



Presidential Climate Action Project

Questions and Answers Emissions Reductions Needed to Stabilize Climate

by Susan Joy Hassol, for the Presidential Climate Action Project

1. How much can the atmosphere's temperature rise from its current level before we cross the threshold into dangerous climate change?

What exactly constitutes “dangerous human interference with the climate system” is somewhat subject to interpretation. Many analysts think we have already crossed into “dangerous” territory and that what we must now seek to avoid is truly catastrophic climate change. The European Union and many scientific bodies have concluded that avoiding the most severe outcomes will require keeping the total global average warming to no more than 2°C/3.5°F relative to pre-industrial levels (about 1.1°C/2°F above present levels).

While remaining below this threshold does not guarantee avoidance of significant adverse impacts, if we exceed it, impacts are projected to become much more severe, widespread, and irreversible, and we are likely to cross more dangerous thresholds in the climate system that could trigger large-scale catastrophic events. Some have suggested (Hansen et al., 2006) that principal criteria for defining “dangerous” should include sea level rise and extinction of species, as these are effects that could not be reversed on timescales relevant to humanity.

Also note that a global average rise of 2°C/3.5°F means that the center of large continents, including North America, will see temperature increases about twice this large, with even larger increases in the Polar Regions. For further details, see IPCC 2007, Working Groups 1 and 2 reports.

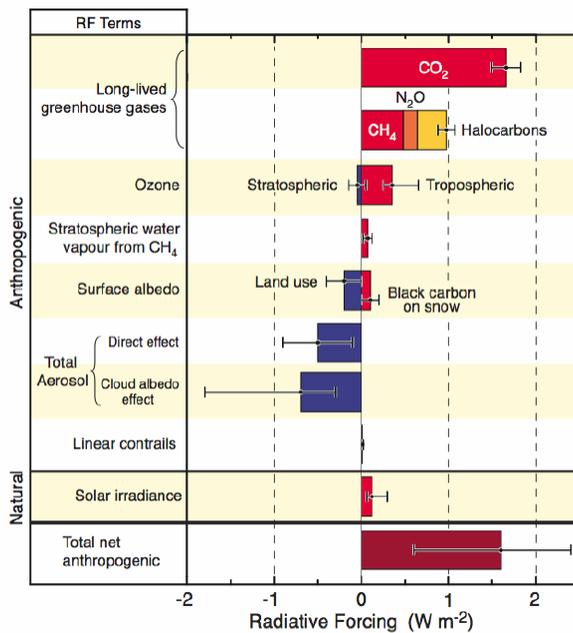
2. What limits must be put on atmospheric concentrations of CO₂ (and CO_{2e}) to stay below that temperature?

To have a good chance (not a guarantee) of avoiding temperatures above those levels, atmospheric concentrations of carbon dioxide would need to peak below about 400 to 450 ppm and stabilize in the long-term at around today's levels. There is not one precise number because the sensitivity of the climate system to greenhouse gases is not known precisely; different models show slightly different outcomes within this range. At the same time, concentrations of the other greenhouse gases including methane, nitrous oxide, soot, and halocarbons also would have to be stabilized at low enough levels to keep global temperatures below the level at which catastrophic impacts would proliferate. When these other gases are added to the calculus, including the offsetting cooling effects of some other compounds (discussed further below), analyses suggest that stabilizing concentrations below about 400 CO₂e would give us about an 80% chance of avoiding crossing the 2°C/3.5°F threshold.

Currently, the atmospheric CO₂ concentration stands at 382 ppm and is increasing by about 2 ppm per year, though this varies somewhat from year to year. The current total influence of human produced emissions (what might be referred to as CO₂ equivalent or CO₂e) is roughly the same as that of CO₂ alone because the non-CO₂ greenhouse gases (methane, nitrous oxide, etc.) roughly balance and cancel out the cooling influence of other human-produced emissions such as sulfate particulates that scientists call "aerosols" (not to be confused with aerosol sprays) (see Figure below; note that CO₂ forcing and total human forcing are roughly equal at present). Some analyses include only the influences of the long-lived greenhouse gases in their CO₂e calculus, leaving out the offsetting cooling effect of the aerosols, and thus estimate the current CO₂e forcing to be 455 ppm. One reason some analysts do not include the offsetting effects of the aerosols is that they have short atmospheric lifetimes, unlike the long-lived greenhouse gases.

