

# What is left in the global carbon budget?

## ARC Centre of Excellence for Climate Extremes Briefing Note 16

- The Paris Agreement requires countries to commit to reducing their greenhouse gas emissions to ensure that the global average temperature remains well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C.
- It is too late to limit warming to 1.5°C with certainty; but, in theory, there is a chance. Achieving net zero emissions before the end of 2027 gives an 83% chance of limiting warming to 1.5°C but is almost certainly not practical<sup>1</sup>.
- It is not too late to limit warming to 2.0°C. At current emission rates the carbon budget will be exhausted in 21 years. This implies achieving net zero emissions by around 2040 for an 83% chance of limiting warming to 2°C but a 17% risk of failing to limit warming to 2°C.
- Net zero emissions by 2050 is almost certainly too slow to limit warming to 2°C with a high degree of probability unless most of the reduction in emissions is achieved in the next decade.

Many of you will have heard that we have about 500 billion tonnes left in the global carbon budget. This is the amount of carbon dioxide humans can release into the atmosphere and still avoid 1.5°C. It is about 1350 billion tonnes to avoid 2°C of warming. These numbers come from the new report by the Intergovernmental Panel on Climate Change (IPCC)<sup>2</sup>. They compare with present global emissions of around 40 billion tonnes per year.

Two things keep being forgotten. First, the budget is calculated from the beginning of 2020 and so the budget at the time of writing in mid-2021 is smaller due to emissions over past 18 months, and, second, that these two numbers are the budgets that give us a 50% chance of avoiding those warming limits. At current emission rates, this means the total carbon budget will be exhausted in about 11 years for the 1.5°C limit, and roughly 32 years for the 2°C warming limit.

You may have missed a critical point here. These are the carbon budgets that give you a **50% chance**—a toss of a coin chance—of avoiding exceeding those temperature changes. Is a 50% chance of achieving the Paris agreement adequate? Remember, the Paris agreement limit of 2°C is not a 'target' or 'ambition', it is a legislated *limit* of warming and we have agreed not to exceed it.

So, how lucky do you feel? The IPCC gives the equivalent carbon budgets, as at January 2020, for an 83% chance of avoiding 1.5°C or 2°C of warming (Table 1). To avoid exceeding 1.5°C, the budget reduces to 300 billion tonnes (used up in 6 years from now at current emission rates) and the 2°C limit reduces to 900 billion tonnes (used up in 21 years from now at current emission rates).

You might feel that a 17% risk of failing to meet these targets is too high. We expect our vaccines to be safe and many people are hesitant where there is a 1 in 100,000 risk of bad side effects. We expect an even higher level of safety in our aeroplanes – a 1 in a million risk of a crash at Heathrow implies roughly one crash every four years. If we impose a limit on global warming of 2°C and accept a 1 in 100,000 risk of exceeding it, how much carbon is left to burn?

Well, it's difficult to calculate this because there are a great many uncertainties. However, first of all, the budget is lower and effectively zero for the 1.5°C limit. There may be some time left for 2°C but this requires we start deeply cutting emissions immediately.

Warming target (relative to 1850-1900)	IPCC estimates of carbon budgets and years before the carbon budget is fully spent at current emission rates	
	50% chance	83% chance
1.5°C	500 GtCO <sub>2</sub> (11 years)	300 GtCO <sub>2</sub> (6 years)
2°C	1350 GtCO <sub>2</sub> (32 years)	900 GtCO <sub>2</sub> (21 years)

Table 1: IPCC estimates of the remaining carbon budget for a given chance of limiting warming to a given warming target, as at the beginning of 2020 (GtCO<sub>2</sub>) and years before the carbon budget is fully spent (from July 2021) at current emission rates.

You will hear a lot about 'net zero by 2050'. Well, if you want certainty – certainty like 'my aeroplane won't crash', or 'my vaccine is safe' – it is too late to avoid 1.5°C and **'net zero by 2050' is too late to avoid 2°C with certainty**. Our climate system is not fussed whether that is difficult or politically inconvenient. We are in this position because governments around the world did not react to the science appropriately following the release of previous IPCC reports in 1995, 2001, 2007, 2013, or even when a special report on the benefits of limiting warming to 1.5 degrees was released in 2018<sup>3</sup>.

Perhaps 1.5°C does not sound too bad to you despite the observed increases in the intensity, frequency and magnitude of many extreme events with warming that has already occurred (1.1°C). Global warming of 1.5°C has extremely serious consequences. As was stated in 2018, pursuing 'policies that are considered to be consistent with the 1.5°C aim will not completely remove the risk of global temperatures being much higher or of some regional extremes reaching dangerous levels for ecosystems and societies over the coming decades'<sup>4</sup>. However, the consequences of warming nearer 1.5°C are much less damaging than those of warming of 2°C or more.

The recent IPCC report highlights many risks that are much worse at warming levels higher than 1.5°C. The negative impacts from climate extremes increase, and the risk of triggering a tipping point in the climate system increases. Tipping points are large, irreversible changes to the climate system, usually associated with catastrophic consequences. Examples include the ultimate collapse of the West Antarctic Ice Sheet, leading to multiple metres of sea-level rise, and a loss of Arctic permafrost, leading to massive releases of

methane into the atmosphere and accelerated global warming. The precise amount of warming required to trigger tipping points is highly uncertain and the risk of triggering some tipping points may be mitigated if the temperature of the globe exceeds 1.5°C for only a short period of time<sup>5</sup>. However, recent research suggests that tipping points associated with irreversible loss of ice from the West Antarctic Ice Sheet, loss of summer sea ice in the Arctic and the destruction of coral reef ecosystems, including the Great Barrier Reef, could be triggered with warming of around 1.5°C to 2°C above the preindustrial temperature.

*Andy Pitman and Ian Macadam, 17<sup>th</sup> August 2021*

## References

- 1 - Can we limit global warming to 1.5°C? ARC Centre of Excellence for Climate Extremes Briefing Note 15. <https://climateextremes.org.au/briefing-note-15-can-we-limit-global-warming-to-1-5c/>
- 2 - Intergovernmental Panel on Climate Change (2021). Climate Change 2021: The Physical Science Basis. <https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/>
- 3 - Intergovernmental Panel on Climate Change (2018). Special Report on Global Warming of 1.5°C. <http://ipcc.ch/report/sr15/>
- 4 - Seneviratne et al. (2018). The many possible climates from the Paris Agreement's aim of 1.5 °C warming. Nature. <https://doi.org/10.1038/s41586-018-0181-4>
- 5 - Ritchie et al. (2021). Overshooting tipping point thresholds in a changing climate. Nature. <https://doi.org/10.1038/s41586-021-03263-2>

## Contacts

ARC Centre of Excellence for  
Climate Extremes science contact:  
Prof Andy Pitman, UNSW Sydney  
[a.pitman@unsw.edu.au](mailto:a.pitman@unsw.edu.au)

ARC Centre of Excellence for  
Climate Extremes knowledge broker:  
Dr Ian Macadam, UNSW Sydney  
[i.macadam@unsw.edu.au](mailto:i.macadam@unsw.edu.au)