ATTACHMENT I

Understanding Global Warming Potentials

Greenhouse gases (GHGs) warm the Earth by absorbing energy and slowing the rate at which the energy escapes to space; they act like a blanket insulating the Earth. Different GHGs can have different effects on the Earth's warming. Two key ways in which these gases differ from each other are their ability to absorb energy (their "radiative efficiency"), and how long they stay in the atmosphere (also known as their "lifetime").

The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide (CO_2). The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. The time period usually used for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gases.

- CO_2, by definition, has a GWP of 1 regardless of the time period used, because it is the gas being used as the reference. CO_2 remains in the climate system for a very long time: CO_2 emissions cause increases in atmospheric concentrations of CO_2 that will last thousands of years.
- Methane (CH_4) is estimated to have a GWP of 27-30 over 100 years. CH_4 emitted today lasts about a decade on average, which is much less time than CO_2. But CH_4 also absorbs much more energy than CO_2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. The CH_4 GWP also accounts for some indirect effects, such as the fact that CH_4 is a precursor to ozone, and ozone is itself a GHG.
- Nitrous Oxide (N_2O) has a GWP 273 times that of CO_2 for a 100-year timescale. N_2O emitted today remains in the atmosphere for more than 100 years, on average. (Learn why EPA's U.S. Inventory of Greenhouse Gas Emissions and Sinks uses a different value.)

- Chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are sometimes called high-GWP gases because, for a given amount of mass, they trap substantially more heat than CO_2. (The GWPs for these gases can be in the thousands or tens of thousands.)

Frequently Asked Questions

Why do GWPs change over time?

> EPA and other organizations will update the GWP values they use occasionally. This change can be due to updated scientific estimates of the energy absorption or lifetime of the gases or to changing atmospheric concentrations of GHGs that result in a change in the energy absorption of 1 additional ton of a gas relative to another.

Why are GWPs presented as ranges?

> In the most recent report by the Intergovernmental Panel on Climate Change (IPCC), multiple methods of calculating GWPs were presented based on how to account for the influence of future warming on the carbon cycle. For this Web page, we are presenting the range of the lowest to the highest values listed by the IPCC.

What GWP estimates does EPA use for GHG emissions accounting, such as the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (Inventory) and the Greenhouse Gas Reporting Program?

The EPA considers the GWP estimates presented in the most recent IPCC scientific assessment to reflect the state of the science. In science communications, the EPA will refer to the most recent GWPs. The GWPs listed above are from the IPCC's Sixth Assessment Report, published in 2021.

The EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (Inventory) complies with international GHG reporting standards under the United Nations Framework Convention on Climate Change (UNFCCC). UNFCCC guidelines now require the use of the GWP values from the IPCC's Fifth Assessment Report (AR5), published in 2013. The Inventory also presents emissions by mass, so that CO_2 equivalents can be calculated using any GWPs, and emission totals using more recent IPCC values are presented in the annexes of the Inventory report for informational purposes.

The data collected by EPA's Greenhouse Gas Reporting Program is generally reported in mass units of greenhouse gas and is used in the Inventory. The Reporting Program, generally uses GWP values from the AR4 to determine whether facilities exceed reporting thresholds and to publish data in CO_2 equivalent values. The Reporting Program collects data about some industrial gases that do not have GWPs listed in the AR4; for these gases, the Reporting Program uses GWP values from other sources, such as the AR5.

EPA's CH_4 reduction voluntary programs also use CH_4 GWPs from the AR5 report for calculating CH_4 emissions reductions through energy recovery projects, for consistency with the national emissions presented in the Inventory.

Are there alternatives to the 100-year GWP for comparing GHGs?

The United States primarily uses the 100-year GWP as a measure of the relative impact of different GHGs. However, the scientific community has developed a number of other metrics that could be used for comparing one GHG to another. These metrics may differ based on timeframe, the climate endpoint measured, or the method of calculation.

For example, the 20-year GWP is sometimes used as an alternative to the 100-year GWP. Just like the 100-year GWP is based on the energy absorbed by a gas over 100 years, the 20-year GWP is based on the energy absorbed over 20 years. This 20-year GWP prioritizes gases with shorter lifetimes, because it does not consider impacts that happen more than 20 years after the emissions occur. Because all GWPs are calculated relative to CO_2, GWPs based on a shorter timeframe will be larger for gases with lifetimes shorter than that of CO_2, and smaller for gases with lifetimes longer than CO_2. For example, for CH_4, which has a short lifetime, the 100-year GWP of 27–30 is much less than the 20-year GWP of 81–83. For CF_4, with a lifetime of 50,000 years, the 100-year GWP of 7380 is larger than the 20-year GWP of 5300.

Another alternate metric is the Global Temperature Potential (GTP). While the GWP is a measure of the heat absorbed over a given time period due to emissions of a gas, the GTP is a measure of the temperature change at the end of that time period (again, relative to CO_2).The calculation of the GTP is more complicated than that for the GWP, as it requires modeling how much the climate system responds to increased concentrations of GHGs (the climate sensitivity) and how quickly the system responds (based in part on how the ocean absorbs heat).

GHG Emissions and Removals Home <https://epa.gov/ghgemissions>

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