RESOURCES *for the* FUTURE

The Economic Benefits of Achieving the Paris Agreement Goals

Issue Brief 23-08 by **Jordan Wingenroth**, **Brian C. Prest**, and **Kevin Rennert** — October 2023

1. Overview

The 2023 Global Stocktake (GST) that is scheduled to conclude at COP28 offers an opportunity to not only look back and measure progress toward the Paris Agreement goals but also look ahead and consider the benefits of achieving them. Estimating the economic benefits of reducing climate change requires a model that incorporates both socioeconomic and climatological elements, accounting for both the long-lived repercussions of near-term emissions and uncertainty in future emissions and temperature trajectories.

In this issue brief, we use the Greenhouse Gas Impact Value Estimator (GIVE) model (Rennert et al. 2022) to estimate the global economic benefits of limiting temperature rise to the Paris Agreement targets of 1.5°C and "well below" 2°C above preindustrial levels. We construct modified versions of the GIVE model that are calibrated to meet these targets, and we compare them to the baseline model, which combines estimates made by a panel of experts about future population, GDP, and emissions trajectories with a robust climate model to arrive at a central outcome of 2.5°C above preindustrial levels in 2100. This baseline reflects an estimate of anticipated future emissions pathways as of the date of the elicitation, which was conducted in 2021. This sets it apart from business-as-usual scenarios because it captures the benefits that experts estimated would be achieved with the knowledge that they possessed at the time.

We find that mitigation efforts that reduce expected warming from that scenario with a 2.5°C central temperature outcome to instead remain well below 2°C would generate cumulative expected economic benefits of $467 trillion in present value through 2300, equivalent to 1.5 percent of the cumulative expected present value of global GDP over the same time frame. In equivalent annual terms, this $467 trillion figure corresponds to $5.2 trillion in annual benefits. Holding the temperature increase to below 1.5°C would generate an additional $138 trillion, bringing the total benefits to $605 trillion or 2 percent of cumulative GDP. $605 trillion amounts to $6.8 trillion in equivalent annual terms.

These estimated benefits incorporate the societal impacts of climate change that research suggests are most significant, but many other impacts have yet to be accounted for. Furthermore, our estimates represent incremental benefits from increasingly ambitious scenarios, but even the baseline scenario reflects some of the progress made since the Paris Agreement was signed and how such progress influenced our expert panel's expectations for the future. For both of these reasons, our results should be understood as conservative estimates of the total benefits of achieving the agreement's goals.

2. Methods

The GIVE model features a detailed, probabilistic representation of uncertainty in future socioeconomic, emissions, and temperature trajectories and the resulting impacts on society in terms of human mortality, agricultural losses, energy use, and coastal effects of sea level rise. The model generates a set of 10,000 randomly sampled scenarios, each representing one possible future of country-level population and GDP, global greenhouse gas emissions, global mean surface temperature, and monetized climate damages. GIVE draws its population, GDP, and emissions scenarios from the Resources for the

Future Socioeconomic Projections (RFF-SPs) (Rennert et al. 2021), which are multicentury probabilistic projections of these variables. The RFF-SPs combine econometric and expert-elicitation methods to account for uncertainty about future technology and policy, as we describe in greater detail in a **previous issue brief** also submitted to the GST (Wingenroth et al. 2023).

To create modified versions of GIVE that reflect the Paris Agreement goals, we imposed an upper bound on the trajectories of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) annual emissions in the RFF-SPs. For both the 1.5°C and 2°C goals, we set the upper bound at the quantile that achieved the respective goal (1.5°C or 2°C) in 2100 with the respective probability (50 or 67 percent) indicated in the Sixth Assessment Report (AR6) (IPCC 2023). We used the same quantiles across all three gases and for all years covered by the model. In other words, we determined two different limits on greenhouse gas emissions: one that achieves exactly a two-thirds chance of staying below 2°C and another, more ambitious, scenario that has a 50 percent chance of staying below 1.5°C.

