressive testament to humanity's remarkable capacity for adaptation. Such improvements would not have occurred, however, had government policies prevented people from developing and using affordable, abundant, and scalable energy from fossil fuels to master climate-related risks.[35]



Source: *Bjorn Lomborg.*[36]

We often hear that the weather is becoming increasingly destructive. In most cases (for example, hurricanes) that is an illusion due to a failure to adjust ("normalize") weather-related damages for increases in exposed wealth and population.[37]

What matters from a sustainability perspective is relative economic impact—climate-related damages as a share of GDP. Weather-related loss rates per exposed GDP declined nearly five-fold from 1980–1989 to 2007–2016.[38] That progress occurred in both low-middle and high-middle income countries, and with respect to all forms of damaging weather. In the case of coastal floods, the greatest reductions in climate vulnerability were achieved by low-income countries.

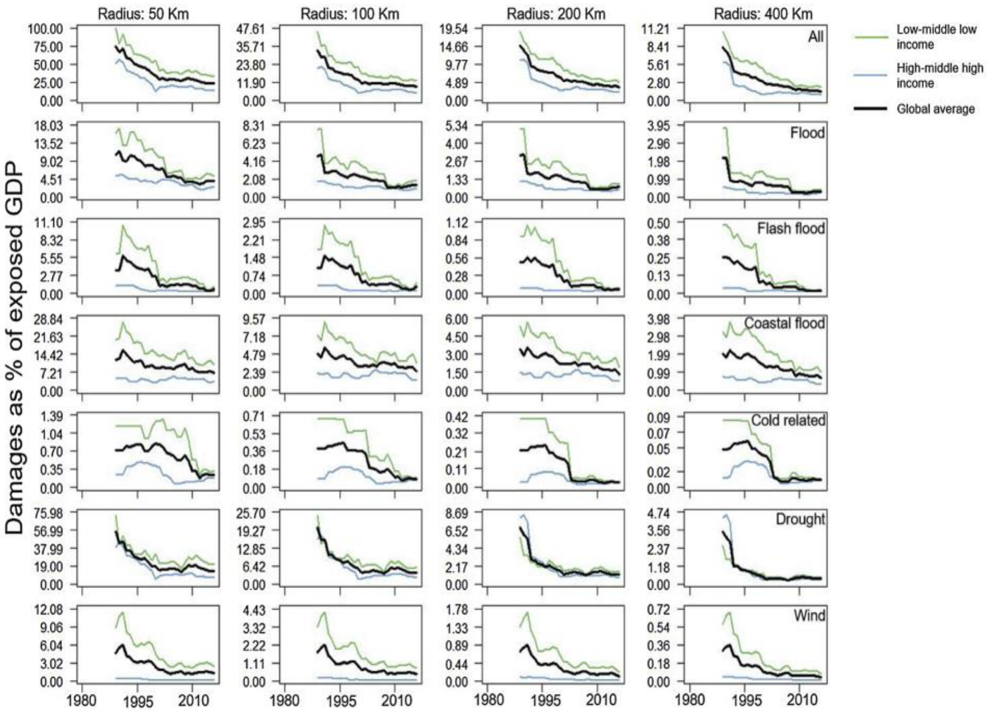


Fig. 3. Loss rates for the analyzed hazards. Results for each hazard represent 10-year moving average of the median (for each year per income class) loss rates for two income levels (low/middle-low income in green and high/middle-high income in blue) and all countries (average of low/middle-low and high/middle-high income classes). Multi-hazard loss rates are the sum of single hazard median values.

