CLIMATE ANALYTICS

Clearing the air on methane: a global review of emissions, ambition and the policy landscape

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About Climate Analytics

Climate Analytics is a global climate science and policy institute. Our mission is to deliver cutting-edge science, analysis and support to accelerate climate action and keep warming below 1.5°C.

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Summary

Rapidly reducing methane emissions is critical to keeping the 1.5°C temperature limit within reach. Methane is a highly potent greenhouse gas, with a global warming potential roughly 28 times that of carbon dioxide over a 100-year period. Although its atmospheric lifetime is much shorter – about 12 years – its potency means that cutting methane can deliver rapid and significant climate benefits.

This report assesses emissions, targets, and policies for 72 countries that collectively account for over 90% of global methane emissions, providing a robust foundation for understanding progress and gaps in global methane mitigation efforts. All databases developed for this project are publicly available through the Global Methane Explorer.

The Intergovernmental Panel on Climate Change's Sixth Assessment Report makes clear that rapid methane reductions are essential. In pathways compatible with the 1.5°C limit, global methane emissions need to fall by 34% by 2030 and 40% by 2035, compared to 2019 levels. However, the world is not on track. Global methane emissions have continued to rise, reaching an average of 345 Mt CH_4 in 2022 and putting the world on a dangerous path compatible with 2.7°C of warming by the end of the century. Reversing this trend will require increased government ambition and concrete action to deliver deep, sustained methane reductions.

Measurement and reporting of methane emissions remain a significant challenge. Uncertainties in methane emissions stem from differences in measurement approach, methodology, and sector-specific challenges. These uncertainties directly impact the effectiveness of policies, the ability to evaluate outcomes, and efforts to track progress towards methane targets. They also hinder accountability for both governments and the private sector.

To assess both historic methane emissions data and associated uncertainties, this report draws on four major datasets – the Community Emissions Data System, the Emission Database for Global Atmospheric Research, the PRIMAP (HISTCR) national historical emissions dataset, and official country submissions to the United Nations Framework Convention on Climate Change. Through comparative analysis of these datasets, we provide a comprehensive view of global, sectoral, and national methane emissions trends.

Our analysis finds that agriculture is consistently the largest source of global anthropogenic methane emissions, followed by the energy and waste sectors, with waste being the fastest growing. Global emissions from waste increased by 4.8% between 2019 and 2022, accounting for 70% of the total growth in methane emissions during this period. Methane emissions are highly concentrated: China, the United States, and India are the largest emitters, together representing about one-third of global methane emissions in 2022. While some regions, including the European Union and the United States, have seen reductions in methane emissions since 1990, emissions continue to rise in most major emitters – namely countries with rapid population growth and expanding fossil fuel production. Despite differences in magnitude of emissions reported, the datasets show consistent trends in global, sectoral, and country-level emissions, though notable discrepancies remain, especially in the energy sector and for countries with less robust reporting systems.

While 81% of countries in our study include methane in their nationally determined contributions, only a small share (16%) has adopted methane-specific reduction targets. Our analysis of policies directly targeting methane emissions finds that implementation has accelerated in the past decade, with most active policies adopted since the late 2000s. Many countries have introduced policies to reduce methane emissions in the energy, agriculture, and waste sectors. However, some policies are stalled or have been rolled back, and several major emitters have adopted few or no direct methane mitigation policies in key sectors. Although policies take time to deliver results, the collective effort to date has not translated into a reduction in global methane emissions.

This report represents the first phase of an ongoing project to track and assess methane emissions. The next phase will identify global, sectoral, and country-level methane reduction pathways and assess the gaps between current emissions, targets, and policies, and what's required to align with the 1.5°C temperature limit. By evaluating these gaps and highlighting successful approaches, we aim to provide stakeholders with the evidence and tools needed to develop, advocate for, and implement stronger methane policies required to keep the 1.5°C goal within reach.

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Introduction

Limiting global warming to 1.5°C above pre-industrial levels is critical to avoiding the most severe impacts of climate change. While deep and sustained reductions in carbon dioxide are essential to peak global warming, rapidly cutting methane emissions is a crucial complement to limit peak warming as close as possible to 1.5°C within the next 25 years. Methane is a potent greenhouse gas, with a global warming potential (GWP) approximately 28 times greater than carbon dioxide over a 100-year period.[1] Despite its relatively shorter atmospheric lifespan of about 12 years, compared to centuries to millennia for carbon dioxide, its higher warming potential makes it a major driver of near-term warming. Reducing methane emissions can therefore deliver rapid and significant climate benefits. Notably, about 60% of the total methane reductions needed by 2030 can be achieved by curbing fossil fuel use, highlighting the relationship between efforts to reduce methane and carbon dioxide emissions, especially within the energy sector.

