commentary

Duality in climate science

Kevin Anderson

Delivery of palatable 2 °C mitigation scenarios depends on speculative negative emissions or changing the past. Scientists must make their assumptions transparent and defensible, however politically uncomfortable the conclusions.

In July, Paris hosted 'Our Common Future Under Climate Change', a key conference organized as a prelude to the political negotiations scheduled for December 2015, also in Paris. In the conference summary that immediately followed, the scientific committee noted that limiting "warming to less than 2 °C" is "economically feasible" and "cost effective"[1]. The statement chimed with the press release that accompanied the Synthesis Report published by the Intergovernmental Panel on Climate Change (IPCC) last November, in which IPCC representatives suggested that "to keep a good chance of staying below 2 °C, and at manageable costs, our emissions should drop by 40–70 per cent globally between 2010 and 2050, falling to zero or below by 2100"[2], and that mitigation costs would be so low that "global economic growth would not be strongly affected"[2].

If these up-beat — and largely uncontested — headlines are to be believed, reducing emissions in line with a reasonable-to-good chance of meeting the 2 °C target requires an accelerated evolution away from fossil fuels; it does not, however, necessitate a revolutionary transition in how we use and produce energy. Such conclusions are forthcoming from many Integrated Assessment Models, which are key tools for informing policy makers of alternative climate change futures. In these models, prices, markets and human behaviour are brought together with the physics of climate change to generate 'policy-relevant' and cost-optimized emission scenarios that typically offer highly optimistic views of the future. However, these positive outcomes are delivered through unrealistically early peaks in global emissions[3], or through the large-scale rollout of speculative technologies intended to remove CO_2 from the atmosphere[3,4], yielding so-called negative emissions.

In stark contrast, I conclude that the carbon budgets associated with a 2 °C threshold demand profound and immediate changes to the consumption and production of energy. According to the IPCC's Synthesis Report, no more than 1,000 billion tonnes (1,000 Gt) of CO_2 can be emitted between 2011 and 2100 for a 66% chance (or better) of remaining below 2 °C of warming (over preindustrial times)[5]. Without resorting to 'changing the past', or making the leap of faith that substantial amounts of CO_2 can be removed from the atmosphere in the coming decades, the IPCC's 1,000 Gt budget requires an end to all carbon emissions from the energy system by 2050 — five decades earlier than the IPCC headline suggests.


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Geo-engineering as systemic bias

In most Integrated Assessment Models, 2 °C carbon budgets are effectively increased through the adoption of negative-emission technologies. These technologies are currently at little more than a conceptual stage of development, yet are ubiquitous within 2 °C scenarios. Nowhere is this more evident than in the IPCC's scenario database[6]. Of the 400 scenarios that have a 50% or better chance of no more than 2 °C warming (with three scenarios removed due to incomplete data), 344 assume the successful and large-scale uptake of negative-emission technologies. Even more worryingly, in all 56 scenarios without negative emissions, global emissions peak around 2010, which is contrary to available emissions data[7].

In plain language, the complete set of 400 IPCC scenarios for a 50% or better chance of meeting the 2 °C target work on the basis of either an ability to change the past, or the successful and large-scale uptake of negative-emission technologies. A significant proportion of the scenarios are dependent on both.

Reality check

Building on the concept of carbon budgets[8–10], I present an alternative line of reasoning that suggests a radically different challenge to that dominating the current discourse on climate change.

As the IPCC reiterates (in section 2.1 of ref. 5), it is cumulative emissions of CO_2 that matter in determining the global mean surface warming out to 2100. Specifically, and as noted earlier, the IPCC's Synthesis Report concludes that no more than 1,000 Gt of CO_2 can be emitted between

2011 and 2100 for a 66% chance, or better, of remaining below a 2 °C rise[5].

However, between 2011 and 2014 CO_2 emissions from energy production alone amounted to about 140 Gt of CO_2 (ref. 7). To limit warming to no more than 2 °C, the remaining 860 Gt of CO_2 (out to 2100) must be apportioned between the three principal emission sources: energy, deforestation and cement production (for cement, I count process CO_2 only; energy-related cement emissions are accounted for in total energy CO_2).