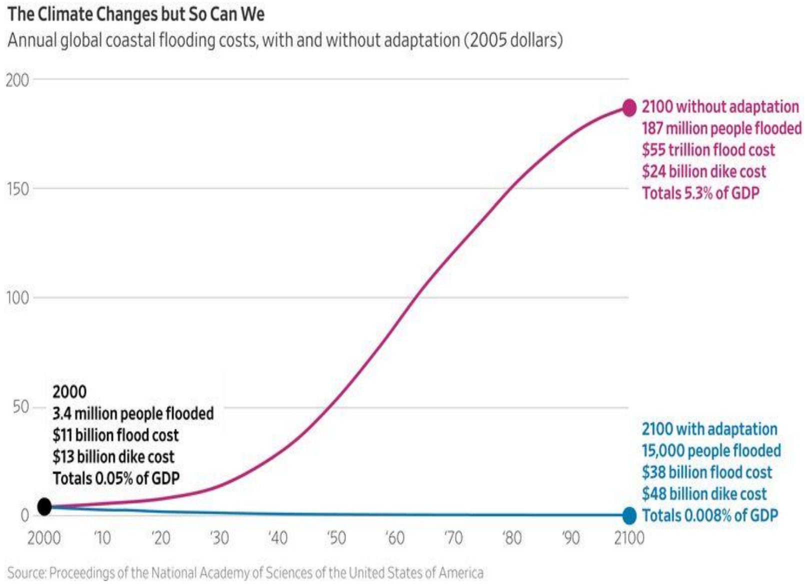
Source: *Formetta and Feyen (2019).*

Some of you may wonder: What if SSP5-8.5 turns out to be correct, the CMIP6 ensemble gets climate sensitivity right, and sea-levels rise six feet by 2100, as some scientists warn? Would that make the pursuit of NetZero a sound policy path? No, it would not.

Even in the improbable worst case of an RCP8.5 warming that increases sea levels six feet by 2100, prudent adaptive measures could dramatically reduce the relative economic impact and number of flood victims to the point where people are much better off than they are today.[39]

As Bjorn Lomborg explains in his review of Hinkel et al. (2014),[40] a study published by the National Academy of Sciences, six feet of sea-level rise could cost $55 trillion (5.3% of GDP) or even $100 trillion (11% of global GDP) in 2100 if people do nothing more than maintain current sea defenses. But societies are unlikely to put up with ineffective protections year after year, decade after decade.

Here's what happens if societies invest in coastal protections to keep ahead of rising seas. 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 global economic impact of coastal flooding actually declines from 0.05% of GDP to 0.008%. Moreover, the number of people experiencing coastal flood damages declines by more than 99%—from 3.4 million in 2000 to 15,000 in 2100.[41]



Source: *Bjorn Lomborg, WSJ, October 21, 2021, adapted from Hinkel et al. (2014).*

Conclusion

The key takeaways are as follows.

First, we should be skeptical about worst-case sea-level rise projections. Such estimates derive from warm-biased models run with warm-biased emission scenarios. They are methodological sandcastles.

Second, emission reduction policies can provide little if any discernible mitigation of sea-level rise in the policy-relevant future—the next 30 years—and perhaps not even by 2100. Measuring the actual reduction in sea-level rise economic impacts would be even more difficult.

Third, the best defense against sea-level rise is sustained investment in adaptation. Mankind's amazing and ongoing mastery of climate-related risks is chiefly due to increasing wealth and technological advancements. Fossil fuels remain critical to sustaining such progress.

As energy scholar Alex Epstein puts it, human beings using fossil fuels did not take a naturally safe climate and make it dangerous; rather, they took a naturally dangerous climate and made it much safer.

Thank you again for the opportunity to present testimony. I would be happy to address your questions.

