On the duality of climate scientists:

… how integrated assessment models are hard-wired to deliver politically palatable outcomes

Kevin Anderson October 2015

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The value of science is undermined when we adopt questionable assumptions and fine-tune our analysis to conform to dominant political and economic sensibilities. The pervasive inclusion of speculative negative emission technologies to deliver politically palatable 2°C mitigation is but one such example. Society needs scientists to make transparent and reasoned assumptions, however uncomfortable the subsequent conclusions may be for the politics of the day.

June's UNFCCC Bonn Conference reiterated the headline 'conclusions' of November's IPCC Synthesis Report, which itself was heralded as delivering clear messages to policy makers. As the *Financial Times*[1] noted, meeting the 2°C dangerous 'limit' would "only cause an annual 0.06 percentage point cut in … economic growth", a small cost that would, according to the UK's Guardian, rise by less than 50% even if emissions reductions were delayed to 2030[2]. In similar optimistic vein, The *US Associated Press*[3] and *Hindustan Times*[4] reported that maintaining "the temperature rise below a level that many consider dangerous" may require emissions from fossil fuels "to drop to zero", but not before "the end of this century". *The Sydney Morning Herald*[5] concluded that staying below 2°C would require "a fairly strong level of action on greenhouse gas emissions" with, *ChinaDaily*[6] reporting that in delivering the requisite action "the solutions are many and allow for continued economic and human development."

Based on such reports it is easy to be left with the impression that the shift away from fossil fuels needs to be much more an evolutionary transition than an immediate revolution in how we use and produce energy. Moreover, it could be suggested that delaying action until 2030 would give more time for considered reflection of the options, yet still only have a very marginal impact on economic growth (i.e. less than a 0.1 percentage point cut) - not a bad exchange perhaps?

In stark contrast, this commentary concludes that the carbon budgets needed for a reasonable probability of avoiding the 2°C characterisation of dangerous climate change demand profound and immediate changes to the consumption and production of energy. The IPCC's own 1,000 $GtCO_2$ carbon budget for a "likely" chance of 2°C, requires global reductions in emissions from energy of at least 10% p.a. by 2025, with complete cessation of all carbon dioxide emissions from the energy system by 2050.

Diluting the message

Whilst the endeavours of the IPCC, since its inception in 1988, are to be welcomed, I have grave reservations as to how the implications of their analysis are being reported. This is not solely the failure of incisive journalism, but is also the outcome of repeated and questionable commentary from some experts engaged in the IPCC process. Even the press release[7] for the IPCC's Synthesis report provided an optimistic spin, with the then IPCC chair stating that "To keep a good chance of staying below 2ºC, and at *manageable costs*, our emissions should drop by 40 to 70 percent globally between 2010 and 2050, falling to zero *or below* by 2100"[emphasis added]. Moreover, the Co-Chair of the IPCC's section on reducing emissions made the all-important comment that mitigation costs would be so low that "global economic growth would not be strongly affected" - echoing the conclusion of the recent and influential report from *The New Climate Economy*[8].

But does the IPCC's own analysis support the upbeat rhetoric of evolution as opposed to the more challenging and fundamental language of revolution?

Certainly such evolutionary conclusions are forthcoming from many highly complex integrated assessment models (IAMs) - whereby an understanding of prices, markets and human behaviour is brought together with the physics of climate change to generate 'policy-relevant' and cost-optimised emission scenarios. These typically offer highly optimistic futures through a combination of very early peaks in global emissions and a belief that negative emission technologies will prove practically and economically viable in removing CO_2 from the atmosphere (hence the reference to "or below" zero emissions in Pachauri's earlier statement).

'Geo-engineering' as systemic bias

The analysis within this Commentary makes no allowance for carbon budgets being increased through the adoption of 'geo-engineering' technologies, specifically those delivering so-called negative emissions. Such technologies are ubiquitous in 2°C scenarios[9,10], despite their remaining at little more than the conceptual stage of development. However, whilst speculative negative emissions are *de rigueur*, similarly imprecise Earth system processes (but with the potential to *reduce* the available budgets) are seldom included in quantitative scenarios. The relative importance of negative emissions and Earth-system processes for the size of the available carbon budget varies across the spectrum of temperatures being considered. Yet until both can be adequately and robustly quantified their widespread inclusion within quantitative emissions pathways should be avoided. A small suite of 2°C scenarios may, of course, assume the successful uptake of negative emissions (or further positive feedbacks), but such scenarios should be in the minority and not dominate the outputs from across the IAM community.

As it stands, the expedient and ubiquitous use of speculative negative emissions to expand the available 2°C carbon budgets, implies a deeply entrenched and systemic bias in favour of delivering politically palatable rather than scientifically balanced emission scenarios. Nowhere is this more evident than in the IPCC's scenario database[11]. Of the 113 scenarios with a "likely" chance (66% or better) of 2°C (with 3 removed due to incomplete data), 107 (95%) assume the successful and large-scale uptake of negative emission technologies. The remaining 6 scenarios all adopt a global emissions peak of around 2010. Extending the probability to a 50% chance of 2°C paints a similar picture. Of the additional 287 scenarios, 237 (83%) include negative emissions, with all the remaining scenarios assuming the successful implementation of a stringent and global mitigation regime in 2010.

In plain language, the complete set of 400 IPCC scenarios for a 50% or better chance of 2°C assume either an ability to travel back in time or the successful and large-scale uptake of speculative negative emission technologies. A significant proportion of the scenarios are dependent on both 'time travel *and* geo-engineering'.