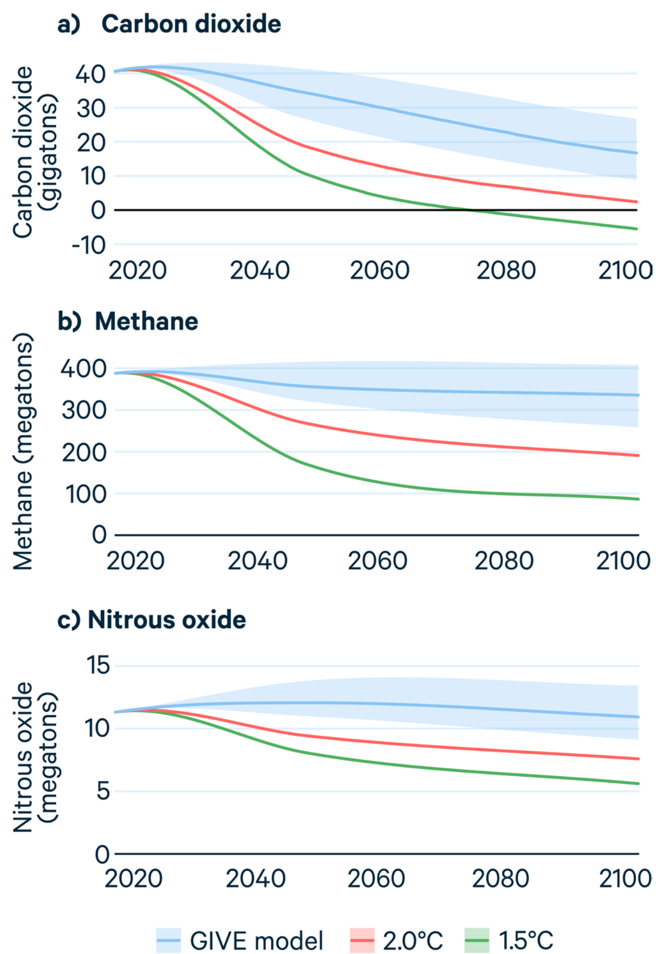
We then ran the baseline GIVE model and the two modified versions 10,000 times each, randomly sampling other variables tied to socioeconomics, the climate model, and the damage functions from GIVE's standard probability distributions. We maintained consistency between the three model configurations by setting the same seed for the random number generator used for sampling, thus isolating the benefits of reaching the Paris Agreement goals from the random variance in other factors. We excluded sea-level-rise damages from our estimates for technical reasons, but Rennert et al. (2022) demonstrates that this sector only contributes about 1 percent of the benefits of incremental emissions reductions, suggesting that its inclusion would only slightly increase our estimated benefits.

The GIVE model estimates climate damages for each year from 2020 to 2300, a time frame chosen in light of the long atmospheric residence time of CO_2 (NASEM 2017). To convert future climate damages into present-day values, we used GIVE's default, Ramsey-like discounting approach, which corresponds to a 2 percent annual near-term discount rate (Newell et al. 2022; Rennert et al. 2021).