Global pathways consistent with the 1.5°C limit[2], as assessed in the Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report (AR6), highlight the urgency of methane mitigation. These pathways require global methane emissions to fall by 34% by 2030 and 40% by 2035 relative to 2019 levels, with energy-related methane emissions declining by 66% this decade.[3] However, since the release of AR6, global methane emissions have continued to rise. Getting on track for 1.5°C will therefore require a rapid scale-up of action this decade, followed by even faster reductions in the 2030s and beyond.

Methane's critical role in mitigating near-term warming is gaining attention, reflected in initiatives like the Global Methane Pledge (GMP). Launched at COP26 in 2021 by the European Union and the United States, the GMP is a voluntary commitment to reduce global methane emissions by 30% by 2030 relative to 2020 levels. With 159 signatories representing 58% of global methane emissions in 2023, it reflects a growing

[1] Over a 20-year period, methane has a GWP approximately 84 times greater than carbon dioxide, however using 20-year GWPs would attach more weight to short-lived pollutants and could further delay deep, sustained reductions in carbon dioxide. See Michiel Schaeffer et al., *Why Using 20-Year Global Warming Potentials (GWPs) for Emission Targets Are a Very Bad Idea for Climate Policy* (Climate Analytics, 2017).
[2] In our analysis, we use the C1a pathways from the AR6 report. These pathways are compatible with the long-term temperature goal of the Paris Agreement, which commits signatories to hold warming "well below 2°C" and pursue efforts to limit warming to 1.5°C. See IPCC, "Climate Change 2022 - Mitigation of Climate Change: Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change", ed. Intergovernmental Panel On Climate Change (IPCC), Cambridge University Press, 17 August 2023.
[3] Climate Analytics, *2030 Targets for 1.5C: Clarifying Ambition* (2023).

international commitment to tackling methane. Momentum was further reinforced by the Global Stocktake, concluded at COP28: paragraph 28(f) explicitly recognizes the need to accelerate and substantially reduce methane emissions by 2030. It also calls on Parties to align their next round of nationally determined contributions (NDCs) with pathways consistent with limiting warming to 1.5°C. Ambitious methane action is therefore recognized as an essential part of achieving these targets.

While the GMP and other initiatives are important milestones, achieving a 1.5°C-aligned pathway will require even steeper reductions and concrete action. The continued rise in global methane emissions underscores the need for governments to transition from pledges to policies that deliver measurable results this decade.

With the support of the Global Methane Hub and to monitor implementation of the GMP, Climate Analytics is tracking national methane emissions, targets, and policies for countries accounting for 90% of global methane emissions and evaluating alignment with the GMP and 1.5°C pathways. This report summarizes findings from the first phase of this project, where we developed comprehensive databases of methane emissions, targets, and policies for countries representing 90% of global methane emissions. These databases are accessible through our Global Methane Explorer.

These databases provide valuable insights to advance effective and meaningful action on methane emissions by creating a comprehensive foundation for evidence-based decision-making. The emissions database unpacks the uncertainties and variations in methane emissions estimates that hinder effective policy planning and progress tracking. By analysing and comparing multiple datasets, this project aims to bring clarity to the differences across emissions estimates–both historical and projected–while identifying consistent underlying trends. This approach offers policymakers, researchers, and advocates transparent and detailed data to more accurately track methane levels over time.

Complementing this, the targets and policies databases collate detailed information about the ambition and actions of countries, illuminating gaps between commitments and implementation while cataloguing successful approaches that can be adapted across countries and regions. Together, these resources will equip stakeholders with the detailed information they need to develop, advocate for, and implement stronger methane measures aligned with global climate goals.

This report is organized as follows. Section 2 takes a deep dive into methane emissions data, examining global, sectoral, and national trends across multiple datasets and discusses measurement and reporting challenges. Section 3 presents findings from our target database, summarizing countries' methane reduction commitments. Section 4 details the policies across the energy, waste, and agriculture sectors.

Methane emissions

In this section, we begin by providing important context on the issue of uncertainty in methane emissions estimates, outlining the main challenges and implications for data accuracy and policy. Next, we introduce the four major datasets used in our assessment, detailing their methodologies and sectoral coverage. We then explore historical, sectoral, and country-level trends in global methane emissions, using these datasets to illustrate how emissions have evolved over time and how current trajectories compare with global climate targets. Finally, we unpack the differences in emissions estimates across these datasets, highlighting how methodological choices and data coverage affect reported values.

