Curbing emissions: cap and rate

STEFFEN KALLBEKKEN, NATHAN RIVE, GLEN P. PETERS AND JAN S. FUGLESTVEDT

Climate policy should aim to limit the rate of warming, as well as setting a cap on total allowable emissions.

One of the challenges central to climate policy is agreeing on an appropriate timetable for reducing greenhouse gas emissions. Some scientists have argued recently that rather than focusing on the amount of carbon being emitted incrementally, decision makers should instead place a cap on the total carbon released into the atmosphere over the long term.

The argument is that if we are to limit global warming caused by carbon dioxide emissions to less than 2 °C, widely regarded as representing dangerous climate change, we need to restrict total emissions to less (and possibly much less) than one trillion tonnes of carbon[1]. Without mitigation, we could reach this limit in 40 years. Focusing policy on a long-term target, however, provides limited guidance for mitigation on the timescale of decades[2], and as acknowledged by its proponents[3], may tempt decision makers to delay emissions reductions.

Failure to start curbing emissions soon comes with substantial risks, however. It would inevitably require more substantial mitigation in later decades[4], which could prove to be technologically or politically unfeasible. It could also result in rapid warming at a rate above that which would allow ecosystems, plants and animals to migrate or adapt[5], thus violating a core objective of the United Nations Framework Convention on Climate Change — that mitigation should take place in a timeframe sufficient to enable adaptation.

TARGET PRACTICE

Here we propose that, in addition to a cumulative emissions budget, a maximum limit on the rate of warming should also be considered as an element in the design of climate policies. A rate-based target could be implemented in many ways, but we argue that it can be effectively achieved by setting a supplementary cumulative emissions budget for the period 2010–2030. With a few notable exceptions[6], there has been very little focus on the rate of climate change outside of studies on the impacts on ecosystems, and very few proposals on targets for limiting this rate.

The German Advisory Council on Global Change has proposed that a warming rate of more than 0.2 °C per decade is intolerable[7]. Some studies suggest that ecosystems cannot adapt to a rate of change faster than 0.05–0.1 °C per decade[8], so a more stringent target could be considered. But given that we are already committed to warming of around 0.2 °C per decade even with constant (year 2005) emissions[9], a more stringent target would likely be unfeasible. As such, we adopt the rate of 0.2 °C per decade.

Taking this as an illustrative example of the maximum allowable rate, we performed an analysis of alternative mitigation scenarios to 2250 in a simple climate model to determine the cumulative emissions budget for 2010–2030, assuming a climate sensitivity of 3 °C (Fig. 1). We calculate that in order to avoid a rate of change above 0.2 °C per decade in the short term, cumulative emissions in the period 2010–2030 must not exceed approximately 190 gigatonnes of carbon (GtC). The exact budget for carbon, of course, will also depend on the levels of the non-CO_2 components in the atmosphere, such as methane, sulphur dioxide, and black carbon, but here we only show carbon dioxide emissions as this is relevant to the existing proposal for a cumulative emissions budget.

The cumulative target of 190 GtC for the period 2010–2030 is equal to an average of 9.5 GtC per year, compared to global