While 450 ppm CO₂ is a reasonable target that has been widely accepted, it is not really a precise point below which we are "safe" and above which we are in "dangerous" territory; it's more like a continuum. The lower the level at which we can stabilize concentrations, the better, because the higher the level, the more climatic thresholds we are likely to cross and the more severe the impacts will become. Thus, an inability to achieve any particular target is no reason to give up.

However, before deciding, for example, that stabilizing at 550 ppm is the best we can do, we should recognize that if we do choose that level, we'd most likely exceed the 2°C/3.5°F threshold. Furthermore, in addition to having only about a 15% chance of staying below the temperature threshold, we'd also have about the same chance of exceeding a much higher temperature level of about 4.5°C/8.1°F if we stabilized concentrations at 550 ppm CO₂e (see Meinshausen, 2006 for more details).



Source: IPCC, 2007, WG 1 Figure SPM-2

3. What is the relationship between CO₂ and CO_{2e}?

There is not a simple answer as CO₂ and CO_{2e} are expected to change at different rates because the concentration of each gas changes at its own rate depending upon emissions; thus there is no consistent formula to convert one to the other. At present, the two are roughly equal because the warming effects of the non-CO₂ greenhouse gases (methane, nitrous oxide, soot, halocarbons, etc.) roughly equal and thus cancel out the cooling effects of the sulfate aerosols and other cooling influences.

This can be confusing because different analyses handle CO_{2e} differently. For example, the methodology of the Stern Review of the Economics of Climate Change (2006) added in the warming influence of methane and nitrous oxide to that of CO₂ to come up with their estimate of a present concentration of 430 ppm CO_{2e}. They did not include greenhouse gases other than those three, and did not include the offsetting cooling effect of aerosols. Others, using the total net forcing, consider current CO_{2e} to be roughly the same as that of CO₂, that is, about 380 ppm.

Under scenarios that assume no explicit climate policy, like the IPCC Special Report on Emissions Scenarios (SRES), the current rough equality between CO₂ and CO_{2e} is expected to change because the cooling aerosols are projected to remain constant or decrease (as scrubbers are increasingly used on coal plants to reduce smog and acid rain) while the non-CO₂ greenhouse gases that add to warming are projected to increase. Thus, by the middle of the century, under these scenarios, CO_{2e} (including both the warming

effect of non-CO₂ greenhouse gases and the cooling effect of sulfate aerosols, etc.) would be some 50-100 ppm higher than CO₂ only. On the other hand, it is also possible that the non-CO₂ greenhouse gases could be controlled (just as CO₂ could be controlled) so they do not grow as projected, so how this plays out is entirely dependent on human decisions.

4. How much and how fast do industrialized and developing countries need to reduce emissions in order to meet this temperature target?

In order to stabilize CO₂ concentrations at about 450 ppm by 2050, global emissions would have to decline by about 60% by 2050. Industrialized countries greenhouse gas emissions would have to decline by about 80% by 2050.

One way of doing this, proposed recently in a study by scientists at Duke University's Nicholas School, would be for the G8 countries to decrease emissions by an average of 2% per year starting in 2011, using 2010 as a baseline, for 40 years, resulting in an 80% reduction by 2050. In addition, the five largest developing countries (China, India, Brazil, South Africa, and Mexico) would begin a similar program ten years later, reducing their emissions by 2% a year starting in 2021, using 2020 as a baseline, and the rest of the world would have to stabilize emissions between 2030 and 2050.

Around mid century, most other nations would also have to begin reducing emissions and/or the initial G8+5 would have to make greater reductions, in order to maintain the CO₂ concentration at or below 450 ppm. In addition, we would have to reduce emissions of the non-CO₂ greenhouse gases (methane, nitrous oxide, soot, halocarbons, etc.) sufficiently to keep the temperature below the threshold discussed above. If we did not reduce those gases as well, their warming effect would take us above the target temperature discussed above.

