

CARBON BUDGETS FOR 1.5 & 2°C

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SUMMARY

- IPCC carbon budgets underestimate current and future warming, omit important climate system feedback mechanisms, and make dangerous assumptions about risk-management.
- 1.5°C of warming is likely by 2030 or earlier, a product of past emissions.
- There is no carbon budget for the 1.5°C goal; such “budgets” rely on overshoot, with unrealistic reliance on speculative technologies.
- The current level of greenhouse gases is enough for around 2°C of warming, or more.
- 2°C of warming is far from safe, and may trigger the “Hothouse Earth” scenario.
- There is no carbon budget for 2°C if a sensible risk-management approach is taken.
- Even accepting the IPCC carbon budget for 2°C at face value, emissions need to be zero before 2030 for developed countries with higher per capita emissions.

“The high-profile cumulative carbon quota concept carries several and significant uncertainties, many of which are not fully appreciated, and these limit the political usefulness of the quota concept”... uncertainties about quotas “remain persistently large, questioning the direct applicability of the carbon budget quota concept to policy”. — Glen Peters

Peters, 2016, *Nature Climate Change* 6:646–649.

1. NO CARBON BUDGET FOR 1.5°C

- **Warming trend of 1.5°C is likely by 2030 or earlier** (Jacob et al, 2020, *Earth's Future* 6:264-285; Xu et al, 2018, *Nature*, 5 December; Henley and King, 2017, *Geophysical Research Letters* 44:4256-4262). The most recent climate models show 1.5°C by 2025-27, regardless of the emissions path (Tebaldi et al, 2020, *Earth System Dynamics*, 16 September, pre-print). Reaching 1.5°C by 2030 would be a decade ahead of IPCC projections (Xu et al, 2018, *Nature*, 5 December).
- **There is no budget for 1.5°C:** Michael E Mann says of the carbon budget: "And what about 1.5°C stabilization? We're already **overdrawn**" (Mann, 2015, *Huffington Post*, 23 December). "No scenarios that have a high probability of limiting warming to below the 1.5°C limit during the entire twenty-first century exist in the literature" (Rogelj et al, 2015, *Nature Climate Change* 5:519-527).
- **Overshoot:** Published 1.5°C emissions-reduction scenarios involve significantly "overshooting" (exceeding) the target for several decades before returning to the target figure by 2100. The more damaging impacts, and risk of triggering non-linear events, associated with a higher level of warming for several decades in overshoot scenarios, are understated or ignored.
- **Carbon budgets for 1.5°C are highly speculative** and assume unrealistically large amounts of drawdown in the second half of the century using BECCS, a technology unproven at scale and cost (Anderson & Peters, 2016, *Science* 354:182-183).

Summary: 1.5°C of warming is likely by 2030 or earlier, irrespective of any action taken in the interim. This is a product of past emissions, and will occur regardless of the emissions path over the next decade. There is no carbon budget for 1.5°C.

1.5°C case studies

- **The IPCC Fifth Assessment Report** Working Group 1 Synthesis report (Table 2.2) shows a carbon budget for 1.5°C of 400 gigatonne (GT) carbon dioxide (CO₂) for the period 2011-2100 (66% chance of success). Emissions for the period 2011-2019 exceeded 400 GT CO₂, so the budget reduced to zero by 2020.
- **The 2018 IPCC Special Report** on *Global Warming of 1.5°C* increased the 1.5°C budget by **underestimating the warming to date by around 0.2°C**, and using an estimate of climate sensitivity — the TCRE or transient climate response — which **underestimates warming at system equilibrium**. This created the illusion of a budget when none existed. "We are closer to the 1.5°C and 2°C thresholds than they [the IPCC] indicate and our available carbon budget... is considerably smaller than they imply... they paint an overly rosy scenario by ignoring some relevant literature," said Michael E Mann (Waldman, 2018, 'New climate report actually understates threat, some researchers argue', *Science*, 12 October).

