Principles for Responsible Use of Short-Lived Climate Pollutant (SLCP) Mitigation for CO_2 Compensation

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Summary

Here, we explore how short-lived climate pollutants (SLCPs), such as methane, should be accounted for if they are credited or otherwise used to compensate for long-lived greenhouse gas emissions like CO_2. SLCP mitigation is essential if we want to achieve near-term warming reductions. Yet, there is an open question about whether it should be treated as directly interchangeable with CO_2. Doing so risks obscuring differences in climate impact of different greenhouse gases, leaving us with a climate future that is net zero on paper while the amount of CO_2 in the atmosphere and long-term global average temperatures keep rising.

It isn't necessary to allow SLCP mitigation to compensate for CO_2 emissions, as the two can be accounted for separately. But if the two are to be compared, we propose a framework for how to do it responsibly based on five key principles. These principles are intentionally written at a high level: They are not a step-by-step guide for project developers, buyers, or policymakers, but rather guardrails to stress-test emerging methodologies and ensure early precedents do not lock in flawed assumptions.

1. **Independent Tracking of SLCPs From CO_2**: Short- and long-lived greenhouse gases must be tracked and managed distinctly. Interchangeability is not justification for aggregation.
2. **Radiative Forcing Should Match the Climate Claim**: Climate benefits must be matched in both magnitude and duration. Radiative forcing reductions must be aligned to the warming impact of the CO_2 emissions they are offsetting.
3. **Ensure Accountability Across Climate Timescales**: SLCP mitigation used as an offset for CO_2 or other long-lived greenhouse gas emissions must be paired with credible, long-term strategies to ensure the full climate liability is addressed. This should be done on timescales that match the persistence of CO_2, with mechanisms to ensure obligations extend beyond the lifetime of any single actor.
4. **Align Accounting with Source and Context**: SLCP accounting must reflect the specific characteristics of the emissions source and mitigation pathway, including project scope, regional conditions, and socio-economic context.
5. **Enable Innovation Within Clear Boundaries**: Encourage innovation in mitigation and accounting bounded by safeguards that protect climate integrity and transparency.

By embedding these principles in accounting and reporting structures, climate benefits can be matched to the timing, duration, and reversibility of the harms they address, ensuring that neither warming impacts nor responsibility are deferred. If used correctly, these principles encourage systems that reinforce, not replace, CO_2 decarbonization.

Introduction: Short-Lived Climate Pollutants (SLCPs) and Why We Should Care

Climate strategies have historically focused on carbon dioxide (CO_2), the most abundant and long-lived anthropogenic greenhouse gas. Since CO_2 stays in the atmosphere for centuries and accounts for roughly half of all observed warming to date, it has dominated inventories, climate policy, and carbon markets (IPCC 2023; UNEP 2021; CCAC 2024; CCAC and UNEP, 2024). However, a growing body of scientific and policy literature highlights the critical role of short-lived climate pollutants (SLCPs) in driving near-term warming and increasing the likelihood of crossing tipping points (UNEP & CCAC, 2021).

SLCPs are gases and particles that remain in the atmosphere for much shorter periods than CO_2 – typically years or less – but are much more potent while present. Examples include methane (CH_4), hydrofluorocarbons (HFCs), tropospheric ozone, and black carbon. Learn more about radiative forcing here & here.

For example, methane has over 80 times the global warming potential (GWP) of CO_2 over a 20-year time frame (GWP20). Even over a 100-year time period (GWP100), methane's warming potential is still roughly 30 times higher than CO_2 (IPCC, 2023). Although methane's physical lifetime in the atmosphere is about 10–12 years, GWPs at 20 or 100 years are commonly used to express its cumulative impact on warming over those periods. These values also account for the fact that methane eventually oxidizes to CO_2, which contributes to longer-term forcing. Because of their potency and short atmospheric lifetime, targeted reductions in SLCP emissions or removal of SLCPs from the atmosphere can yield rapid climate benefits.

