

Superpollutants: Tackling a Major Climate Threat

Prepared by The Carbon Containment Lab and Calyx Global

REPORT

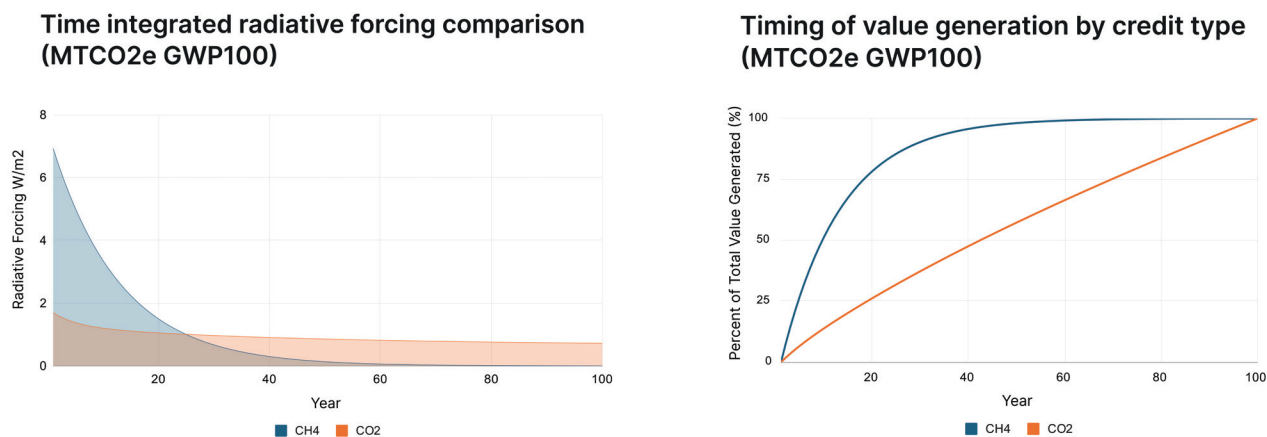
SEPTEMBER 2025

Superpollutants are a major planetary threat

Accessible, affordable action that will immediately and drastically slow near-term climate warming is at our fingertips. As we exceed 1.5°C, damages in the near term are large and growing exponentially due to a subset of greenhouse gases—superpollutants—that create high near-term global warming. Climate leaders Google, Netflix, Workday, and others are adding these gases into the core of their climate action playbooks, scaling their investments up quickly to address the climate crisis.^{1 2 3}

Superpollutant emissions are key contributors to near-term warming. Gases such as methane, nitrous oxide, and fluorocarbons are responsible for approximately half of the warming observed today.⁴ Each of them has properties that accelerate warming in the near term, with warming effects of 100s or 1000s of times that of carbon dioxide. Superpollutant emissions have an outsize effect on the current rate of warming, whereas carbon dioxide (CO₂) emissions are more deterministic of the ultimate extent of warming over longer time periods. By reducing emissions of superpollutants, we can achieve an immediate reduction in the rate of warming, buying our planet critical time by bending the climate curve when it matters most.

To put the challenge into context, studies suggest that mitigating the entire stock of superpollutants could avoid more than half a degree Celsius of warming by midcentury and over one degree by the end of the century⁵. Investing in superpollutant mitigation may be amongst the best uses of climate capital today.



Source: Takahashi & Crotty, 2025, in prep.

Figure 1. The global warming potential (GWP) of superpollutants is even more potent in the near term, which is why they are also sometimes referred to as “short-lived climate forcers.” Historically, a carbon credit has been quantified as equivalent to the avoided or removed emission of one metric ton of CO₂ in units of aggregate radiative forcing over 100 years. To illustrate, Figure 1 on the left shows that one ton of CO₂ emitted in the first year will persist in the atmosphere and contribute to radiative forcing over centuries, whereas one MTCO₂e of CH₄ over 100 years behaves differently. It starts as a much more potent contributor to radiative forcing, and therefore has an outsized impact in the near term. Figure 1 on the right shows that the climate benefits arrive sooner with superpollutants (using methane as the example), as discussed in a forthcoming paper by Takahashi and Crotty⁶. With annual superpollutant emissions from anthropogenic sources estimated to be around 15 billion metric tons of CO₂ equivalent (MTCO₂e)⁷, there is potential for a wide variety of mitigation projects and near-term impact on warming.

