POLICY FORUM

An automobile is filled with compressed natural gas in Karachi, Pakistan.

CLIMATE POLICY

Unmask temporal trade-offs in climate policy debates

Both 20- and 100-year time scales should always be reported

By **Ilissa B. Ocko,[1] Steven P. Hamburg,[1] Daniel J. Jacob,[2] David W. Keith,[2] Nathaniel O. Keohane,[1] Michael Oppenheimer,[3] Joseph D. Roy-Mayhew,[4] Daniel P. Schrag,[5] Stephen W. Pacala[6]**

Global warming potentials (GWPs) have become an essential element of climate policy and are built into legal structures that regulate greenhouse gas emissions. This is in spite of a well-known shortcoming: GWP hides trade-offs between short- and long-term policy objectives inside a single time scale of 100 or 20 years (*1*). The most common form, GWP_{100}, focuses on the climate impact of a pulse emission over 100 years, diluting near-term effects and misleadingly implying that short-lived climate pollutants exert forcings in the long-term, long after they are removed from the atmosphere (*2*). Meanwhile, GWP_{20} ignores climate effects after 20 years. We propose that these time scales be ubiquitously reported as an inseparable pair, much like systolic-diastolic blood pressure and city-highway vehicle fuel economy, to make the climate effect of using one or the other time scale explicit. Policy-makers often treat a GWP as a value-neutral measure, but the time-scale choice is central to achieving specific objectives (*2*–*4*).

Addressing climate change requires an understanding of the climate impacts of a diversity of pollutants with differing radiative effects and atmospheric lifetimes (*3*, *4*). GWPs have evolved as the default metric for this purpose, resistant to change despite decades of proposed alternatives (*1*, *2*, *5*, *6*). Because a GWP requires a single time horizon, it has been criticized as a poor metric for comparing impacts of short- and long-lived climate pollutants (*2*) and has prompted development of metrics that incorporate a range of time scales into a single value (*1*). However, when comparing regulations targeting two pollutants with different atmospheric lifetimes, such as carbon dioxide (CO_2) and methane, the trade-off between short- and long-term benefits is not only unavoidable but also at the heart of political and ethical choices (*7*).

Acknowledging the dominant role of GWP in the policy arena, our proposal abandons the quest for an alternative metric because there is a simpler way to prevent confusion and focus debate on the temporal trade-off: report GWPs based on the 20- and 100-year time scales together as an inseparable slashed pair. Regardless of whether 20 and 100 years are the most appropriate time horizons, they have evolved as defaults within the climate policy community, just as GWP is the default metric. Attempts to shift the community toward different time horizons would encounter the same resistance as switching metrics. Because 20- and 100-year time scales capture near- and long-term climate effects and because of the urgency of climate action, we believe that benefits of advocating different time horizons do not compensate for delays of implementation that continued wrangling could incur.

An example of our approach is as follows: Using GWP_{100}, a pulse of emissions from cars fueled by compressed natural gas (CNG) (see the photo) versus gasoline (*8*) emits 80 versus 89 kg CO_2e_{100} per unit energy, respectively (carbon dioxide equivalent, CO_2e, represents emissions weighted by GWP). Here, CNG appears better for the climate. If GWP_{20} is used, the same pulse of emissions yields 115 versus 95 kg CO_2e_{20} per unit energy, respectively. Here, gasoline appears better for the climate. Our reporting method would yield: "the CNG car emits 115/80 kg CO_2e per unit energy, the gasoline car emits 95/89 kg CO_2e per unit energy." This makes it clear that a shift from gasoline to CNG would create more short-term warming but less in the long-term. Although ethical considerations remain, the technical implications are transparent.

This convention can extend to other metrics should users choose different constructs (although we emphasize that GWP should also be used for consistency). For example, global temperature potential (GTP, the change in global mean surface temperature due to an emission relative to that by CO_2) is considered by some to be a superior metric to GWP, as it gives less weight to short-lived climate pollutants in the long-term (2, *5*, *6*, *9*), by focusing on temperature change at a specific point in time rather than radiative forcing averaged over a time period. The time horizon contrast is even starker with GTP; this makes the use of a two-valued approach an even greater imperative.

The two-valued strategy will provide much-needed clarity to climate policy analyses, which typically use only one time horizon and thus suffer from confusing and often misleading debates about policy trade-offs. Consider two gas-versus-coal studies with conflicting conclusions regarding climate benefits (*10*): Anti–shale gas advocacy often emphasizes GWP_{20}, whereas the pro–shale gas community emphasizes GWP_{100}. Similar contradictions have occurred in an analysis of diesel versus CNG buses (*11*). Advocates of vegan diets often emphasize GWP_{20} because it elevates the importance of methane emissions associated with livestock (*12*).