2. AEROSOLS MASK DANGEROUS WARMING

- **Reduced aerosols:** Current warming is ~1.2°C but another 0.5°C or more is masked by short-lived cooling aerosols (Samset et al, 2018, *Geophysical Research Letters* 45:1020-1029). A by-product of burning fossil fuels, sulfate aerosols have a strong cooling impact and have been masking some of the warming so far. As fossil fuel use declines, so does the aerosol cooling, so that **for the next two decades lower emissions will not ameliorate the warming trend** (Samset et al, 2018, *Geophysical Research Letters* 45:1020-1029).
- **The Earth has already passed several tipping points:** for coral reefs, Arctic sea ice and some Antarctic glaciers. Further tipping points could be triggered at low levels of global warming and a cluster of abrupt shifts could occur between 1.5°C and 2°C (Lenton et al, 2020, *Nature* 575:592-595). The IPCC has identified a number of "Reasons for concern" including "Large-scale singular events", which may include tipping points for major Earth-system elements — such as polar ice sheets, permafrost, boreal forests and the Amazon — which could trigger irreversible, self-sustaining warming. The risk of such "singular events" is assessed as "moderate" between 1.5-2°C.
- **Global temperature is on track for 3–5°C of warming by 2100** and the temperature increase is still on the high-emissions RCP8.5 path. RCP8.5 is also the best match to mid-century under current and stated policies (Schwalm et al, 2020, *Proc. Natl. Acad. Sci.* 117:19656-19657).
- **2°C may trigger a "Hothouse Earth" scenario** in which climate system feedback mechanisms and their mutual interaction drive the Earth System climate to a point of no return, whereby further warming would become self-sustaining (Steffen et al, 2018, *Proc. Natl. Acad. Sci.* 115:8252-8259).

Summary: The world is likely entering a period of accelerated warming, and reducing emissions will have little or no effect on that trend for the next 20-25 years. The imminence of further tipping points makes this a wicked problem, because 2°C is far from safe.

3. ZERO EMISSIONS BEFORE 2030 FOR 2°C TARGET

- **The world needs to be at zero emissions by 2030** for the 2°C target, based on three assumptions: 1. Mitigation expenditure no more than 3% of GDP; 2. No geoengineering; 3. Climate sensitivity is not low (Lamontagne et al, 2019, *Nature Climate Change*, 9:290–294).
- **Budgets need to be at zero before 2030 for European countries.** Bringing together the IPCC's carbon budgets for a likely chance of 2°C with the equity steer of Paris, a carbon budget for developed nations is 95 to 136 billion tonnes of CO₂ from 2020. For the UK, this range is 7-9 years (based on 2018 emissions data), with Sweden's range being 6-8 years (Anderson & Stoddard, 2020, *The Ecologist*, 8 June).
- **Double-digit annual mitigation rates are required of developed countries.** Without a belief in the successful deployment of planetary scale negative emissions technologies, double-digit annual mitigation rates are required of developed countries, from 2020, if they are to align their policies with the Paris Agreement's temperature commitments and principles of equity (Anderson et al, 2019, *Climate Policy* 10:1290-13040).

Summary: For developed nations, emissions need to be at zero by 2030 or earlier; and there is a strong case of that applying to the whole world.

4. CURRENT GREENHOUSE GAS LEVEL ENOUGH FOR 2°C OR MORE

- **The Earth energy imbalance is 0.6–0.75°C** (von Schuckmann et al, 2020, *Earth System Science Data* 12:2013–2041). Added to the 1.2°C of warming so far, expected warming is 1.8–1.95°C for the current level of greenhouse gases.
- **The warming for the level of greenhouse gases in 2019 may be greater than 2°C**, using CMIP6 models (Huntingford et al, 2020, *Climatic Change* 162:1515–1520).

Summary: If the current level of greenhouse gases is enough for 2°C of warming, how can there be a substantial carbon budget for this goal?