This opportunity is increasingly reflected in policy and market activity. Methane abatement interventions (like leak detection and repair in the oil and gas industry and landfill gas capture) are now being incorporated into voluntary carbon markets and corporate climate strategies. Programs targeting HFC destruction and black carbon emissions from cookstoves or diesel engines are also being proposed and piloted.

SLCP mitigation offers a powerful lever for climate action. Because these pollutants have such high near-term potency, reducing them can rapidly slow warming rates, lower peak temperatures in the coming decades, and reduce the likelihood of triggering climate tipping points. This dynamic is illustrated in **Figure 1**, which shows how methane exerts a much stronger warming effect than CO_2 in the near-term, but declines rapidly while CO_2 persists for centuries to millennia. SLCP mitigation can also deliver major co-benefits, including improved air quality and associated health benefits (Shindell et al., 2012). Taken together, these impacts make SLCP mitigation a vital complement to long-lived CO_2 mitigation.

At the same time, if SLCP mitigation is treated as directly interchangeable with CO_2 reductions or removals, it can create accounting loopholes which can delay structural decarbonization and undermine the integrity of net zero targets. Differences in lifetime, reversibility, and measurement rigor make direct comparisons to CO_2 complex and nuanced. Without guardrails, SLCP-focused projects may be used to offset long-lived fossil emissions, undermining the permanence and credibility of net zero pathways (Rogelj et al., 2021; Allen et al., 2018).

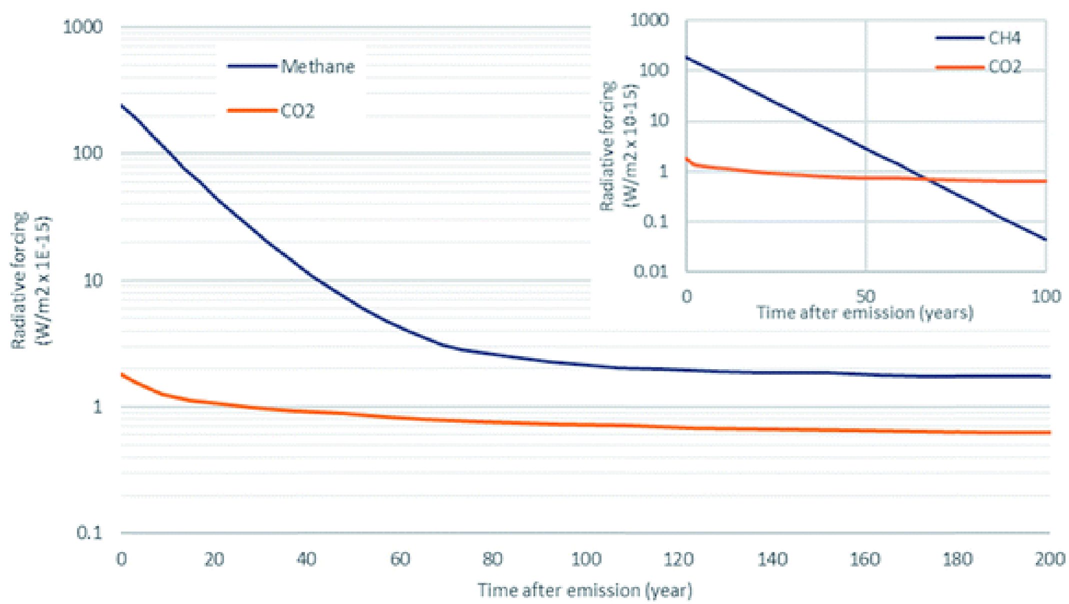

Figure 1: Radiative forcing of a 1 kg pulse emission of methane (CH_4) and carbon dioxide (CO_2) over time. Methane creates a much stronger warming effect in the near-term but declines rapidly, while CO_2 persists for centuries to millennia. The inset shows methane's radiative forcing without accounting for its eventual oxidation into CO_2. Source: Balcombe et al., 2018

There are already existing and emerging frameworks exploring how to integrate SLCP mitigation into CO_2-oriented markets and inventories, but our focus is not to endorse or critique specific methodologies. Instead, we outline the principles that any such framework should meet to maintain climate integrity. Our perspective is shaped by lessons from CO_2 accounting, where we have seen both progress and pitfalls, and we apply those insights here to help ensure SLCP mitigation avoids repeating the same mistakes.