We have the tools to mitigate superpollutants today

We know many of the key actions that are needed to reduce superpollutants and their potential impact. Methane, nitrous oxide, fluorinated gases, and black carbon are emitted from well-understood sources. For many of these sources, mitigation is underway and carbon credit methodologies are in place. These elements provide the groundwork to scale now, with significant impact.⁸

	Methane	Nitrous oxide	Fluorocarbon	Black carbon
Key considerations	Methane has caused half of the total observed warming since the Industrial Revolution. ⁹	Nitrous oxide has the same global warming potential over both 20-year and 100-year timescales. ¹⁰	Fluorocarbons comprise a wide variety of compounds, each with distinct GWP values from the tens to over 10,000. Banks of fluorocarbons (HFCs, ODS) still exist even with the phaseout and phasedown of the highest GWP gases under the Montreal Protocol.	Black carbon is a particle rather than a gas. It contributes to warming when it absorbs sunlight and releases it as heat. ¹¹ Black carbon is released by incomplete combustion processes.
Examples of mitigatable sources	Manure, livestock, rice cultivation, mines, wastewater, landfills.	Adipic acid/nylon production, manure, fertilizer use, tilling soils, burning crop residues.	Venting and leaks of high-GWP refrigerants from refrigeration and air conditioning equipment.	Fossil fuel combustion, municipal solid waste, diesel engines, kerosene lamps, fuelwood or charcoal cookstoves, steel and brick kilns, agricultural residue.
Impact opportunity	0.2°C of warming can be avoided by 2050 by mitigating just 30 percent of the 11 billion MTCO ₂ e GWP100 of methane emitted annually. ¹²	0.1°C of warming can be avoided by 2050 ¹³ by cutting anthropogenic emissions, currently at annual levels of 2.79 billion MTCO ₂ e ^{14 15} , by 50-75 percent.	0.5°C of warming can be avoided by 2100 by achieving complete international compliance with the Kigali Amendment to the Montreal Protocol. ¹⁶ Potential for further reducing emissions of ~2 GtCO ₂ e / yr by 2050 and ~3-4 GtCO ₂ 3 / yr by 2100.	0.2°C of warming can be avoided by 2050 ¹⁷ with aggressive reduction of current emissions of approximately 5.2 billion MTCO ₂ e annually ^{18 19} . Reductions also achieve substantial improvements in local air quality, public health, and food security. ²⁰

Carbon markets have demonstrated that many of these activities are possible today with financial support. This is evidenced by regulatory compliance activities as well as the voluntary carbon market (VCM), a proving ground for financing, implementing, and verifying the abatement of these emissions. Figure 2 illustrates mitigation activities within the VCM that delivered emission reductions in 2024. Furthermore, there is a pipeline of up-and-coming activities that reduce superpollutants. The most project listings (i.e., intended activities) on the VCM’s largest registries are manure methane digesters, followed by landfill gas capture/flaring, rice methane management, biodigesters, and wastewater methane management.²¹ While registries will need to promote ongoing improvement in impact measurement based on the latest scientific knowledge (see discussion on integrity below), these issuances and project listings already provide a blueprint for activity that can be accelerated.