5. IPCC OVERESTIMATES CARBON BUDGET

- **The IPCC underestimates current warming by 0.3°C**. This halves carbon budget for 2°C (Schurer et al, 2018, *Nature Geoscience*, 11, 220-221)
- **Climate models exclude important system feedbacks**. Until now, climate models used for projecting future warming and calculating carbon budgets in IPCC reports estimate a warming sensitivity of ~3°C (for doubled CO₂), which excludes factors such as “slow” feedbacks (carbon stores, such as permafrost) and albedo changes (reflectivity). “The danger of omitting these big risks [feedbacks] is that policymakers underestimate the scale and urgency of the situation,” says Bob Ward of the Grantham Research Institute on Climate Change (Waldman, 2018, ‘New climate report actually understates threat, some researchers argue’, *Science*, 12 October). Carbon-cycle feedbacks could result in up to 25% more warming than in the main IPCC projections. (Hausfather & Betts, 2020, ‘How ‘carbon-cycle feedbacks’ could make global warming worse’, *Carbon Brief*, 14 April). When the full risks are included, warming may be as high as 5–6°C for a doubling of CO₂ for a range of climate states between glacial conditions and ice-free Antarctica (Hansen et al, 2008, *Open Atmospheric Science Journal* 2:217-231; Palaeosens Project Members, 2012, *Nature* 491:683–69).
- **Permafrost feedback reduces carbon budget**. Accounting for permafrost releases, the median remaining budget for the 2°C target reduces by 8% (1–25%) if the target is avoided and net negative emissions prove feasible, by 13% (2–34%) if they do not prove feasible, by 16% (3–44%) if the target is overshoot by 0.5°C and by 25% (5–63%) if it is overshoot by 1°C. For the 1.5°C target, reductions in the median remaining budget range from ~10% to more than 100% (Gasser et al, 2018, *Nature Geoscience* 11:830–835).
- **Models underestimating warming**. The models that best capture current conditions (the “observationally informed” predictions) produce 15% more warming by 2100 than the IPCC suggests, hence reducing the “carbon budget” by around 15% for the 2°C target (Brown & Caldeira, 2017, *Nature* 552:45-50).

Summary: The IPCC carbon budgets overestimate the carbon budget and are not a reliable foundation for policy-making.

6. IPCC CARBON BUDGETS HAVE UNACCEPTABLE RISK OF FAILURE

- **Poor risk management:** IPCC carbon budgets are often associated with a 50 or 66% chance of staying below the target, that is, a one-in-two, or one-in-three, chance of failure, for example in the IPCC *Fifth Assessment Report* and the 2018 Special Report on *Global Warming of 1.5°C*. We would never accept those risks of failures in our own lives. Why accept them for impacts which may destroy civilisation as we know it?
- **The “fat tail” risk is underestimated.** A model that predicts 2°C of warming has an approximately 10% chance of 4°C (based on Wagner & Weitzman, 2015, *Climate Shock: The economic consequences of a hotter planet*, Princeton NJ, Princeton University Press). Likewise, scenarios with a 50% chance of not exceeding the 1.5°C target have a 33% chance of exceeding 2°C of warming, and a 10% chance of exceeding 3°C of warming. Such risks are unacceptable.
- **There is no carbon budget for the 2°C target** if a prudent risk-management approach is taken, with attention given to the high-damage, high-end possibilities rather than middle-of-the-road probabilities (Spratt, 2015, *Recount: It's time to do the math again*, Breakthrough, Melbourne).
- **Climate change is an existential risk** to human civilisation, that is, to contemporary society (Lenton et al, 2020, *Nature* 575:592-595).
- **This requires special precautions** beyond conventional risk management practice if the increased likelihood of “fat tail” (high end) risks are to be adequately dealt with. The IPCC carbon budgets do not do this (Spratt and Dunlop, 2018, *What Lies Beneath*, Breakthrough, Melbourne).
- **Precautionary action must be taken** to ensure that tipping points with catastrophic outcomes are not triggered. This emphasises the importance of reaching net zero emissions by 2030.

Summary: The IPCC carbon budgets are reckless in their approach to risk. If a prudent risk-management approach is taken, there is no carbon budget for the 2°C goal. This further emphasises the importance of reaching net zero emissions before 2030.

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