Department of Energy

Attn.: Docket ID No. DOE-HQ-2025-0207

Subject: Public Comment on "Notice of Availability: A Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate"

Professors Jeffrey Shrader and Matthew Gibson submit the following comments to the Department of Energy regarding the agency's proposal "Critical Review of Impacts of Greenhouse Gas Emissions on the U.S. Climate" (Docket ID No. DOE-HQ-2025-0207). Professor Shrader is an environmental economist at Columbia University's School of International and Public Affairs and Professor Gibson is an environmental economist at Williams College. We study the economics of climate change and regulatory policy and have published studies on the design of environmental policy, the economic effects of climate change, how the government should weigh evidence when evaluating policy, and other topics relevant to this regulatory analysis.[1]

These comments are **technical** and provide **references**. They lay out our understanding of the state of the scientific literature on the impacts of climate change before and after 2009, the year of the original endangerment finding. We provide timelines for three domains: mortality, non-fatal health effects, and market impacts measured by GDP. In brief, the review shows that in all three domains, the evidence of climate change effects has become more robust and comprehensive over time. The CWG Report does not cite important literature on climate change impacts nor does it accurately reflect the weight of evidence on the economics of climate change.

Mortality

The report's discussion of mortality in section 10.3 (starting on page 111) is incomplete and misleading. In particular, the report relies heavily on Zhao et al. 2021, Gasparini et al. 2015, and Lee and Dessler 2023 (as well as Ritchie 2024 which is not a published paper, does not present any novel estimates of climate change impacts, and does not comprehensively review the literature on climate change effects on mortality). This set of papers does not address the projected effects of *climate change* on mortality. Rather, these citations discuss the current or recent historical effect of weather on mortality. The summary of the literature below provides multiple important references that do actually estimate the effect of climate change on mortality. This literature became especially common after the publication of Deschênes and Greenstone (2011), a crucial missing citation.[2]

State of the literature prior to 2009

[1] For more information on our research, please see our CVs at the following links: Gibson and Shrader.

[2] Deschênes, Olivier, and Michael Greenstone. "Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US." *American Economic Journal: Applied Economics* 3, no. 4 (2011): 152-185.

Two review papers, Basu and Samet (2002) and Basu (2009), summarize epidemiology studies on the effect of ambient temperature on mortality published prior to 2009.[3] By that time, dozens of studies had established that suboptimal temperatures, whether hot or cold, lead to elevated mortality. Few studies, however, projected how mortality in the U.S. might change as the climate changes, and no study had done so comprehensively for the entire U.S. population. Basu (2009) cites just one study–Gosling et al. (2007)–with projections of how mortality in the U.S. might change under climate change. This study looked at six cities (Boston, Budapest, Dallas, Lisbon, London, and Sydney).[4] Additional research is reviewed in the WHO review McMichael et al. (2004).[5] The summarized research again focuses on effects for a relatively small number of cities.[6]

Important developments since 2009

Deschênes and Greenstone (2011) provided the first study, to our knowledge, that: (1) estimated the effect of temperature on comprehensive data on mortality in the U.S. from the universe of death certificate records and (2) projected changes in mortality due to climate change through the end of the century.[7] The analysis captures both the effects of increasing the frequency of hot days and decreasing the frequency of cold days, finding a net mortality increase of roughly 3% by 2100 under a high-emissions scenario. Subsequent work has built on this analysis to incorporate adaptation and to extend the analysis globally.[8]

Non-fatal Health Effects

Morbidity is only mentioned once in the report, on page 113. As the review below highlights, there has been a substantial increase in research on non-fatal health impacts of climate change over the last decade which the report should cite.

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[3] Basu, Rupa, and Jonathan M. Samet. "Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence." *Epidemiologic Reviews* 24, no. 2 (2002): 190-202; Basu, Rupa. "High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008." *Environmental Health* 8, no. 1 (2009): 40.

[4] Gosling, Simon N., Glenn R. McGregor, and Anna Páldy. "Climate change and heat-related mortality in six cities Part 1: model construction and validation." *International Journal of Biometeorology* 51, no. 6 (2007): 525-540.

[5] McMichael, Anthony J., Diarmid Campbell-Lendrum, Sari Kovats, Sally Edwards, Paul Wilkinson, Theresa Wilson, Robert Nicholls, Simon Hales, Frank Tanser, David Le Sueur, Michael Schlesinger and Natasha Andronova. *Comparative Quantification of Health Risks Global and Regional Burden of Disease Attributable to Selected Major Risk Factors Volume 1*. Ezzati, Majid , Alan D. Lopez, Anthony Rodgers and Christopher J.L. Murray. eds. World Health Organization (2004): 1543–1649.

[6] *Ibid* at 1629-1630.

[7] Deschênes, Olivier, and Michael Greenstone. "Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US." *American Economic Journal: Applied Economics* 3, no. 4 (2011): 152-185.

[8] Carleton, Tamma, Amir Jina, Michael Delgado, Michael Greenstone, Trevor Houser, Solomon Hsiang, Andrew Hultgren et al. "Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits." *Quarterly Journal of Economics* 137, no. 4 (2022): 2037-2105.