In subsequent sections, we offer a set of principles to assess when and how SLCP mitigation can be responsibly used to compensate for CO_2 emissions. While this paper focuses on SLCPs as conventionally defined, the principles could apply more broadly to any gas or particle with a shorter atmospheric lifetime than CO_2, since the accounting challenges stem from that fundamental distinction. Given the significant differences in atmospheric behavior, durability, and reversibility between SLCPs and CO_2, treating them as interchangeable carries real risks.

These principles are intentionally written at a high level: They are not a step-by-step guide for project developers, buyers, or policymakers, but rather guardrails to stress-test emerging methodologies and ensure early precedents do not lock in flawed assumptions. They are designed to ensure accountability and prevent the misuse of SLCP reductions when used to compensate for CO_2. If used correctly, these principles encourage systems that reinforce, not replace, CO_2 decarbonization.

Challenges in Accounting for Short-Lived Climate Pollutants (SLCPs)

Before applying these principles, we first diagnose the accounting pitfalls they are meant to prevent. Responsible use of SLCP mitigations against long-duration emissions will necessarily address four core challenges.

Short-horizon metrics can over-emphasize SLCP mitigation impacts while CO_2's impacts endure

In contrast to CO_2 which has a moderate warming effect over a millennium, SLCPs have intense impacts over time periods ranging from just a few days to several decades. Therein lies the benefit: Climate impacts are frontloaded and lead to near-term harm reductions. This also means attempting to create appropriate comparability is tricky, and extremely sensitive to the time horizon used. In the case of methane, a mitigation project could issue three times the number of CO_2e credits by using GWP20 instead of GWP100. This creates a powerful incentive to choose shorter horizons, even if doing so leads to overestimated long-term climate impacts.

This dynamic is illustrated in **Figure 2**, which shows the integrated radiative forcing and temperature response of CO_2, methane, and nitrous oxide emissions. The figure highlights two crucial issues. First, CO_2 continues to accumulate and drive warming long after methane and other SLCPs have decayed, underscoring that SLCP mitigation cannot substitute for addressing CO_2. Second, reliance on GWP100 – the standard practice for mapping equivalency between CO_2 and other greenhouse gases (UNFCCC) – misrepresents their true climate impact. It underestimates the near-term benefits of SLCP mitigation, leaving value on the table for the next two decades, and overestimates their long-term equivalence to CO_2, masking the continued accumulation of CO_2 in the atmosphere. Together these distortions risk obscuring carbon budget overshoot and creating a false sense of long-term net zero.