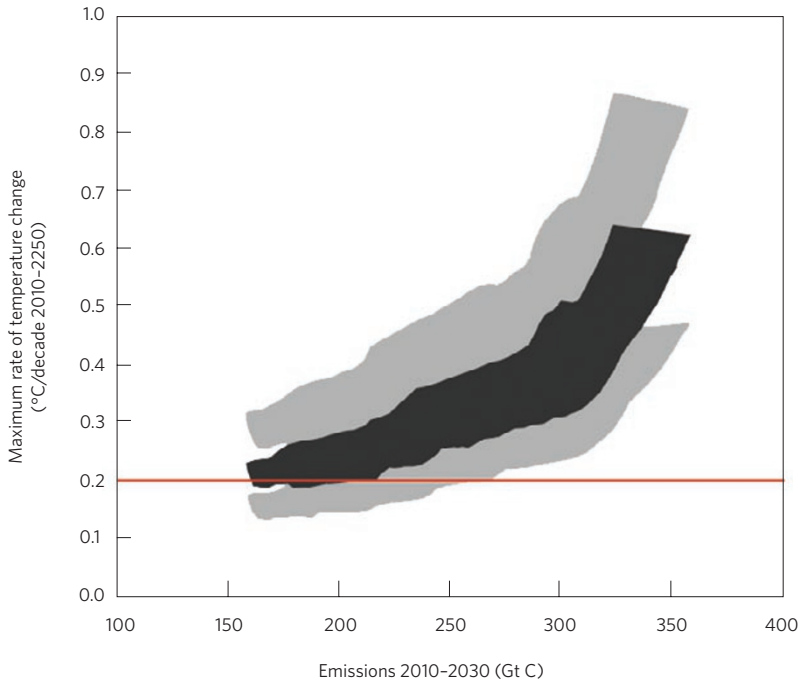

Figure 1 The rationale for rating change. The maximum rate of temperature change is strongly associated with cumulative emissions 2010–2030.The darker shading represents model simulations with the best-estimate climate sensitivity (3 °C). The lighter shading shows the range for the 68 per cent cumulative probability interval for climate sensitivity from the literature (2.0–4.9 °C).

emissions of 9.9 GtC in 2008[10]. Taking the 190 GtC budget for 2010–2030 within the context of an overall one-trillion-tonne budget suggests that only about 300 GtC are available for post-2030 emissions, given that humans have already released around 500 GtC into the atmosphere in the past quarter century.

An alternative policy approach to limiting the rate of warming would be to focus on reducing short-lived atmospheric components. This may have a limited effect on long-term temperature change, however, since these components have atmospheric lifetimes in the order of days, in the case of black carbon, or a decade, in the case of methane. By focusing on CO_2, which has an impact over centuries or longer, our proposed mitigation strategy has the benefit of limiting the rate of warming in the short term, as well as addressing long-term temperature change.

RAPID RESPONSE

There are many important benefits to adopting a maximum rate of temperature change as a supplement to a cumulative carbon budget. A short-term target provides much clearer guidance for mitigation over the next two decades than a long-term temperature target or a cumulative emissions budget. Adherence to this target would ultimately result in a more feasible mitigation strategy over the long term. A short-term focus would also increase the likelihood of ecosystems and species adapting to climate change.

Additionally, a climate policy with a focus on the maximum rate of temperature rise would enable easier inclusion of potent short-lived warming agents, thus allowing for rapid mitigation in the short term through a broader set of components than those regulated under the Kyoto Protocol. Reducing some of these short-lived components, such as black carbon, would have the added bonus of bringing substantial co-benefits to human health.[11] Short-term targets provide useful and necessary guidance for policymakers on how to limit warming in the short term, while at the same time keeping the focus on what matters in the long term: reducing CO_2 emissions.

Published online: 19 November 2009

doi: 10.1038/climate.2009.121

References

1. Allen, M. R. *et al. Nature* **458**, 1163-1166 (2009).
2. Rive, N. A., A. Torvanger, T. Berntsen, S. Kallbekken *Clim. Change* **82,** 373-391 (2007).
3. Allen, M. R. *et al. Nature Rep. Clim. Change* **3,** 56-58 (2009).
4. Kallbekken. S. & Rive, N. *Clim. Change* **82**, 27-45 (2007).
5. Hare, W. *Assessment of Knowledge on Impacts of Climate Change – Contribution to the Specification of Art. 2 of the UNFCCC* (WBGU, Berlin, 2003); http://www.wbgu.de/wbgu_sn2003_ex01.pdf
6. O'Neill, B. C.& Oppenheimer, M. *Proc. Nat. Acad. Sci. USA* **101,** 16411-16416 (2004).
7. WBGU. *Climate Protection Strategies for the 21st Century: Kyoto and Beyond* (WBGU, Berlin, 2003); http://www.wbgu.de/wbgu_sn2003_engl.pdf
8. Warren, R. in *Avoiding dangerous climate change* (eds. Schellnhyber, H. J., Cramer, W., Nakicenovic, N., Wigley, T. & Yohe, G.) 93-131 (Cambridge University Press, Cambridge, 2005).
9. Hare, B. & M. Meinshausen, *Clim. Change* **75**, 111-149 (2006).
10. Le Quéré, C. *et al. Nat. Geoscience* doi: 10.1038/ngeo689 (in the press).
11. Rypdal, K. *et al. Tellus B* **61,** 625-641 (2009).

Steffen Kallbekken, Nathan Rive, Glen P. Peters and Jan S. Fuglestvedt are based at the Center for International Climate and Environmental Research (CICERO) in Oslo, Norway.
e-mail: steffen.kallbekken@cicero.uio.no