An analysis by Meinshausen shows that the achievement of long-term stabilization at 400 or 450 ppm CO₂e will imply a temporary peaking of CO₂e concentrations at higher levels, for example, peaking at 475 ppm and then stabilizing at 400 ppm roughly a century later. Following such a path would result in about a 75% chance of keeping the temperature rise below the 2°C/3.5°F target. However, as noted in the Stern Review, overshooting paths generally involve greater climatic risks than if the stabilization level were approached from below. In addition, overshooting paths require that, following the peak, emissions be reduced to extremely low levels, below the level of natural carbon absorption, which may prove to be very difficult. However, the only option for achieving the lower stabilization levels (400 ppm CO₂e and below) in the long-term is to temporarily overshoot concentrations (not temperatures).

5. What is the estimated cost of such a reduction plan?

The Intergovernmental Panel on Climate Change reported in 2007 that an emissions reduction scenario similar to that described here would result in an estimated reduction in *cumulative* global GDP of about 3% by 2030. This is equivalent to a reduction in global annual GDP growth of 0.12%. Applying this to the U.S. economy would mean that

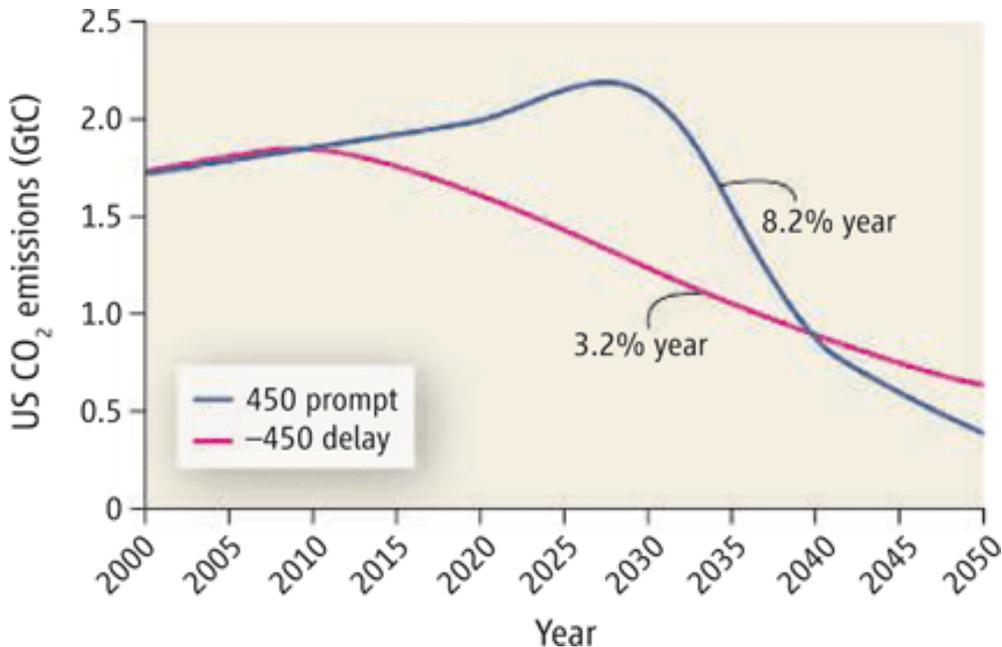
instead of growing at 3.2% per year, as it has for the past two years, it would grow at 3.08%. So the bottom line is that it would not unduly affect economic growth. In fact, as the Stern Review and other studies make clear, the costs of *not* urgently embarking on an aggressive emissions reduction program would be *much* greater than the costs of undertaking one. The Stern review concludes that “the benefits of strong, early action considerably outweigh the costs.”

Note that the IPCC findings rely on models that incorporate the best information currently available to estimate the cost of reducing heat-trapping gases. Real-world costs will depend on many variables, such as how the tax and trading systems are structured and how revenues are spent. Investing revenues from carbon taxes or auctioned permits from a carbon trading system back into the economy would lower costs. A reduction in public health costs and other benefits would offset and thus also lower costs. Omitting some regions, sectors, heat-trapping gases, technologies, or policy options would raise costs. In particular, it should be noted that these types of studies do not accurately foresee how technological innovation can reduce projected costs. Past experience in the U.S. demonstrates that various air pollution control measures have turned out to be much less costly than originally projected because the pace of technological innovation had been underestimated.

