KEY MESSAGES

- Global methane emissions from livestock have a substantial impact on climate, albeit much smaller than the impact of fossil fuel emissions.
- Comparing greenhouse gases as “CO₂-equivalent” using the 100-year Global Warming Potential (GWP₁₀₀) misrepresents the warming impact of methane.
- Expressing methane emissions as “CO₂-warming-equivalent” reflects the actual impact of cattle and sheep farming on global temperatures much more accurately.
- Increasing methane emissions causes substantial warming, but reducing methane emissions faster than 3% per decade acts to reduce global temperatures.
- Setting a separate target for methane emissions helps clarify the implications of emission goals for global temperature.
How temperature responds differently to cumulative and short-lived climate pollutants

Surface temperature responds differently to carbon dioxide (CO$_2$) and methane (CH$_4$) emissions because CO$_2$ accumulates in the climate system, while methane is broken down by natural processes on a timescale of about 12 years. Hence the level of warming caused by CO$_2$ is determined by total cumulative CO$_2$ emissions to date, while the level of warming due to methane is determined more by the current rate of methane emissions in any given decade, and depends much less on historical methane emissions.

These differences matter because the world has set a target under the Paris Agreement to limit warming, limiting emissions is a means to this end. The below diagram contrasts the response to a long-lived, or cumulative, pollutant such as CO$_2$ (red) with a short-lived climate pollutant such as methane (blue). Three cases are shown: emissions rising steadily, emissions constant, and emissions falling to zero, in all cases over several decades. Lower panels show the warming caused by these emissions.

When emissions are rising, CO$_2$ and methane both cause warming. Temperature continues to rise under constant emissions of CO$_2$, as CO$_2$ continues to accumulate. In contrast, constant methane emissions lead to constant methane concentrations in the atmosphere, which hold temperature at an elevated, but nearly stable, level, rising only very slowly due to continued very slow adjustment of the climate system over centuries to past methane emissions increases.

Temperature continues to rise in response to any remaining CO$_2$ emissions as long as they are greater than zero, even if they are falling rapidly. In contrast, temperature falls in response to methane emissions falling faster than about 3% per decade. When emissions reach net zero, the level of warming due to CO$_2$ remains constant for many decades, while the level of warming due to methane falls rapidly, halving within a couple of decades and continuing to decline thereafter, because of methane’s short atmospheric lifetime.

Expressing methane emissions as CO$_2$-equivalent using the GWP$_{100}$ metric, which equates one tonne of methane with 28 tonnes of CO$_2$, overstates the impact of a constant methane source on global temperature by a factor of 3 to 4 and understates the impact of a new methane source by a factor of 4 to 5 over the 20 years following the introduction of the new source.

So-called “warming-equivalent” metrics, such as GWP* or CGTP (Combined Global Temperature change Potential), can overcome this problem.

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APPLICATION TO RUMINANT LIVESTOCK

Ruminant livestock emit large amounts of methane, generated as a by-product from enteric fermentation and from the anaerobic decomposition of organic material in their manures. Per molecule in the atmosphere, methane has a stronger global warming impact than CO₂. That is why methane from ruminant livestock has a warming impact on climate even though it is part of a natural carbon cycle.

Emission comparisons are often based on GWP₁₀₀ (the 100-year Global Warming Potential), which simply equates one tonne of methane (tCH₄) with 28 tonnes of CO₂ (tCO₂). GWP₂₀ is sometimes used, which equates 1 tCH₄ with 84 tCO₂. However, neither GWP₁₀₀ nor GWP₂₀ accounts for the very different behaviour of methane and CO₂. Nitrous oxide, the other important greenhouse gas for agriculture, behaves much more like CO₂ and so is well represented by such conventional measures of GWP.

GWP* was developed to accurately represent the increased warming impact of each methane molecule while taking into account its short lifespan. To calculate CO₂-warming-equivalent emissions using GWP*, current methane emissions are multiplied by a factor of 8 and added to any net methane emissions increase or decrease over the previous 20 years multiplied by 120.

Warming-equivalent emissions reflect impact on global temperature: one tonne CO₂-warming-equivalent added or removed from the atmosphere increases or decreases global temperature by 0.45±0.18 trillionths of a degree Celsius.¹²

Implications of CO₂-warming-equivalent emissions:
- A constant methane emission of one tonne of methane per year established for longer than 20 years has approximately the same warming impact as an emission of 8 tonnes of CO₂ per year. This is 3½ times smaller than implied by GWP₁₀₀, and 10 times smaller than implied by GWP₂₀.

- A new emission source of one tonne of methane per year has the same warming impact as 128 (8+120) tonnes of CO₂ per year over the first 20 years after the introduction of the new source. This is 4½ times larger than implied by GWP₁₀₀, and 50% larger than implied by GWP₂₀.

- Any methane emission declining faster than 3% per decade (8/120 over 20 years), acts to reduce global temperatures: negative CO₂-warming-equivalent emissions have the same temperature impact as active removal of CO₂.

SUMMARY

CO₂-warming-equivalent emissions, which can be calculated from CO₂-equivalent emissions using GWP*, provide a more accurate indication of the global temperature impact of emissions of methane and other greenhouse gases, and the impact of activities, decisions and practices that affect these emissions. There are various ways this information can be used depending on other considerations, including goals, values and priorities³.

Of particular importance for ruminant livestock farming are the following observations:

- Increasing methane emissions cause very substantial warming, but constant ongoing methane emissions cause relatively little additional warming. In contrast, every tonne of CO₂ emitted causes the same amount of warming whenever it occurs. In recent years, global methane emissions have increased, causing lots of warming.

- Gradually declining methane emissions of 10% over 30 years (equivalent to halving over about 200 years) cause no additional warming.

- Faster reductions in methane emissions lead to a lowering of global temperatures. In contrast, until net emissions of CO₂ and nitrous oxide are reduced to zero, they continue to increase global temperatures. Reducing methane to zero while continuing to emit CO₂ could delay, but not prevent, global temperatures rising.