SCIENCE NOTES

Emission Equivalence Metrics

by Maggie DeLessio

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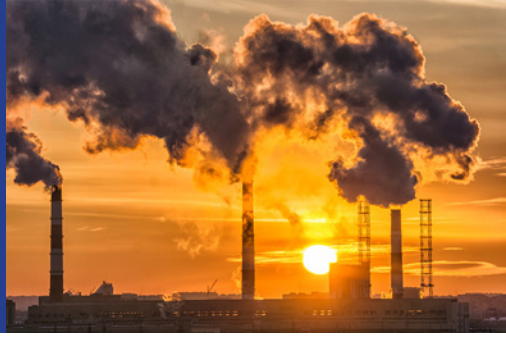

RESEARCH HIGHLIGHTS

- **Carbon dioxide emission equivalence (CO_2e) metrics relate the climate effect of greenhouse gases over a certain amount of time to that of carbon dioxide.**
- **New York State uses a CO_2e metric that considers greenhouse gas effects over 20 years, more heavily weighting methane than the 100-year metric used by the United Nations and US federal government.**
- **Use of different CO_2e metrics changes the resulting climate impacts and relative ease therein of achieving what counts as net-zero emissions.**

Emission equivalence metrics are a way to quantitatively compare the effects of different greenhouse gases relative to each other. Carbon dioxide (CO_2) acts as a greenhouse gas by absorbing heat and warming the atmosphere. Other greenhouse gases include methane, nitrous oxide, and some refrigerants. As human-driven emissions of these gases increase, more heat is trapped in the atmosphere, causing global warming and subsequent climate change. Each gas has a different chemical structure that impacts how much heat it traps, and how long it's in the atmosphere. For example, methane is short-lived, remaining in the atmosphere on average for approximately 12 years, but it absorbs much more heat than CO_2.

Rather than separately tracking and regulating the emissions of each different greenhouse gas, emissions for each can be converted to a common measure or unit using an emission metric. An emission metric can express the total magnitude of climate effect (like heat absorbed or resulting surface temperature change) a unit mass of emitted gas has, or it can express the effect of a gas relative to a reference species, most commonly CO_2. A gas's carbon dioxide equivalence (CO_2e) metric determines the amount (in tons) of CO_2 that would have the same effect in the atmosphere as 1 ton of the gas. Total mass of a gas is therefore multiplied by the CO_2e value to get the amount in tons of CO_2e.

Global warming potential (GWP) is a commonly used CO_2e metric: it expresses the heat absorbed by greenhouse gas emissions over a certain amount of time (or time horizon), relative to CO_2. A shorter time horizon more heavily weights the warming impact of short-lived greenhouse gases, like methane, while a longer time horizon more heavily weights long-lived greenhouse gases, like refrigerants. GWP over 100 years (GWP100) is used by the United Nations and the US federal government, while New York State uses GWP over 20 years (GWP20).

To understand how these two metrics relate to each other in practice, we can consider a hypothetical example. Imagine a dairy farm in upstate New York, with annual emissions of 3,000 metric tons (mt) of CO_2 and 150 mt of methane. If we use GWP100 metric values to equate these two gases, the total farm emissions are 7,200 mt CO2e. In comparison, if we use GWP20 to equate these, total farm emissions are much greater—15,600 mt CO_2e—because methane is more heavily weighted. These values, and the GWP conversion factors, are shown in the table on the next page.

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REFERENCES

Full references are available on the web-based version of this note, which can be accessed using the QR code below or at rockinst.org/blog.

ABOUT SCIENCE NOTES

Science Notes are short memos that describe scientific and technological artifacts, concepts, principles, and research related to policy topics and legislative proposals.

MORE INFO

Gas	Emissions (metric tons)	GWP100 Value*	CO_2e Emissions GWP100 (mt)	GWP20 Value	CO_2e Emissions GWP20 (mt)
CO_2	3,000	1	3,000	1	3,000
Methane	150	28	4,200	84	12,600
Total			**7,200**		**15,600**

* GWP100 and GWP20 values are taken from the Fifth IPCC Assessment Report (AR5). While AR6 has more up to date values, the New York State Climate Act calls for the use of AR5 values. See Statewide Greenhouse Gas Emissions Report—NYSDEC.

The use of these different emission metrics can change which entities meet thresholds to qualify for federal and state regulations. For example, the recently published New York State Mandatory Greenhouse Gas Reporting Program requires entities meeting a certain emissions threshold to report their emissions to the New York State Department of Environmental Conservation; any facility emitting at or above that threshold would be subject to the program and required to report emissions. The typical emissions threshold is 10,000 mt CO_2e, using GWP20. Under this regulation, the hypothetical dairy described above must report its emissions. However, if New York State were to require the use of the GWP100 metric instead, the dairy's total calculated emissions would be lower, and it would not be subject to the reporting program.

Different emission metrics also change the tangible meaning (resulting climate impacts) of net-zero greenhouse gas emissions. Some emissions of greenhouse gases, like methane, cannot be fully abated, leaving "residual" emissions that must be balanced by the removal of CO_2 from the atmosphere to get to net-zero. Under GWP100, this "drawdown" of CO_2 would cause global temperatures to peak and then decrease. Under GWP20, because methane is more heavily weighted relative to CO_2, far more CO_2 would have to be removed to get to net-zero. While theoretically, this would cause global temperatures to decline faster after they peak, experts have suggested that the sheer magnitude of CO_2 drawdown required may make reaching GWP20 net-zero more challenging to achieve over the same period of time.

The value of using different metrics has been a part of New York State climate policy discussions, especially as concerns the state's landmark Climate Leadership and Community Protection Act (CLCPA), which was enacted in 2019.