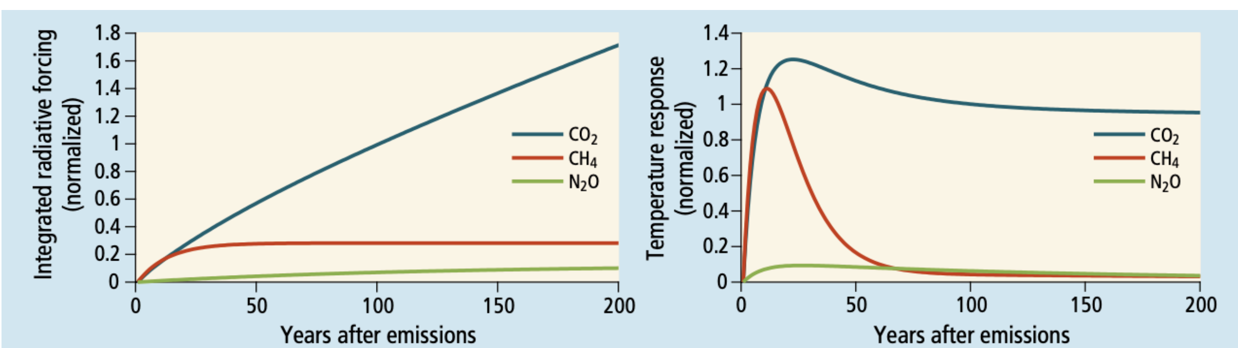

Figure 2: Implications of metric choices on the weighting of greenhouse gas (GHG) emissions and contributions by sectors for illustrative time horizons. Integrated radiative forcing (left) and resulting warming at a given future point in time (right) from global net emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in the year 2010, with no emissions thereafter, shown for time horizons up to 200 years. Integrated radiative forcing underpins Global Warming Potentials (GWPs), while warming at a given time underpins Global Temperature change Potentials (GTPs). Results are based on global 2010 emission data from WGIII 5.2 and absolute GWPs and GTPs from WGI 8.7, normalized to the 100-year impact of CO_2. Source: IPCC AR5 Report, page 88

Radiative forcing matching requires long-term commitments
One way to avoid the comparability issue is to match radiative forcing through time ("horizontal stacking") by purchasing a series of sustained methane mitigations so that the cumulative impact continuously counterbalances the forcing from a CO_2 emissions pulse. The science of this approach is sound. But it requires assurances on follow-through that may be challenging for organizations to credibly provide today. Since the radiative forcing benefits of SLCP mitigations are so short lived, full compensation for the CO_2 emissions implies continuous mitigation (and funding) for centuries. Another approach would be to eventually neutralize the emissions with durable carbon dioxide removal (CDR). This still introduces execution risks since the promised CDR procurement may not actually occur. If the long term obligation is not fulfilled for any reason, the burden is shifted to society.

Additionality and perverse-incentive risk
If SLCP projects are monetized to compensate for CO_2, additionality screens must be exceptionally strict. Otherwise fraud is guaranteed. We know this because it's already happened. Under the Kyoto CDM, lucrative crediting for HFC-23 destruction led to well-documented perverse incentives, where manufacturers started producing HFC-23 for the purpose of crediting its destruction (EIA, 2010). Today, an analogous feedstock squeeze and fraud risk is visible in "waste-based" fuels like used cooking oil SAF, where the price of used cooking oil is higher than virgin cooking oils, creating an incentive to produce more cooking oil for the sole purpose of generating biofuels (Swanson et al., 2024). An even greater risk: Without tight baselines, strong leakage tests, and policy-interaction rules, SLCP-for-CO_2 compensation can delay structural regulation, or catalyze the creation of more "mitigatable" emissions.

Balancing the books, but not the carbon cycle
National inventories and most climate target systems are built on a mass-balance of emissions, and long-term warming tracks cumulative CO_2. We will know when a country reaches net zero because the corresponding fluxes in their national inventory will balance. However, large-scale use of SLCP mitigation to compensate for CO_2 can make the aggregate CO_2e metrics appear neutralized, while the amount of CO_2 in the atmosphere and global average temperatures keep rising long-term. The result could be a larger long-term warming burden that must be addressed by CDR. It may also lead to poorer climate estimates, and may cause policymakers to believe net zero targets are on track while continuing to overshoot long-term temperature limits.

Principles for Short-Lived Climate Pollutant Accounting

While SLCPs and CO_2 should not be treated as interchangeable, in practice they often are. When this occurs, there are important considerations to ensure accounting remains scientifically robust and aligned with climate goals.

Rather than proposing or endorsing a methodology, we offer guidance for how to think about how to responsibly account for SLCPs when these interventions are used to offset or compensate for CO_2 emissions. These are intended to offer guardrails. They can provide clarity on what outcomes robust accounting should achieve, while leaving space for multiple approaches to emerge.