2024 VCM credit issuance volume by superpollutant project type

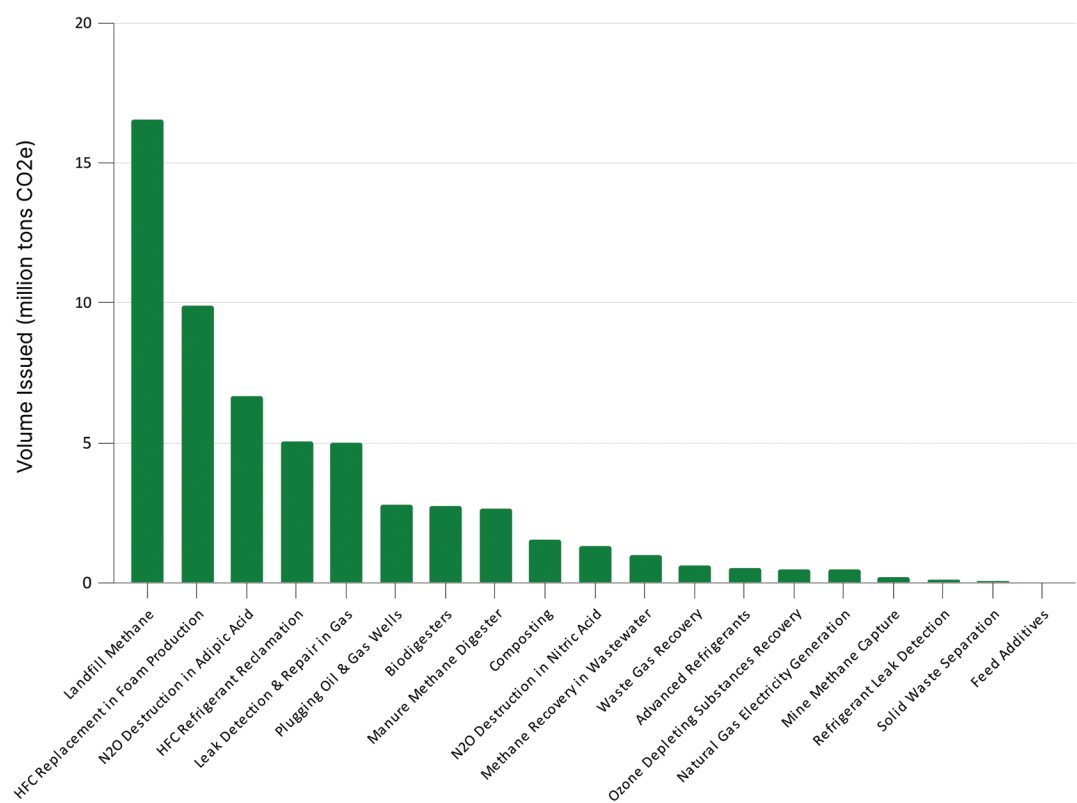


Figure 2. Superpollutant mitigation activity (by credits issued) in the VCM in 2024 provides a view into what is both feasible and affordable in the very near term for climate action. Methane projects represent the largest share of activity to date compared to nitrous oxide and fluorocarbons. Methane abatement—through flaring or capturing landfill gas and, more recently, addressing leaks in transmission lines or orphaned wells, and capturing gas from mines, manure, or wastewater—comprises over 50 percent of the superpollutant credits issued. In terms of available carbon credits (i.e., those issued but not yet retired or used) from these types of activities, landfill gas (41 million credits), HFC replacement (36 million credits), leak detection and repair (25 million credits from less than 10 projects), and biodigesters (14 million credits) offer the highest volumes. Expanding the view to include California’s Air Resources Board-eligible credits brings mine methane and manure methane digesters into the picture, each with just over 10 million credits available. Issuance figures do not include credits issued via the Clean Development Mechanism.

These figures also show how far off the mark we are—the 420 million MTCO₂e addressed in the VCM since 2015²² is staggeringly short, less than 3 percent of the approximately 15 billion MTCO₂e being emitted every year^{23 24}. This statistic suggests there is a significant opportunity for additional investment. Projections from the Carbon Containment Lab indicate one billion MTCO₂e of mitigation via the existing VCM is likely in a business-as-usual scenario (see Figure 3), and, in a more aggressive scenario, 3.5 billion MTCO₂e is within reach through the existing VCM by 2035.