Methane measurement and uncertainty

Despite significant advances in methane emissions monitoring, reporting, and verification, persistent uncertainties in methane emissions data limit the accuracy of both inventories and models, hindering policy development, implementation, and progress tracking.

Several factors contribute to the uncertainty in methane emissions estimates. The sections below explore key sources of uncertainty related to anthropogenic methane emissions across measurement approaches and sectors. While our analysis centres on these human-driven sources, it is worth noting that natural sources of methane emissions, particularly from wetland and inland water systems, remain even more uncertain.[4] These natural sources, however, are outside the scope of our study.

Key sources of uncertainty across measurement approaches

Large variations in methane emission estimates arise from the choice of measurement approach. Both bottom-up and top-down measurement approaches have been developed for methane emissions estimations.[5] It is important to note that uncertainties arise at each step of the emissions calculations and compound through the calculation chain.

[4] Marielle Saunois et al., "Global Methane Budget 2000–2020", *Earth System Science Data* 17, no. 5 (2025): 1873–958.

[5] David T. Allen, "Methane Emissions from Natural Gas Production and Use: Reconciling Bottom-Up and Top-Down Measurements", *Current Opinion in Chemical Engineering* 5 (2014): 78–83.

Bottom-up approaches

Historically, most methane measurement has been based on bottom-up approaches, which typically use activity data and emission factors to estimate methane emissions.[6] An example of bottom-up methodologies are the emission inventories countries provide under their commitment to the United Nations Framework Convention on Climate Change (UNFCCC). The reporting methodology is stacked into different tier approaches based on the significance of emission sector subcategories and the detail of available data. A Tier 1 approach is the most simplified approach – typically using default IPCC emission factors and basic activity data – but also comes with significant uncertainties that can be up to an order of magnitude.[7] Tier 2 uses country- or region-specific emission factors and more detailed activity data, improving accuracy. Tier 3, by contrast, employs direct monitoring or advanced modelling at the facility or process level, offering the highest accuracy but requiring more resources and technical capacity.

Bottom-up approaches, like those used in national inventories and compiled in datasets such as PRIMAP, are specifically designed to produce coherent and consistent time series of emissions for countries. The primary goal is to enable the assessment of progress in emissions reductions and climate action at the national level, in line with government pledges and international commitments. These inventories are structures to provide sectoral emission trends as required by UNFCCC and IPCC reporting guidelines, ensuring that changes over time can be reliably tracked within and across key sectors. This means that, alongside estimating the absolute magnitude of emissions, ensuring the coherence and reliability of emissions trends over time is equally important for assessing progress and informing policy decisions. As a result, uncertainty in these inventories impacts both the emissions totals and the trends that underpin national and international climate assessments.

Emission factors

The IPCC defines emission factors as the “coefficient that quantifies the emissions or removals of a gas per unit of activity.”[8] They are used in bottom-up emission inventories to estimate the emissions from given data on the activity and operating conditions. The choice of emission factor depends on the sector for which emissions are calculated. Within sectoral estimates, further activity information, such as amount and size of operation, is taken into account when choosing the appropriate emission factor. The choice further depends on the detail of the available data. Data availability and quality is

[6] Intergovernmental Panel on Climate Change, *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006).
[7] Intergovernmental Panel on Climate Change, *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2006).
[8] Intergovernmental Panel on Climate Change, *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC, 2019).

mostly a question of capacity. Many governments do not have the resources to accurately monitor and assess large datasets to use for their emissions inventories.

Apart from the uncertainty arising from infilling data by using emission factors on a small sample of sources, another source of uncertainty is outdated emission factors. An example of the consequences of using outdated emission factors is observed in Germany's coal mining sector. Ember[9] analyses the potential systematic underestimation of emissions from this sector, with satellite-based, top-down measurements suggesting actual emissions could be as high as 28 to 200 times higher than officially reported. Among other issues, the report attributes the large discrepancy to an outdated, unverified emission factor from 1989.

Regularly updating both activity data and emission factors is essential for keeping inventories up to date. As economic activities and technologies change over time, and research and measurement approaches improve, outdated data can lead to misleading results that undermine confidence in emissions data.