Independent Tracking of SLCPs From CO_2

Treating CO_2 and SLCPs as directly interchangeable in emissions inventories and reporting can create false equivalencies that obscure climate timelines, distort mitigation incentives, and undermine transparency. While it may be useful to express emissions in aggregated CO_2e terms for simplicity, climate accountability requires that SLCPs be tracked distinctly, even if SLCP mitigation is being used to compensate for CO_2 emissions. Otherwise, we risk meeting our climate goals on paper, while still seeing a rise in global average temperature.

Principle

Short- and long-lived greenhouse gases must be tracked and managed distinctly. Interchangeability is not justification for aggregation.

Outcome

Accounting systems maintain distinct ledgers for SLCPs and CO_2. Even when aggregate CO_2e values are reported, the underlying gases remain disaggregated so that claims, targets, and crediting structures clearly reflect the different warming profiles and timescales involved.

Success Indicators

- Separate crediting, reporting, and/or target tracking for SLCPs and CO_2 across inventories, registries, and climate plans.
- Transparent disclosures when SLCP mitigation is used to offset CO_2 emissions, including explicit justification of comparability assumptions.
- Net zero and interim climate goals specify which portion of reductions come from SLCPs versus CO_2 and other long-lived greenhouse gas emissions.
- Keeping separate records for each greenhouse gas means that if scientific methods or policy frameworks change in the future, mitigation claims can be reassessed accurately – even decades later.

Rationale

- The Oxford Offsetting Principles suggest that offsets for residual emissions should transition toward permanent removals, and using short-lived or temporary offsets is at best a short-term measure (with those offsets needing to be replaced or maintained over time) (Allen et al., 2020).
- Allen et al. (2022) argue that while aggregate CO_2e metrics can be retained, climate strategies should separately track progress on short- and long-lived greenhouse gases to reflect their distinct warming dynamics and policy implications.
- New Zealand climate policy set a separate methane target (reducing biogenic methane 24 - 47% by 2050) alongside net zero target for CO_2 and N_2O by 2050, explicitly acknowledging the difference between greenhouse gases (New Zealand Ministry for the Environment, 2024).

Radiative Forcing Should Match the Climate Claim

SLCPs behave very differently from CO_2 in the atmosphere. They exert intense warming over short periods of time but decay relatively quickly, whereas CO_2 persists for centuries. If climate benefits are reported without attention to these temporal dynamics, it can obscure meaningful differences in impact and accountability. SLCP mitigation is not inherently equal to CO_2 removal or mitigation unless their full radiative forcing impact is transparently addressed in magnitude and duration.

Principle

Climate benefits must be matched in both magnitude and duration. Radiative forcing reductions must match the warming impact of the emissions they are offsetting. For CO_2, that would mean selecting comparability metrics that attempt to closely match the full duration of atmospheric impact.

Outcome

Climate benefits are understood and communicated in terms of their timing, duration, and reversibility. SLCP mitigation activities are evaluated based on how well they match the duration and intensity of the CO_2 climate impact for which they are compensating. Both climate benefit and mitigation claims must be grounded in what is actually delivered from the intervention.

Success Indicators

- Comparability metrics used for applying SLCP mitigation reflect the full time horizon of damage caused by CO_2. As shown in Figure 2, only considering the first 20 or 100 years of impact significantly under-estimates the long-term radiative forcing and temperature impacts of CO_2 emissions. To fully capture all impacts, a comparability metric with a time horizon matching the duration of damage should be chosen, such as GWP1000 (matching the 1000 year durability estimate of CO_2).
- Temporal dynamics are disclosed through tools like crediting duration or depreciation, in which the offset value of an SLCP intervention declines over time to reflect that its climate benefit cannot neutralize the centuries-long persistence of CO_2.
- Accounting structures clearly prevent one-time, short-lived mitigation from being treated as equivalent to centuries of CO_2 warming.