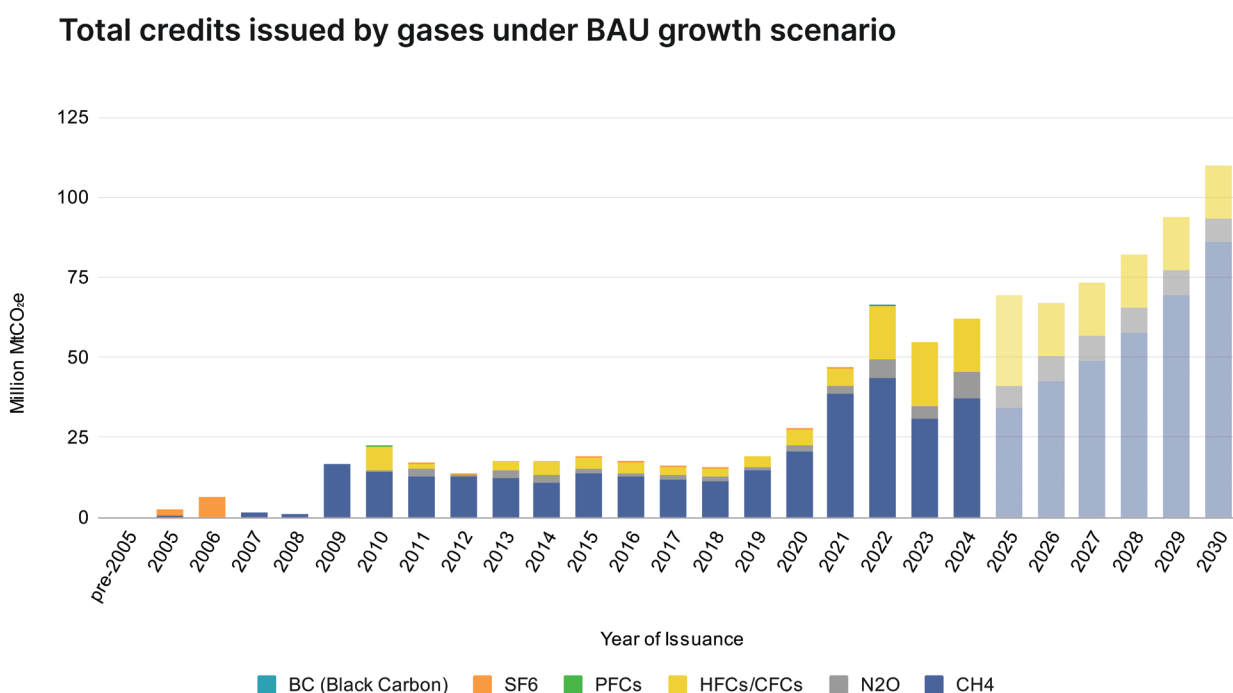


Figure 3. Projections show business-as-usual growth, and there is significant potential to accelerate with investment beyond these rates. By applying a growth rate to existing data on voluntary carbon credits from the four largest registries (ACR, Climate Action Reserve, Gold Standard, and Verra) for superpollutants, three scenarios were modeled: business-as-usual (BAU), medium, and aggressive growth rates. The BAU pathway was generated by applying the compounded annual growth rate observed from 2014 to 2024. This reflects a cumulative total of 0.47 billion MTCO₂e for 2025–2030. In the aggressive-growth pathway (applying the BAU plus a 20 percent growth per year), credit issued volumes are projected at roughly 0.7 billion MTCO₂e for 2025–2030. Figures for 2025 include actuals through June, and projections through December. Of course, different types of projects face different drivers and constraints than in the past, and project activity will vary based on region and demand.

Scale is achievable but requires improvement in credit claims. Calyx Global has generated over 1000 greenhouse gas integrity ratings and found that 40 percent of superpollutant ratings fall into the Tier 1 range—the top tier for greenhouse gas integrity (AAA, AA, or A)—compared to only one percent of non-superpollutant credits (see Figure 4). While superpollutant credits tend to make stronger climate benefit claims compared to non-superpollutant credits, over half remain in the lower tiers, suggesting considerable room for improvement. Fortunately, addressing these issues is possible and the carbon market is seeing steady improvement in carbon credit quality. The stakes are high and getting it right matters to earn the confidence of buyers and the broader public that is needed to scale the market.

Distribution of Calyx Global GHG ratings for credits from superpollutant and non-superpollutant project types