[1] NOAA, Global and Regional Sea Level Rise for the United States, February 2022, https://aambpublicoceanservice.blob.core.windows.net/oceanserviceprod/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf.
[2] Sarah Kaplan and Brady Dennis, "Sea level to rise one foot along U.S. coastlines by 2050, government report finds," *Washington Post*, February 15, 2022, https://www.washingtonpost.com/climate-environment/2022/02/15/sea-level-rise-2050-climate/; Henry Fountain, "Costal Sea Levels in U.S. to Rise a Foot by 2050, Study Confirms," *New York Times*, February 15, 2022, https://www.nytimes.com/2022/02/15/climate/us-rising-sea-levels.html; Evan Bush, "U.S. sea level rise accelerating, NOAA says; U.S. coastlines expected to endure on average another foot of sea level rise by 2050, according to a report released Tuesday," NBC News, February 15, https://www.nbcnews.com/science/science-news/us-sea-level-rise-accelerating-noaa-says-rcna16205.
[3] 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.
[4] Roger Pielke, Jr. and Justin Ritchie, "How Climate Scenarios Lost Touch with Reality," Issues in Science and Technology, Summer 2021, https://issues.org/wp-content/uploads/2021/07/74-83-Pielke-Ritchie-How-Climate-Scenarios-Lost-Touch-With-Reality-Summer-2021-ISSUES.pdf.
[5] Kevin Rennert et al. *The Social Cost of Carbon: Advances in Long-Term Probabilistic Projections of Population, GDP, Emissions, and Discount Rates, Resources for the Future*, October 2021, https://www.rff.org/publications/working-papers/the-social-cost-of-carbon-advances-in-long-term-probabilistic-projections-of-population-gdp-emissions-and-discount-rates/.
[6] 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.
[7] EPRI, *Understanding the Social Cost of Carbon: A Technical Assessment*, October 2014, Section 4, pp. 3-4, https://www.epri.com/research/products/3002004657.
[8] EPA, External Review Draft of the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances, September 2022, https://www.epa.gov/system/files/documents/2022-11/epa_scghg_report_draft_0.pdf.
[9] Keywan Riahi, et al. 2011. RCP 8.5—A scenario of comparatively high greenhouse gas emissions. *Climate Change* 109: 33-57, https://link.springer.com/article/10.1007/s10584-011-0149-y.
[10] Pielke, Jr. and Ritchie, 2021.
[11] Zeke Hausfather, "CMIP6: The next generation of climate models explained," CarbonBrief, December 2, 2019, https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained/.
[12] John R. Christy and Richard T. McNider. 2017. Satellite Bulk Tropospheric Temperatures as a Metric for Climate Sensitivity. *Asia-Pac. J. Atmos. Sci.*, 53(4), 511-518, https://www.sealevel.info/christymcnider2017.pdf; Christy, J.R.: 2017, *Bull. Amer. Meteor. Soc*. 98, (8), S16-S17, https://journals.ametsoc.org/view/journals/bams/98/8/2017bamsstateoftheclimate.1.xml.
[13] Zeke Hausfather, "Cold Water on Hot Models," The Breakthrough Institute, February 11, 2020, https://thebreakthrough.org/issues/energy/cold-water-hot-models.
[14] Zeke Hausfather, Kate Marvel, Gavin A. Schmidt, John W. Nielsen-Gammon & Mark Zelinka, "Climate simulations: recognize the 'hot model' problem," *Nature* Vol. 605, May 5, 2022, https://media.nature.com/original/magazine-assets/d41586-022-01192-2/d41586-022-01192-2.pdf.
[15] Jiang Zhu, Christopher J. Poulsen & Bette L. Otto-Bliesner. 2020. High climate sensitivity in CMIP6 model not supported by paleoclimate. *Nature Climate Change* Vol. 10, pages 378–379, https://www.nature.com/articles/s41558-020-0764-6.
[16] 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.
[17] Zhu et al. (2020), Op. Cit.
[18] Hausfather et al. (2022), Op. Cit.
[19] All models predict a strong warming signal in the tropical atmosphere at 300-200 hPa. The region is well-monitored by satellites and weather balloons. It is too high in altitude to be influenced by urban heat islands. Moreover, climate models have not been previously "tuned" to match tropical troposphere temperature data. See