3. Results

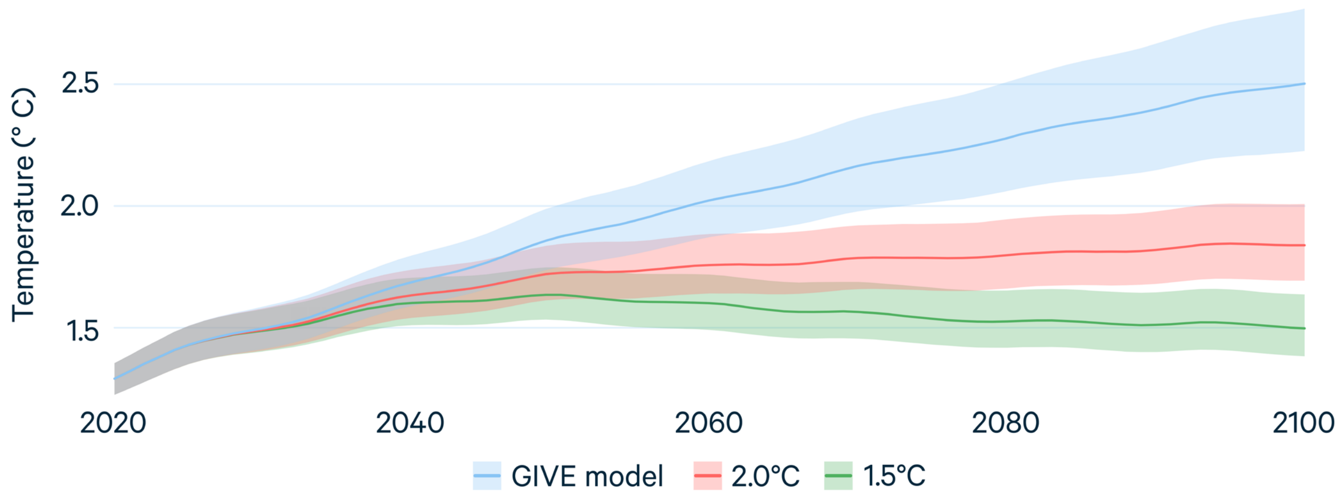
The central values from the unconstrained RFF-SPs suggest a gradual decline in annual CO_2 emissions (Figure 1), with the median of the dataset's 10,000 runs reaching half of present-day emissions in the last two decades of the twenty-first century. Annual CH_4 emissions are projected to decline much more slowly, with the median values staying well above 300 megatons (Mt) per year until 2100. N_2O emissions are not projected to decline meaningfully within the century.

Figure 1. Annual Global Net Emissions of Greenhouse Gases from the GIVE Model, Including Pathways for Reaching the 1.5°C and "Well Below" 2°C Paris Agreement Goals



Note: The solid lines represent medians and the shaded ranges 33–67 percent quantile ranges.

Figure 2. Global Surface Temperature Change Relative to 1850–1900 (°C) from the GIVE Model, Including Pathways for Reaching the 1.5°C and "Well Below" 2°C Paris Agreement Goals



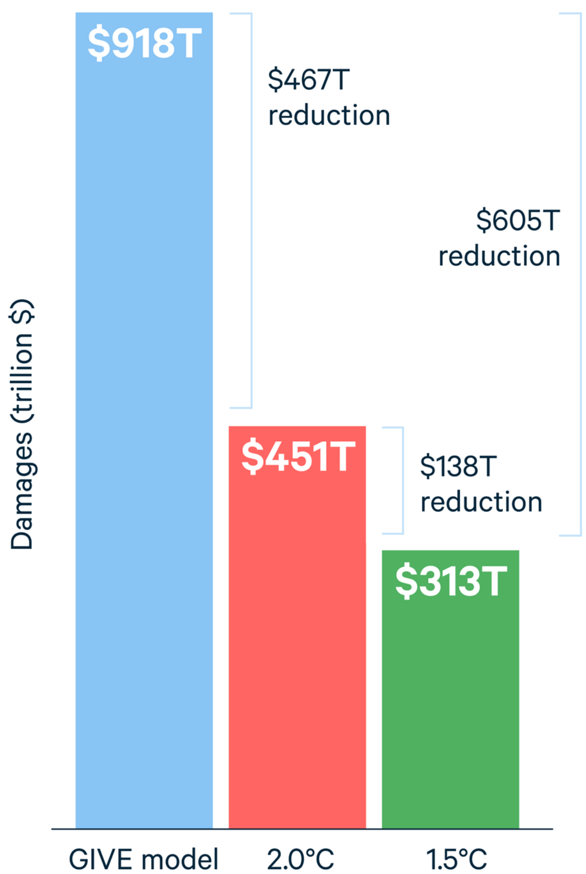
Note: The solid lines represent medians and the shaded ranges 33–67 percent quantile ranges.

