LETTERS

Solar technology has increased the energy sector's low-cost potential, but challenges persist.

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Edited by **Jennifer Sills**

Accurately interpreting IPCC assessments

In their Policy Forum, "The costs of 'costless' climate mitigation" (1 December 2023, p. 1001), M. J. Kotchen *et al.* assert that the greenhouse gas mitigation potential identified by the Intergovernmental Panel on Climate Change (IPCC) in its latest assessment report is larger and cheaper than what is found in widely used cost-benefit–based (as opposed to process-based) integrated assessment models such as DICE, FUND, and PAGE. They suggest that the IPCC report underestimates the costs of mitigation by excluding hidden or nonmonetary costs in various sectors. Their criticism of the IPCC assessment is unfounded.

Kotchen *et al.* address the discrepancy between the mitigation potential curves based on various models by excluding options with "negative costs" from the cost curve derived from the IPCC data (first figure, bottom panel, in the Policy Forum). They justify the change by suggesting that the negative-cost options do not account for hidden costs. However, hidden costs have been extensively studied, and they have been quantified only to a small extent (*1*, *2*). There is no evidence that they can fully compensate for the negative costs. The focus in these studies was on energy efficiency options, which make up only part of the negative cost potential. Also, hidden costs can be reduced by adequate measures such as stimulating energy service providers (*3*). Assuming that such hidden costs are high would shift the marginal abatement cost curve a bit upward but not to the right, leaving a substantial discrepancy. In any case, because the uncertainties in the IPCC outcomes are substantial, the assessment leaves room for explanations other than unrecognized hidden costs.

Kotchen *et al.* say that they "are not aware of...efforts to cross-validate top-down mitigation cost assumptions with bottom-up empirical estimates." But mitigation potentials and their costs are highly dynamic, as demonstrated by comparing the findings of the 2022 IPCC assessment report (*4*) with the conclusions in the 2007 report (*5*). Over 15 years, the total mitigation potential has increased substantially, by 40 to 100%, even though the part of the potential that has already been implemented is omitted from the analysis.

The shifts vary between sectors. For the buildings sector, the low-cost potential has declined; if new buildings during the intervening 15 years were not built according to the best available technology, then their associated potential is foregone. For the energy supply sector, however, there is a massive increase of low-cost potential due to the rapid innovation of solar and wind technology.

New options have also entered the 2022 analysis, such as recycling and material efficiency, dietary changes, food loss prevention strategies, and modal shifts in transportation. Mitigation potentials, even for one specific year (2030) are changing over time, and overall mitigation potentials tend to increase and become cheaper.

Given the strong dynamics in mitigation potentials, the lack of cross-validation among various approaches implies that models such as DICE, FUND, and PAGE are, in their current form, not fit to be used as a tool for climate change cost-benefit analysis. Updating of these models is badly needed.

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Response

Blok *et al.* characterize our Policy Forum as an indictment of the Intergovernmental Panel on Climate Change's (IPCC's) estimates of mitigation costs, but that was not our intention. We agree with

Blok *et al.*'s call to continually update the economics-focused integrated assessment models. This action, along with more cross-validation between bottom-up and top-down approaches, is precisely the goal of the piece.

We disagree with Blok *et al.* that there is limited evidence showing hidden costs to mitigation activities. Given that the IPCC suggests that 16% of emissions reductions cost less than zero dollars, the fact that global emissions are not on track to decrease by anywhere near 16% by 2030, even with many policy interventions in place, serves as evidence of costly barriers (*1*). Moreover, the literature on the energy efficiency paradox, which we cite in our Policy Forum, is full of examples in which the direct cost savings of mitigation activities are overly optimistic. We are encouraged by work that diagnoses the source of estimated shortfalls in certain cases and also designs ways to overcome them (*2*, *3*).

We agree with Blok *et al.* that accounting for hidden costs would shift the marginal cost curve vertically. We proposed a leftward shift only to illustrate the source of the discrepancy between approaches rather than to identify the correct estimates. We did not mean to suggest that the actions that the IPCC treat as zero-cost abatement opportunities should be dismissed entirely, nor do we assert that this would address the discrepancy. However, the critical question is how much these actions cost when doing a full cost accounting. Blok *et al.* predict that costs will only shift "a bit upward," but we argue that more research should be conducted to answer this empirical question.

Blok *et al.* also suggest that the uncertainty in IPCC estimates leaves room for alternative explanations. We agree but question whether the IPCC is taking these uncertainties into account in its recommendations. For example, it is unclear whether the presented analysis warrants stating with "high confidence" that global emissions could decline by half in 2030 at a cost of $100 per tonne of CO_2 (*4*).

Blok *et al.* rightly note that mitigation costs change over time (*5*). Many such costs have declined substantially, particularly in the case of solar photovoltaics (*6*), but barriers still exist even in this example. Long-term contracts can lock in existing coal power plants (*7*), and the rate of return on investment in renewable sources of energy is lower than comparable alternatives (*8*).

We in no way minimize the potential of available mitigation options. Rather, we highlight behavioral, institutional, political, and other potential barriers to adoption to emphasize the need for policies that overcome them (*9*). For example, McKinsey & Company estimated that switching incandescent to LED light bulbs in residential areas (*10*) would pay for itself, but it took the US Energy Independence and Security Act of 2007 to institute light bulb efficiency standards to eliminate incandescent bulbs in the United States within 15 years (*11*).

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Design studies for clinical prediction

In their Research Article "Illusory generalizability of clinical prediction models" (12 January, p. 164), A. M. Chekroud *et al.* demonstrate that making robust and generalizable predictions in clinical contexts is difficult. Their results reveal flaws in the current strategy of applying artificial intelligence to prediction tasks. The reuse of existing data from randomized controlled trials and the lack of iterative model development hinder the ability of machine learning models to contribute in clinical settings.

Studies that were initially designed to answer fundamentally different questions (such as randomized controlled trials conducted to assess treatment efficacy) are only moderately suited to prediction analyses. Such studies lack the constructs relevant for prediction, focusing instead on sociodemographic and diagnostic information. Because they were not developed for a specific prediction use case, they are often designed to measure the maximum overall accuracy of prediction metrics, such as sensitivity and specificity, instead of allowing optimization depending on what is necessary for a particular application. PREACT, a prospective longitudinal naturalistic study in outpatient centers in Berlin, Germany, was designed for treatment outcome prediction, serving as an example of a study that may provide the basis for accurate machine learning predictions (*1*).

When a machine learning model achieves good results, researchers should work to optimize and further develop that existing model instead of starting from scratch and building a new model that then achieves results in the moderate range. Such studies, developed specifically for prediction, could start a process of slow but continuous improvement of clinical prediction models that will eventually lead to accurate, robust, and generalizable models for clinical practice.

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COMPETING INTERESTS

K.H. is a scientific adviser and has received virtual stock options for Mental Tech GmbH, which develops an artificial intelligence–based chatbot that provides mental health support.

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