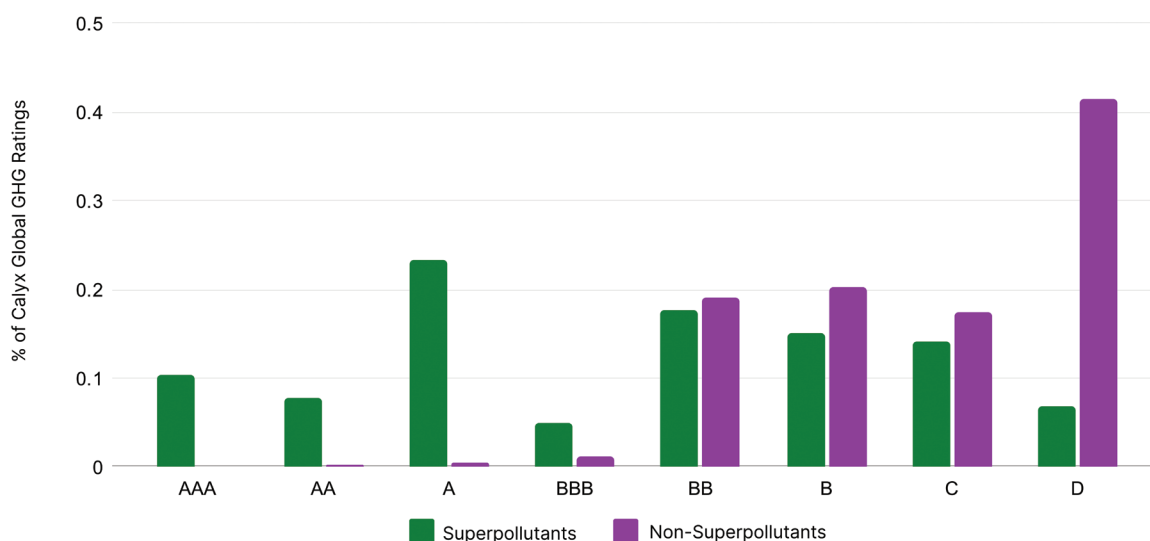


Figure 4. Ratings of superpollutant credits versus other credit types. Among Calyx Global's 1000+ ratings, superpollutant credits tend to score higher, on average, than all other project types (e.g., forestry, renewable energy, etc.). This is not to suggest that other projects cannot achieve a higher rating. It simply suggests that, at this time, the quality of credits that reduce non-CO₂ gases is higher. We note that many other project types—in particular, nature- and household-based (e.g., cookstove) projects—are undergoing methodology revisions that we believe will change the distribution of these ratings over time.

Finally, there is still space to innovate, scaling new mitigation technologies and new approaches to support early-stage projects. While policy and carbon market activity is underway for some of the major sources of superpollutant emissions, there are still many superpollutant emissions that need attention. For example, the Carbon Containment Lab has identified natural and agricultural sources of methane emissions for which mitigation pathways are being tested²⁵. In addition, novel approaches to gathering and mitigating disparate sources of HFC emissions are being developed with the help of new traceability technology. Existing mitigation pathways can also be applied in new regions. However, for these pathways to operate in the market, new methodologies may need to be developed, and regional capacity needs to be built. Furthermore, funding would be required for field testing, measurement and analysis to meet the rigors of carbon credit markets.

Lead the charge: Address near-term warming by supporting superpollutant mitigation

Companies can “bend the curve” of warming by supporting superpollutant mitigation. With more certain demand, supply will follow. Purchasing high-quality superpollutant credits sends a signal that will accelerate the development of new projects. Currently, high-quality superpollutant credits trade at prices far below lower-quality credits²⁶. In other words, companies can have more impact at a lower cost by supporting superpollutant mitigation.

Join companies, including Google, Netflix, and Workday, that have made tackling superpollutants part of their climate action playbooks. Many companies are creating carbon credit portfolios. Some are going further by entering into forward offtake agreements and helping to build new projects with their investments and technical support. We believe it is worthwhile to consider such credits—alongside CO₂-focused credits including removals—as part of your company’s climate strategy. **The fact is, we need it all.**

About us



The Carbon Containment Lab is a nonprofit organization that creates an enabling environment for emerging climate solutions by applying scientific, entrepreneurial, and investment expertise. Founded in 2020 at Yale University, it became an independent 501(c)(3) charitable organization in 2024. The Lab partners widely and draws inspiration from academics, practitioners, past efforts, and parallel fields. Our superpollutant publications can be found at: <https://carboncontainmentlab.org/programs/super-pollutants>



Calyx Global empowers companies to make high-impact carbon credit decisions through independent, rigorous carbon credit ratings, investment decision tools and research. Their expert team provides unbiased analysis of carbon credit integrity across greenhouse gas claims, Sustainable Development Goals and social and environmental safeguards. Recognized as the most reliable carbon credit rater by Carbon Market Watch, Calyx Global has evaluated the majority of credits available on the market, with over 1,000 projects and counting. To learn more about superpollutant carbon credits and credit quality, visit www.calyxglobal.com.

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Cover photo image: Anastasia O'Rourke, September 2025

Citation

Lee, D, O'Rourke, A, Cooper, J (2025) Superpollutants: Tackling a Major Climate Threat, Carbon Containment Lab and Calyx Global.

Endnotes

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