

## Myth: Carbon dioxide lasts 25 to 100 years in the atmosphere.

Moore and Braswell, in *Global Biogeochemical Cycles*, Global Biogeochemical Cycles, 1994 considers the average lifetime of carbon dioxide in the atmosphere to be 31 years.

The IPCC 2001 Technical report estimates the lifetime of CO<sub>2</sub> in the atmosphere to be 5 to 200 years.

*Table 1: Examples of greenhouse gases that are affected by human activities. [Based upon Chapter 3 and Table 4.1]*

	CO <sub>2</sub> (Carbon Dioxide)	CH <sub>4</sub> (Methane)	N <sub>2</sub> O (Nitrous Oxide)	CFC-11 (Chlorofluoro-carbon-11)	HFC-23 (Hydrofluoro-carbon-23)	CF <sub>4</sub> (Perfluoro-methane)
Pre-industrial concentration	about 280 ppm	about 700 ppb	about 270 ppb	zero	zero	40 ppt
Concentration in 1998	365 ppm	1745 ppb	314 ppb	268 ppt	14 ppt	80 ppt
Rate of concentration change <sup>b</sup>	1.5 ppm/yr <sup>a</sup>	7.0 ppb/yr <sup>a</sup>	0.8 ppb/yr	-1.4 ppt/yr	0.55 ppt/yr	1 ppt/yr
Atmospheric lifetime	5 to 200 yr <sup>c</sup>	12 yr <sup>d</sup>	114 yr <sup>d</sup>	45 yr	260 yr	>50,000 yr

<sup>a</sup> Rate has fluctuated between 0.9 ppm/yr and 2.8 ppm/yr for CO<sub>2</sub> and between 0 and 13 ppb/yr for CH<sub>4</sub> over the period 1990 to 1999.

<sup>b</sup> Rate is calculated over the period 1990 to 1999.

<sup>c</sup> No single lifetime can be defined for CO<sub>2</sub> because of the different rates of uptake by different removal processes.

<sup>d</sup> This lifetime has been defined as an "adjustment time" that takes into account the indirect effect of the gas on its own residence time.

### IPCC 2001

David Archer's article *Fate of Fossil Fuel CO<sub>2</sub> in Geologic Time*, published in the *Journal of Geophysical Research*, Volume 110, 2005, argues quite differently. This report looks at anthropogenic CO<sub>2</sub> concentrations in our atmosphere on the 1,000, 10,000 and 100,000 year scale. Today, sure – because of conditions on the planet today, it is likely that any given molecule of CO<sub>2</sub>, generated today, will be gone in 31 years - or, at least 31 years from when those calculations were done in 1994.

It has taken 31 years for the oceans and the forest and prairies to absorb this CO<sub>2</sub>. One of the results of this extended period of absorption is that there is a lag in climate. Climate generally reacts slowly to change, or forcing as the climatologists call it. The CO<sub>2</sub> forces the climate to change, but slowly, very slowly (generally). But this 31-year average life is only appropriate if one considers the world as we know it today. The planet is slowly warming. This slow warming may very well be in the process of changing to an abrupt change right now, but for this analysis, we must consider the continued slow warming that we have seen over the last several decades.

A warming that will rapidly increase as we realize the effects of more and more GHGs that have been emitted over the last 31 years – the effective lag period of the Earth's response to changes in GHG concentrations. So in the last 30 years, our planet's population has doubled, and our per capita GHG emission has more than doubled. You can see that we are in for a lot of warming in the near future.

As the planet and oceans continue to warm, CO<sub>2</sub> is redistributed differently. Warmer water absorbs less CO<sub>2</sub>, this decreases the efficiency of the great ocean CO<sub>2</sub> sink. As more CO<sub>2</sub> is absorbed into the ocean, the acidity of the ocean waters increases. This also makes it more difficult for the oceans to absorb CO<sub>2</sub>. Ocean warming and increases in ocean acidity continue as the planet warms and the CO<sub>2</sub> absorption capacity of the oceans decreases until at some point, the oceans quit absorbing CO<sub>2</sub> altogether.

Then other processes in the oceans and ocean sediments release CO<sub>2</sub> into the atmosphere as the ocean CO<sub>2</sub> sinks become CO<sub>2</sub> and begin to emit CO<sub>2</sub> instead of absorbing it. This changes the lifetime analysis of CO<sub>2</sub> in the atmosphere considerable as well as warming the planet further which causes less CO<sub>2</sub> to be absorbed faster in a negative feedback loop that is self perpetuating. We are seeing the first signs of this change of the oceans from being a CO<sub>2</sub> sink to emitting CO<sub>2</sub>, in areas of the Antarctic Ocean and the far North Atlantic.

Next we must consider that on a significantly warmer planet, the biosphere, or the forests and prairies will no longer be efficient CO<sub>2</sub> sinks and at some point, in many cases will actually reverse their capacity to absorb CO<sub>2</sub> and change to CO<sub>2</sub> sources – emitting CO<sub>2</sub> instead of absorbing it. This will further add to the longevity of CO<sub>2</sub> in our atmosphere, and of course to the further warming on the planet – which also leads to less CO<sub>2</sub> absorption in a negative feedback loop that is again, self perpetuating.

Finally, on an Earth just a few degrees F warmer than we see today, warming that we are likely to see by 2050 or so, methane frozen on the ocean floor began to melt. A conservative estimate of the amount of methane frozen on the ocean floor is 10,000 gigatons. For scale, all of mankind has emitted 300 gigatons of all greenhouse gasses since the beginning of the industrial revolution. Methane is a very powerful GHG, with a CO<sub>2</sub> warming potential of 23 – that is, a given amount of methane has the same amount of warming potential as 23 times the CO<sub>2</sub>. Fortunately, methane has an average life of only 12 years in the atmosphere, and then it changes, or chemically decays into CO<sub>2</sub>. The release of methane from the ocean floor will obviously have another significant effect on the planet's temperature, compounding all of the above-mentioned negative feedback effects.

With a population approaching 10 billion by mid century, a modest decrease in GHG emissions would still see roughly five times the amount of GHGs emitted into the atmosphere by fossil fuel burning and changes in emission patterns from oceans and forests and prairies by the end of the century as have been emitted since the beginning of the industrial revolution. That's a huge big grande amount of GHGs.

When one takes all of this into consideration, and understands that this entire GHG emissions scenario is anthropogenic in nature – that is, the release of the natural GHGs from the oceans and landforms is actually a part of the anthropogenic cycle, the revelation formed by Dr. Archer is a little bit more understandable. Dr. Archer says that, even though mankind will be through with fossil fuels within 1,000 years, because of the

feedbacks involved, the average life of CO<sub>2</sub> can now be expected to be over 100 times longer than previously estimated, or about 30,000 years.