Rationale

- Convention currently holds GWP100 as the standard for comparability with CO_2 and is codified in LCA standards as well as policy and international working agreements. Any solution for creating comparability must grapple with the implications of such short-term accounting when we think about the long-term implications on the planet. GWP100 does not get at the full warming potential of CO_2 over its lifetime in the atmosphere of thousands of years.
- If a company earns credits for reducing an ongoing source of methane emissions but then the project ends, the emissions that were being prevented may resume. Since methane only lasts about a decade in the atmosphere, concentrations adjust quickly to changes in emissions, meaning the avoided warming disappears soon after the project stops. Methodologies are starting to account for this. The American Carbon Registry's new protocol for plugging abandoned oil/gas wells limits crediting to a 10-year period, not indefinitely (Energy Law Blog, 2022).

Ensure Accountability Across Climate Timescales

Accountability in climate action is not just about the physics of warming, it's also about who carries responsibility over time. This creates a challenge for institutional accountability. Corporations and projects are often short-lived, but the climate obligations they incur are not. This mismatch risks offloading future responsibility onto actors who may no longer exist when that liability comes due.

Principle

SLCP mitigation used as a substitute for CO_2 or other long-lived greenhouse gas emissions must be paired with credible, long-term strategies to ensure full climate liability is addressed. These strategies should operate on timescales relevant to the institutions making the claims, with mechanisms in place to ensure longevity beyond the lifetime of any single actor.

Outcome

Short-lived mitigation is transparently managed across time scales. If used to compensate for CO_2, the mitigation strategy includes a plan to extend or replace short-term climate benefits with durable measures that align with the long-lived impacts of CO_2, ensuring that responsibility does not lapse even if the original actor disappears.

Success Indicators

- SLCP-based offsets for long-lived greenhouse gases include a defined timeline after which durable mitigation must replace the original intervention.
- When using horizontal stacking, replacement obligations are transparently documented, enforced, and transferable across entities.
- Financial reserves, pre-purchased durable removal, or insurance-like mechanisms are used to ensure long-term climate benefit is maintained.
- Emissions liabilities cannot be retired until the full radiative forcing they represent has been addressed.

Rationale

- Multiple efforts exist to responsibly address long-term emissions liabilities by pairing short-term interventions with durable governance or financial structures. An example is the concept of a Permanence Trust from the American Forest Foundation (Truitt and Riley, 2025), where an independent entity takes over monitoring, ongoing management, and liability for reversals after a set period in forestry projects.
- Nuclear waste remains hazardous for tens of thousands of years, far beyond the lifetime of a utility company. To address this, governments have created long term waste repositories like the Onkalo spent nuclear fuel repository in Finland, and legally binding funding mechanisms (e.g. decommissioning funds [US NRC, 2025], waste management trusts [National Resources Canada, 2025]) to prevent liabilities from being abandoned. While these structures show it is possible to govern long-lived risks beyond the lifetime of individual actors, they also illustrate the profound sustainability challenge of creating obligations that persist for generations.

- Since mining can often have damaging impacts on the local environment, governments sometimes require reclamation bonds (OSMRE, 2025) or escrowed cleanup funds (Secured Trust Escrow, 2024) be established up front to fund remediation of impacted land. These tools ensure long term industry obligations are met without requiring continued reliance on individual firms.

Align Accounting with Source and Context

If SLCP mitigation is used to compensate for CO_2, the accounting should reflect the context of the emission's source. Methane from oil and gas infrastructure, for example, often reflects avoidable leaks and wasted product, whereas methane from cattle farming arises from biological processes embedded in food systems and is tied to cultural practices. Treating these as equivalent risks incentivizing the creation of low-cost but temporary fixes, rather than permanent solutions. Continuing the example above, policy efforts to prevent methane leaks from orphaned wells might be hindered if mitigation credits from plugging them become a lifeline for ranchers to meet national climate targets.

Using SLCPs to offset CO_2 must reflect sector-specific, geographic, and socio-economic context of the source and mitigation pathway. This ensures that the interventions are leading to impacts in all abatable sectors, that co-benefits and trade-offs are appropriately considered, and that accounting frameworks remain consistent across diverse contexts.

Principle

SLCP accounting must reflect the specific characteristics of the emissions source and mitigation pathway, including project scope, regional conditions, and socio-economic context.