State of the literature prior to 2009

McMichael et al. (2004) summarized the state of the literature on morbidity effects of climate change as follows:

> There is little published evidence of an association between weather conditions and measures of morbidity such as hospital admissions or primary care consultations (Barer et al. 1984; Ebi et al. 2001; Fleming et al. 1991; McGregor et al. 1999; Rothwell et al. 1996; Schwartz et al. 2001). A study of general practitioner consultations among the elderly in Greater London found that temperature affected the rate of consultation for respiratory diseases but not that for cardiovascular diseases (Hajat et al. 2001). However, it is not clear how these end-points relate to quantitative measures of health burden.[9]

Important developments since 2009

Comprehensive estimates of non-fatal health effects from climate change are challenging due to the large number of possible different effects that could be studied and the lack of a nationwide database of effects, in contrast to the universe of mortality records maintained by the CDC. Despite these challenges, substantially more research on non-fatal health effects has been published since 2009. The following is not a comprehensive review, but it highlights the development in the literature.

Weinberger et al. (2016) projected changes in emergency department (ED) visits based on data from Rhode Island.[10] White (2017) estimated effects of temperature on ED visits in California, finding that hot temperatures have an especially severe effect.[11] Salas et al. (2024) used nationwide data on ED visits from Medicare participants to study the effect of climate shocks.[12] Chen et al. (2024) used California ED data to study the effects of both temperatures and wildfires.[13]

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[9] McMichael et al. (2004) at 1563.

[10] Kingsley, Samantha L., Melissa N. Eliot, Julia Gold, Robert R. Vanderslice, and Gregory A. Wellenius. "Current and projected heat-related morbidity and mortality in Rhode Island." *Environmental Health Perspectives* 124, no. 4 (2016): 460-467.

[11] White, Corey. "The dynamic relationship between temperature and morbidity." *Journal of the Association of Environmental and Resource Economists* 4, no. 4 (2017): 1155-1198.

[12] Salas, Renee N., Laura G. Burke, Jessica Phelan, Gregory A. Wellenius, E. John Orav, and Ashish K. Jha. "Impact of extreme weather events on healthcare utilization and mortality in the United States." *Nature Medicine* 30, no. 4 (2024): 1118-1126.

[13] Chen, Chen, Lara Schwarz, Noam Rosenthal, Miriam E. Marlier, and Tarik Benmarhnia. "Exploring spatial heterogeneity in synergistic effects of compound climate hazards: Extreme heat and wildfire smoke on cardiorespiratory hospitalizations in California." *Science Advances* 10, no. 5 (2024): eadj7264.

Market Impacts Measured by GDP

Section 11.1.2 (starting on page 119) again fails to cite important references and thus misrepresents the weight of the evidence on the estimated effects of climate change on gross domestic product (GDP). Most importantly, the report fails to cite a recent review of climate-GDP impacts studies from Kopits et al. (2025).[14]

State of the literature prior to 2009

Prior to 2009, no study had empirically estimated the relationship between climate change and GDP. Existing evidence on such a relationship came from climate integrated assessment models (IAMs) that combined evidence on market impacts on agriculture, coastal infrastructure, and other areas of the economy.

Important developments since 2009

In 2009, the first study estimating the relationship between climate change and GDP was published in the *American Economic Review Papers and Proceedings*, a non-peer reviewed conference proceeding.[15] The first peer-reviewed study of this relationship was published in 2012.[16] This literature has subsequently grown to encompass many papers. A recent review of empirical estimates of the effect of climate change on U.S. GDP can be found in Kopits et al. (2025).[17]

In addition to GDP impacts, research since 2009 has found climate change impacts across a wide range of other areas. Multiple review papers summarize this large literature, much of which emerged after the original endangerment finding.[18] Rigorous meta-analyses of climate damages and expert judgement from academic economists who study the topic also consistently report that climate change is—and will be—damaging to the economy.[19]

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[14] Elizabeth Kopits et al., "Economic Damages from Climate Change to U.S. Populations: Integrating Evidence from Recent Studies" *NCEE Working Paper*, no. 25-01 (2025).

[15] Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. "Temperature and income: reconciling new cross-sectional and panel estimates." *American Economic Review P&P* 99, no. 2 (2009): 198-204.

[16] Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. "Temperature shocks and economic growth: Evidence from the last half century." *American Economic Journal: Macroeconomics* 4, no. 3 (2012): 66-95.

[17] Elizabeth Kopits et al., "Economic Damages from Climate Change to U.S. Populations: Integrating Evidence from Recent Studies" *NCEE Working Paper*, no. 25-01 (2025).

[18] Dell, Melissa, Benjamin F. Jones, and Benjamin A. Olken. "What do we learn from the weather? The new climate-economy literature." *Journal of Economic literature* 52.3 (2014): 740-798;Carleton, Tamma A., and Solomon M. Hsiang. "Social and economic impacts of climate." *Science* 353.6304 (2016): aad9837; National Academies of Sciences, et al. *Valuing climate damages: Updating estimation of the social cost of carbon dioxide*. National Academies Press, 2017; Auffhammer, Maximilian. "Quantifying economic damages from climate change." *Journal of Economic Perspectives* 32.4 (2018): 33-52; Hogan, Dylan, and Wolfram Schlenker. "Empirical approaches to climate change impact quantification." *Handbook of the Economics of Climate Change*. Vol. 1. No. 1. North-Holland, 2024. 53-111.

[19] Howard, Peter H., and Thomas Sterner. "Methodology Matters: A Careful Meta-Analysis of Climate Damages." *Environmental and Resource Economics* (2025): 1-39; Howard, Peter Harrison, and Derek Sylvan. "Wisdom of the

experts: Using survey responses to address positive and normative uncertainties in climate-economic models." *Climatic Change* 162.2 (2020): 213-232.