Ross McKitrick and John Christy. 2018. A Test of the Tropical 200- to 300-hPaWarming Rate in Climate Models. *Earth and Space Science*, 5: 529–536, https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2018EA000401.
[20] McKitrick and J. Christy. 2020. Pervasive Warming Bias in CMIP6 Tropospheric Layers. *Earth and Space Science*, 7, Issue 9, https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EA001281.
[21] IPCC, *Special Report on Global Warming of 1.5°C*, Chapter 2, p. 2, https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Chapter_2_LR.pdf.
[22] Our World in Data, Access to Energy, https://ourworldindata.org/energy-access.
[23] Kevin D. Dayaratna, Katie Tubb, and David Kreutzer, *The Unsustainable Costs of President Biden's Climate Agenda*, Heritage Foundation, Backgrounder No. 3713, June 16, 2022, https://www.heritage.org/sites/default/files/2022-06/BG3713_0.pdf.
[24] Wei Peng et al. 2020. The surprisingly inexpensive cost of state-driven emission control strategies. *Nature Climate Change* 11: 738-745, https://www.nature.com/articles/s41558-021-01128-0. Don't be fooled by the title. What is surprising is that achieving NetZero through heterogeneous state policies would not be much more expensive than a draconian national carbon tax!
[25] Bjorn Lomborg, "Biden's Climate Ambitions Are Too Costly for Voters," *Wall Street Journal*, October 14, 2021, https://www.wsj.com/articles/climate-change-cost-economy-emissions-tax-per-person-net-zero-joe-biden-11634159179.
[26] Our World in Data, U.S. CO_2 Emissions, https://ourworldindata.org/co2/country/united-states.
[27] MAGICC stands for Model for the Assessment of Greenhouse Gas Induced Climate Change. See Magicc.org.
[28] Our World in Data, Life Expectancy, https://ourworldindata.org/life-expectancy.
[29] Our World in Data, Economic Growth, https://ourworldindata.org/economic-growth.
[30] Our World in Data, Food Supply, https://ourworldindata.org/food-supply.
[31] Our World in Data, Crop Yields, https://ourworldindata.org/crop-yields.
[32] Our World in Data, Global Burden of Disease, https://ourworldindata.org/health-meta#burden-of-disease.
[33] 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; "Fewer and Fewer People Die from Climate-Related Disasters," Facebook, https://www.facebook.com/bjornlomborg/posts/475702943914714/.
[34] Bjorn Lomborg, "The risk of dying from climate-related disasters has declined precipitously." Twitter, January 1, 2023, https://twitter.com/BjornLomborg/status/1609568094447456259.
[35] Alex Epstein, *Fossil Future: Why Global Human Flourishing Requires More Oil, Coal, and Natural Gas, Not Less* (New York: Penguin Random House, 2022).
[36] Bjorn Lomborg Facebook Page, updating "Welfare in the 21st century: Increasing development, reducing inequality, the impact of climate change, and the cost of climate policies," *Technological Forecasting and Social Change*, July 2020, Vol. 156, https://www.sciencedirect.com/science/article/pii/S0040162520304157.
[37] Roger Pielke, Jr., "Billion Dollar Weather Disasters Are a National Embarrassment," Substack, January 8, 2023, https://rogerpielkejr.substack.com/p/billion-dollar-disasters-are-a-national.
[38] Giuseppe Formetta and Luc Feyen. 2019. Empirical Evidence of Declining Global Vulnerability to Climate-Related Hazards, *Global Environmental Change*, 57: 1-9, https://www.researchgate.net/publication/333507964_Empirical_evidence_of_declining_global_vulnerability_to_climate-related_hazards.
[39] Bjorn Lomborg, "Climate Change Calls for Adaptation, Not Panic," *Wall Street Journal*, October 21, 2021, https://www.wsj.com/articles/climate-change-adaptation-panic-exaggerating-disaster-11634760376..
[40] Hinkel et al. 2014. Coastal flood damage and adaptation costs under21st century sea-level rise. PNAS 111: 3292-3297, https://www.pnas.org/doi/epdf/10.1073/pnas.1222469111.
[41] 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, available at https://www.pnas.org/content/pnas/suppl/2014/01/29/1222469111.DCSupplemental/pnas.201222469SI.pdf.