Outcome

When used to offset CO_2, SLCP accounting structures differentiate among sectors and contexts so that crediting and inventories reflect real-world conditions and continuous progress towards climate goals. Differentiation ensures that policy and market mechanisms reward interventions proportionally to their actual climate benefit.

Success Indicators

- Project scopes and monitoring, reporting, and verification (MRV) approaches are tailored to the characteristics of the source and mitigation intervention. In some cases, this requires sector-specific frameworks to ensure consistency.
- Explicit consideration of local equity, governance, and co-benefit impacts in crediting and target-setting.
- Differentiation between sources with distinct emission profiles and mitigation options.
- Transparent documentation of how sectoral differences influence crediting rules and fungibility with CO_2.

Rationale

- Cutting HFCs in refrigerators versus black carbon from cookstoves involves different technologies and socioeconomic factors. A single blunt methodology would risk obfuscating these differences.
- Each sector has distinct mitigation options. For example, in energy (oil & gas), improved leak detection and repair, venting bans, and equipment upgrades can cut methane by ~75%. Alternatively, in agriculture, methane comes largely from enteric fermentation (read: cow burps) and rice fields, which may require feed additives, breeding, and dietary shifts. The feasibility and cost vary significantly.
- COP28 outcomes illustrate sectoral unevenness: strong global progress on HFCs and oil/gas methane, but less attention to coal mining, waste-sector methane, and the unique challenges in agriculture (Rabe, 2024).

Enable Innovation Within Clear Boundaries

Achieving credible use of SLCP mitigation as an offset for CO_2 will require innovation. This may include new mitigation technologies, new financing models, and new accounting structures that better reflect the warming impact of short-lived pollutants. Flexibility to pilot and refine these approaches is essential. But innovation is only valuable if it preserves transparency, accountability, and climate benefit.

Principle

Encourage innovation in mitigation and accounting, bounded by safeguards that protect climate integrity and transparency.

Outcome

New methods, technologies, and accounting structures can be tested and adopted reasonably without compromising transparency, accountability, or long-term climate goals.

Success Indicators

- Transparent pilot structures with clear documentation of methods, baselines, and results.
- Adaptive management principles that allow for accounting models to evolve with new evidence.
- Independent review and public access to underlying data and assumptions.

Rationale

- We must acknowledge the need for flexibility and improvement over time. We are not yet perfect at measuring or mitigating SLCPs: we are far from it. For example, up until recently, methane emissions from oil and gas were seriously underestimated because of inadequate monitoring (Alvarez et al., 2018). New airborne and satellite methods corrected that. We can expect similar leaps in other areas (e.g., cheap sensors for landfills or new algorithms for attributing methane spikes to sources).
- The International Methane Emissions Observatory (IMEO) and the Methane Alert and Response System (MARS) are initiatives that aggregate measurement data and make it public to spur action. (UNEP, 2024; IEA, 2024). For example, by having something like

satellite data on major methane leaks publicly available, it empowers researchers, civil society, and regulators to identify problems and verify claims.

Conclusion

Mitigating SLCPs is a valuable way to reduce near-term warming, particularly when carefully integrated into broader net zero strategies. If treated as interchangeable with CO_2 reductions or removals without the right guardrails in place, these interventions risk obscuring differences in atmospheric behavior, misaligning incentives, and undermining progress towards net zero goals.

The principles outlined here provide a framework for responsibly using SLCP mitigation to compensate for CO_2 emissions. By embedding transparency, clear temporal alignment, and durable responsibility into accounting systems, SLCP mitigation can complement, rather than erode, long-term climate strategies.

Framed in this way, SLCP action is not a substitute for structural CO_2 decarbonization, but a critical complement to it, delivering rapid, near-term benefits while reinforcing the durability of long-term climate outcomes. Tackling SLCPs alongside CO_2 is not only necessary for atmospheric restoration, but also one of the most immediate opportunities we have to reduce harm and build resilience.

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