6. What would be the effect of delay on our ability to achieve the target and on the cost of doing so?

Any delay will make a large difference in the annual rate of emissions reductions required to meet the target. A delay of global action by 10 years would nearly double the required rate of emissions reduction in 2025, greatly increasing costs. As an illustration, the example below from Doniger et al., 2006 compares two pathways for U.S. emissions reductions consistent with a 450 ppm target, one begun promptly and one delayed:

A slow start leads to a crash finish. Prompt-start and delay pathways consistent with stabilizing heat-trapping gases at 450 ppm CO₂ equivalent. Global emissions 2000-2100 are 480 gigatons carbon (GtC) from Meinshausen's S450Ce scenario. The U.S. share of global emissions is assumed to decline from 25% to 5% linearly between 2000 and 2100. This results in an emissions budget of 84 GtC in the 21st century. In the prompt-start case, emissions decline by 1.5% per year from 2010 to 2020, 2.5% per year from 2020 to 2030, and 3.2% per year thereafter. The delay case assumes that emissions grow by 0.7% per year from 2010 to 2030, a reduction of 0.5% annually compared with the Energy Information Admin. forecast; emissions must then decline by 8.2% per year thereafter to limit cumulative 21st-century emissions to 84 GtC. Cumulative emissions 2000-2050 are 68 GtC in the prompt-start scenario and 79 GtC in the slow-start scenario.



Note: The key is mislabeled in the graphic. The red curve is prompt and blue is delay

7. Are the goals of holding CO₂ to 450 ppm and 2°C still credible and achievable?

Yes. But there is no time to waste. If we delay action by even a few years, the rate of reduction needed to achieve these goals would then have to be beyond anything achieved historically and could be very costly, making it practically unachievable.

8. Who are the scientists and scientific institutions that subscribe to those goals as the threshold of dangerous climate change?

Essentially all scientific bodies that have taken a stand have agreed with this goal. Some leading researchers, for example, James Hansen of NASA, argue for a slightly lower allowable level of temperature rise, no more than 1°C from current levels. The work of Malte Meinshausen, which has synthesized many studies on climate sensitivities, has concluded that we would need to stabilize at about 400 ppm CO₂e (including all forcings) in order to be *likely* to avoid exceeding the 2°C threshold (even at that stabilization target, there is still about a 20% chance of exceeding the temperature target).

9. Everyone seems in agreement that developed nations need to reduce carbon emissions 80% below 1990 levels by 2050. What goals are needed for 2030 and what is the scientific foundation for the answer?

There is not a simple answer because there is some flexibility in how much emissions are reduced in any given year. What is essential is to begin immediately, as delay will be costly, both economically, and in terms of achieving the climate stabilization goals. There are various pathways to get there, some involving sharper earlier cuts than others. Because energy efficiency provides the cheapest, easiest cuts at present, there should be a good deal of low-hanging fruit, especially in the U.S. where there is so much room for

improvement in this regard. Thus, early inexpensive cuts should be relatively easy and cuts should get harder after those are exhausted. On the other hand, as non-carbon energy technology options are further developed, cuts may well become easier in the future.

10. Many leaders in the U.S. climate-action community stress that our emission reductions should be front-end-loaded – that we should achieve high, early reductions. Let's consider the strategy you outline under Question 4 above – that developed nations would reduce emissions an average of 2% annually between 2010 and 2020, and the five major developing countries would begin reducing their emissions in 2021 at a rate of 2% each year compared to their 2020 emission levels. While 2% annual reductions are nice and neat, they don't fulfill the requirement that cuts be front-end loaded. What should PCAP propose instead -- again on a strong scientific and economic footing? Can we go above 2% annually without damaging the economy?

It would seem to make sense to propose 2% annual reductions as the minimum targets and shoot for more, since the lower and earlier emissions peak, the slower the rate of emissions reductions that will have to be achieved later and the less severe the impacts of climate change will be. It may be possible to exceed 2% annual reductions without damage to the economy if it is done right, with economically efficient policies. This is true because energy efficiency improvements actually save money, and creating a new, low-carbon energy system will have many benefits, like jobs growth and investment, that will offset costs, particularly if one takes a longer term, bigger picture view of the economy. If appropriate, effective, and efficient policies are put in place, economic costs can be minimized and benefits maximized.

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