An arithmetic sense check

With IAM outputs typically clustering around evolutionary rather than revolutionary rates of change, there is clearly merit in undertaking some basic arithmetic to sense-check the model outputs, the consequent framing of policies, and the timeframes for delivering deep cuts in emissions. Building on the concept of carbon budgets[12-14] the following steps summarise a sequence of reasoning and transparent assumptions that suggest a profoundly different challenge to that dominating the current discourse on climate change.

1) From the Copenhagen Accord[12] in 2009 to the New York Climate Summit in 2014 political leaders have repeatedly reaffirmed their commitment to take the necessary action, informed by science[15,16] to "hold the increase in global temperature below 2 degrees Celsius"[15].

2) The IPCC's Synthesis Report reiterates their previous conclusion that "Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond"[17].

3) The Report proposes a headline carbon budget of 1,000 billion tonnes of carbon dioxide (1000 $GtCO_2$) for the period 2011 to 2100 and for a 66% chance, or better, of remaining below a 2°C rise[18].

4) Energy-only CO_2 between 2011and 2014 inclusive has totalled around 140$GtCO_2$.

5) To apportion the remaining 860 billion tonnes between the principal sources of CO_2 emissions, i.e. energy, deforestation, and cement (process only), it is necessary to understand their relevant contexts. In a world genuinely committed to not exceeding the 2°C budget, it is reasonable to assume there exists a concerted effort to reduce emissions across all three emission sources.

6) Against this backdrop, deforestation and land use change emissions for 2011-2100 are based on RCP4.5[19], the IPCC's most ambitious deforestation pathway to exclude net-negative land use emissions. The total deforestation budget is therefore taken as ~60$GtCO_2$.

7) Turning to cement, whilst energy-related emissions are included here in total energy CO_2, the substantial *process* emissions are not and so need to be considered separately. Industrialisation throughout poorer nations and the construction of low-carbon infrastructures within industrialised nations will continue to drive rapid growth in the process emissions from cement production (current ~7% p.a.[20]). An aggressive uptake of lower-carbon alternatives (including CCS) and more prudent use of cement could reduce some of this early growth,[21,22] but in the longer term, such emissions will need to be eliminated. Provisional and highly optimistic analysis building on recent process emission trends,[20,23] suggests such emissions could

be constrained to around 150 $GtCO_2$ from 2011 to their eradication later in the century.

8) Consequently, the remaining budget for energy-only emissions, for the period 2015 to 2100 and for a "likely" chance of staying below 2°C, is ~650 $GtCO_2$.

9) The political and physical inertia of the existing system will likely see emissions continue to rise until ~2020. Assuming there is an unparalleled agreement at Paris and energy-only emissions of CO_2 reach a 2020 peak of ~37 $GtCO_2$, a little under 180 $GtCO_2$ will have been emitted between the start of 2015 and 2020, leaving a post 2020 budget of ~470 $GtCO_2$.

10) This would demand a dramatic reversal of current trends in energy consumption and emissions growth. Global mitigation rates would need to rapidly ratchet up to around 10% p.a. by 2025 and continue at such a rate to the virtual elimination of CO_2 from the energy system by 2050.

Unpalatable repercussions

Applying simple arithmetic to the headline data within the IPCC's Synthesis Report raises fundamental questions as to the realism of both the content and the tone of much of the reporting that followed its publication. Moreover, the failure of the scientific community to vociferously counter the portrayal of the findings as challenging but incremental suggests vested interests and the economic hegemony may be preventing scientific openness and freedom of expression.

The carbon budgets aligned with international commitments to stay below the 2°C characterization of dangerous climate change demand profound and immediate changes to how energy is both used and produced. The IPCC's headline budget of 1,000 $GtCO_2$, even with highly optimistic assumptions on curtailing deforestation and cement emissions, requires global reductions in energy-CO_2 of at least 10% p.a. from 2025, transitioning rapidly to zero emissions by 2050. The severity of such cuts would likely exclude carbon capture and storage (CCS) as a dominant post-2050 technology. 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 plant (typically around 80g CO_2 per kWh[24]), could fossil fuels play any significant role post-2050.

Delivering on such a 2°C emission pathway cannot be reconciled with the repeated and high-level claims that in transitioning to a low-carbon energy system "global economic growth would not be strongly affected"[7]. 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 still on the relatively small proportion of the globe's population with higher emissions. The strains that such 2°C mitigation puts on the framing of our lifestyles cannot be massaged away through incremental escapism. With a growing economy of 3% p.a. the reduction in carbon intensity of global GDP would need to be nearer 13% p.a.; higher still for wealthier industrialized nations, and higher yet again for those individuals with well above average carbon footprints (whether in industrial or industrialising nations).

Conclusions

The IPCC's synthesis report and the scientific framing of the mitigation challenge in terms of carbon budgets was an important step forward. Despite this, there remains an almost global-scale cognitive dissonance with regards to acknowledging the quantitative implications of the analysis, including by many of those contributing to its development. We simply are not 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 scientific colleagues, leaves me in no doubt that whilst they work diligently, often against a backdrop of organised 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 genuinely low-carbon society. But the job of scientists remains pivotal. It is incumbent on our community to be vigilant in guiding the policy process within 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. As we massage the assumptions of our analysis to fit within today's political and economic hegemony, so we do society a grave disservice - one for which the repercussions will be irreversible.

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