The emissions trajectories necessary to reach the Paris Agreement goals are much more ambitious. The "well below" 2°C scenario, whose central values fall at the 18th percentile of the RFF-SPs, approaches net-zero global CO_2 emissions by the end of the century, with CH_4 emissions halved and N_2O emissions declining to less than eight Mt per year, about two-thirds of present-day levels. The 1.5°C scenario, with central values at the sixth percentile of the RFF-SPs, reaches net-zero global CO_2 emissions before 2080, cuts annual CH_4 emissions to 100 Mt per year by 2100—roughly a quarter of present-day emissions—and also halves annual N_2O emissions.

Figure 2 shows the resulting temperature pathways, with the solid lines representing median trajectories and shaded areas spanning the 33rd to 67th percentiles. The baseline GIVE model suggests a central outcome of 2.5°C above preindustrial levels in 2100, with a percentile range of 2.2–2.8°C. The "well below" 2°C scenario rises gradually, arriving at a two-thirds probability of remaining below 2°C in 2100 by construction. The median temperature pathway in this scenario reaches 1.8°C in 2100. As present-day global mean temperature rapidly approaches 1.5°C above preindustrial levels (Rohde 2023; WMO 2022), it becomes increasingly clear that reaching the corresponding Paris Agreement goal by the end of the century will require some degree of "overshoot." That is, although temperature rise will likely exceed the 1.5°C threshold, negative emissions could potentially be deployed to reverse course and meet the goal by 2100, as demonstrated by the negative emissions trajectories in the 1.5°C scenario in Figure 1 and the corresponding declining median temperature trajectory in Figure 2. The median value for this pathway returns to 1.5°C by 2100 after peaking above 1.6°C in 2050.

For the baseline GIVE model, more than $900 trillion of expected discounted climate damages are projected to accumulate between 2020 and 2300. Although this is a striking figure, the global GDP in 2022 alone was more than $100 trillion (IMF 2023; World Bank 2023). Applying the same discounting approach to future GDP estimates that we apply to damages, GIVE projects aggregate global climate impacts equivalent to a loss of 3 percent of expected cumulative discounted GDP. This estimate likely reflects a lower bound because it does not include other climate harms, such as biodiversity loss, decreased labor productivity, and wildfires.

Figure 3. Cumulative Expected Present Value of Total Climate Damages from the Baseline GIVE Model Through 2300, Along with Models That Follow the 1.5°C and "Well Below" 2°C Pathways



As shown in Figure 3, meeting the "well below" 2°C goal from the Paris Agreement would cut projected climate harms in half to $451 trillion, implying an estimated benefit of $467 trillion for achieving the 2°C Paris Agreement target. Both of those figures are equivalent to about 1.5 percent of expected cumulative discounted GDP. In equivalent annual terms, this $467 trillion figure corresponds to $5.2 trillion in benefits per year. Achieving the more ambitious 1.5°C goal would yield an additional $138 trillion of benefits, as mentioned, and would limit the cumulative expected present value of climate damages to effectively 1 percent of expected cumulative discounted GDP. $138 trillion corresponds to $1.6 trillion in equivalent annual terms.

4. Conclusion

Estimating the economic harms of climate change is a complex endeavor, given the innumerable ways in which the climate affects society at all levels, from individual health to global geopolitics. Nevertheless, a scientifically rigorous understanding of the monetized social benefits of following through on the ambitions of the Paris Agreement is key to informing climate policy actions. We show that relative to the path the world is currently expected to take, limiting temperature increases to the Paris Agreement goal of well below 2°C is expected to prevent about half of the climate damages from the sectors covered in our model, which demonstrates the substantial value of near-term cuts to greenhouse gas emissions.

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