Assuming concerted efforts to reduce emissions from all three sources, I base deforestation and land-use change emissions for the period 2011–2100 on RCP4.5 (http://go.nature.com/dDeAWk), the IPCC's most ambitious deforestation pathway to exclude net-negative land-use emissions. I therefore adopt a highly optimistic total deforestation budget of about 60 Gt of CO_2.

Process emissions from cement production must be considered separately. Industrialization throughout poorer nations and the construction of low-carbon infrastructures within industrialized nations will continue to drive rapid growth in process emissions, which currently run at about 7% per year (R. Andrew, personal communication and ref. 11). Although lower-carbon alternatives such as carbon capture and storage and the prudent use of cement may reduce some of this early growth (R. Andrew, personal communication and ref. 11), in the longer term these emissions must be eliminated entirely. A provisional analysis, building on the latest process-emission trends (personal communications from both K. West and R. Andrew, and refs 11,12), suggests process emissions from cement production could be constrained to around 150 Gt of CO_2 from 2011 to their eradication later in the century.

Consequently, the remaining budget for energy-only emissions over the period 2015–2100, for a 'likely' chance of staying below 2 °C, is about 650 Gt of CO_2.

Unpalatable repercussions

A carbon budget this tight suggests a profoundly more challenging timeframe and rate of mitigation than that typically asserted by many within the scientific community. It demands a dramatic reversal of current trends in energy consumption and emissions growth: more than a fifth of the remaining budget has been emitted in just the past four years. To avoid exceeding 650 Gt, global mitigation rates must rapidly ratchet up to around 10% per year by 2025, continuing at such a rate towards the virtual elimination of CO_2 from the energy system by 2050.

The severity of such cuts would probably exclude the use of fossil fuels, even with carbon capture and storage (CCS), as a dominant post-2050 energy source. Only if the life cycle carbon emissions of CCS could be reduced by an order of magnitude from those postulated for an efficiently operating gas-CCS power station (typically around 80 g CO_2 per kilowatt-hour[13]), could fossil fuels play any significant role beyond 2050.

Delivering on such a 2 °C emission pathway cannot be reconciled with the repeated high-level claims that in transitioning to a low-carbon energy system "global economic growth would not be strongly affected"[2]. Certainly it would be inappropriate to sacrifice improvements in the welfare of the global poor, including those within wealthier nations, for the sake of reducing carbon emissions.

But this only puts greater pressure on the lifestyles of the relatively small proportion of the globe's population with higher emissions — pressure that cannot be massaged away through incremental escapism. With economic growth of 3% per year, the reduction in carbon intensity of global gross domestic product would need to be nearer 13% per year; higher still for wealthier industrialized nations, and higher yet again for those individuals with well above average carbon footprints (whether in industrial or industrializing nations).

A candid assessment

The IPCC's Synthesis Report and the scientific framing of the mitigation challenge in terms of carbon budgets are important steps forward. As scientists, we must now leverage the clarity gained by the budget concept to combat the almost global-scale cognitive dissonance in acknowledging its quantitative implications. Yet, so far, we simply have not been prepared to accept the revolutionary implications of our own findings, and even when we do we are reluctant to voice such thoughts openly.

Instead, my long-standing engagement with many colleagues in science leaves me in no doubt that although they work diligently, often against a backdrop of organized scepticism, many are ultimately choosing to censor their own research.

Explicit and quantitative carbon budgets provide a firm foundation on which policy makers and civil society can build a genuine low-carbon society. But the job of scientists remains pivotal. It is incumbent on our community to communicate our research clearly and candidly to those delivering on the climate goals established by civil society; to draw attention to inconsistencies, misunderstandings and deliberate abuse of the scientific research.

It is not our job to be politically expedient with our analysis or to curry favour with our funders. Whether our conclusions are liked or not is irrelevant. Yet, as we evoke a *deus ex machina* (such as speculative negative emissions or changing the past) to ensure our analyses conform with today's political and economic hegemony, we do society a grave disservice — the repercussions of which will be irreversible. ❐

Kevin Anderson is at the Tyndall Centre for Climate Change Research, University of Manchester, Pariser Building, Sackville Street, Manchester M13 9PL, UK.
e-mail: kevin.anderson@manchester.ac.uk

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