Although occasional reports reference both metrics [e.g., (*13*, *14*)], the lack of a standardized format means the two-valued approach has not become the norm. GWP_{100} users are not necessarily "supporters" of a 100-year time horizon but prefer the status quo. GWP_{20}

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users are indeed supporters of a shorter time horizon, because GWP_{100} dilutes the impact of short-lived pollutants. Requiring both time horizons should satisfy the latter community's concern that GWP_{20} has not received the same official imprimatur as GWP_{100} [i.e., in the United Nations Framework Convention on Climate Change (UNFCCC)].

The origination and acceptance of two-valued metrics in other fields reveals no major pushbacks. Default reporting of systolic-diastolic blood pressure and city-highway fuel economy quickly became norms once a clear case was made for the importance and incompleteness of each measure in the pair by itself and once the measure was adopted by a collection of influential and diverse first users. Widespread adoption of a two-valued GWP would be facilitated by working with editorial boards of key scientific journals, scientific societies, and the Intergovernmental Panel on Climate Change to encourage use in the scientific literature, and with the U.S. Environmental Protection Agency, UN Environmental Programme, and UNFCCC to recommend use in reports. A two-valued convention would improve decision-making by turning short-term versus long-term into short-term and long-term. ■

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CLIMATE POLICY

A climate policy pathway for near- and long-term benefits

Climate actions can advance sustainable development

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The Paris Climate Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) explicitly links the world's long-term climate and near-term sustainable development and poverty eradication agendas. Urgent action is needed, but there are many paths toward the agreement's long-term, end-of-century, 1.5° to 2°C climate target. We propose that reducing short-lived climate pollutants (SLCPs) enough to slow projected global warming by 0.5°C over the next 25 years be adopted as a near-term goal, with many potential benefits toward achieving Sustainable Development Goals (SDGs). As countries' climate commitments are formally adopted under the agreement and they prepare for its 2018 stocktaking, there is a need for them to pledge and report progress toward reductions not just in CO_2 but in the full range of greenhouse gases (GHGs) and black carbon (BC) (plus co-emissions) in order to track progress toward long-term goals.

Climate changes over the next few decades will limit the ability of human and natural systems to adapt. This is especially problematic for the poorest populations, which are particularly vulnerable. Additionally, impacts such as sea-level rise and glacier melting are influenced by cumulative heat uptake, and many impacts may be nonlinear.

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Given these challenges, reductions in emissions of SLCPs, including methane and BC—the second and third most important warming agents after CO_2 (*1*)—can provide near-term climate benefits while CO_2 emission reductions are implemented for long-term stabilization. Without reductions in both CO_2 and SLCPs, temperature increases are likely to exceed 1.5°C during the 2030s and exceed 2°C by mid-century (*2–4*).

Many actions to reduce near-term warming by mitigating SLCPs inextricably link to human and ecosystem health, development, and sustainability benefits (*2*, *3*). For example, providing 3 billion of the world's poorest people access to modern forms of energy could eliminate the large health burden from household BC-related air pollution. Reducing methane emissions (see the photo) will help reverse the trend of increasing background levels of health- and crop-damaging tropospheric ozone. Transitioning to climate-friendly alternatives to hydrofluorocarbons (HFCs) in combination with improved energy efficiency can reduce both CO_2 and co-emitted air pollutants.

> *"...ambitious SCLP [short-lived climate pollutant] and CO_2 policies can go hand in hand."*

If limiting long-term peak temperature change were the sole objective, SLCP reductions could be implemented much later with only a modest penalty (*3*). The case for urgency comes from the fact that early mitigation of SLCPs helps to meet SDGs and, within the goal of climate action, (i) reduces damages due to climate change over the next few decades, including those dependent upon the pace of climate change such as biodiversity losses; (ii) slows amplifying feedbacks, such as snow-and-ice albedo that are highly sensitive to BC; (iii) reduces the risk of potential nonlinear changes, such as release of carbon from permafrost or ice-sheet collapse; (iv) increases the probability of staying below 2°C through mid-century (*2*, *3*); (v) reduces long-term cumulative climate impacts; (vi) reduces costs of meeting temperature targets relative to late SLCP mitigation (*5*), and (vii) stimulates progress toward the long-term 2°C target through achievement of near-term benefits (*6*).

A near-term goal provides a way to incor-

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