Top-down approaches

Increasingly, top-down measurement methods are being used to complement bottom-up approaches and more accurately estimate methane emissions. In top-down approaches, source emissions are inferred from processing atmospheric concentration data from a range of mounted measurement technologies, including on aircraft and satellites. For example, the MethaneAIR project uses an airborne spectrometry sensor to map methane emissions in the United States. Data collected in 2023 showed that oil and gas operators had underreported their emissions by a factor of at least four and exceeded industry goals by a factor of at least eight.[10]

Other top-down measurement tools, such as satellites, can monitor emissions at various resolutions. Global mapping satellites like TROPOMI detect emissions over large areas and major point sources, whereas satellites such as GHGSat and Carbon Mapper can attribute emissions to specific facilities. Together, these satellite initiatives are enhancing the monitoring and verification of methane emissions worldwide.

Uncertainties in top-down estimates are directly related to uncertainties in the observation instrumentation and methodology, as well as the model assumptions used to convert concentration data to fluxes. Factors such as instrument differences, calibration, environmental conditions, and timing of measurements all influence results. Methane emissions can vary between day and night as well as seasonally, so measurement schedules and revisit times are important for accurately capturing

[9] Sabina Assan, *Urgency to Update Germany's Coal Mine Methane Emission Factor* (Ember, 2024).
[10] Environmental Defense Fund, "Methane Loss Rate Is Eight Times Greater than Industry Target", 31 July 2024.

emissions. Emissions measurements can be differentiated by their spatial and temporal scale. At the spatial level, measurements can be taken at the individual facility level, at a regional level by sensors mounted on vehicles or aircraft, and at the regional to global scale by sensors integrated on satellites. At the temporal scale, measurement can be taken continuously, at specific time intervals, or sporadically.[11]

Conceptually, top-down approaches are not currently designed to meet the same objectives as bottom-up approaches. While bottom-up inventories are structured to provide coherent, sectorally-detailed time series for tracking national progress and informing policy, top-down methods are primarily intended to provide independent estimates of point, facility, or small area sources of emissions.[12] These independent measurements can be used to improve the overall accuracy of methane estimates by identifying discrepancies, validating reported values, and highlighting potential gaps or uncertainties in bottom-up estimates. For example, preliminary results from Open Methane, which uses a combination of satellite measurements and atmospheric modelling, indicate that methane emissions from Australia's fossil fuel sites could be around double what is currently being reported under the National Greenhouse and Energy Reporting Scheme. As such, top-down estimates can serve as a valuable complement to bottom-up inventories, supporting more robust emissions estimates[13] and playing an increasingly important role in the monitoring, reporting and verification of National Greenhouse Gas Inventories and source level emissions.[14] However, to ensure meaningful comparisons between these approaches, it is essential to carefully define and understand the geographic scope and system boundaries of the data, as differences in these parameters can significantly affect results.[15]

Hybrid approaches

Top-down and bottom-up approaches each play important roles in methane estimation, though each has its own limitations. Combining these approaches in a hybrid strategy can enhance the accuracy and completeness of methane emissions estimates. For example, Canada's integration of atmospheric measurements for oil and gas operations

[11] Engineering National Academies of Sciences and Medicine, *Improving Characterization of Anthropogenic Methane Emissions in the United States* (The National Academies Press, 2018).
[12] The Superpower Institute, *Groundbreaking Satellite Monitoring Tool Shows Significant Underestimation of Methane Emissions from Fossil Fuel Sites* (2024).
[13] Ana Maria Roxana Petrescu et al., "Comparison of Observation- and Inventory-Based Methane Emissions for Eight Large Global Emitters", *Earth System Science Data* 16, no. 9 (2024): 4325–50.
[14] European Gas Research Group, *Methane Emissions: Best Practices in MRV and Abatement in the Agriculture, Energy and Waste Sectors*, Input to European Commission's Workshop, 9th of June (European Gas Research Group, 2020).
[15] Petrescu et al., "Comparison of Observation- and Inventory-Based Methane Emissions for Eight Large Global Emitters."

into its 2024 national inventory led to a reported increase of 25-54% in methane emissions from these facilities over the past decade.[16]

Hybrid approaches can help fill data gaps and increase confidence in emissions estimates[17]. For instance, in regions with limited ground-based measurements, a top-down method using satellite data can provide valuable coverage. At the same time, bottom-up approaches using national activity data can support efforts to distinguish between anthropogenic and natural sources, something top-down measurements struggle to do. However, when integrating top-down and bottom-up data, it is important to consider differences in spatial and temporal scales to enhance accuracy.[18]

Sector-specific measurement challenges

Energy

In the energy sector, a significant source of uncertainty is the choice of emission factors. Their selection depends on at least three considerations: type of fossil fuel extracted (oil, gas and/or coal), extraction methodologies and transport and processing techniques. Critical variables include venting practices at oil and gas wells, leakage rates from distribution infrastructure (pipelines, ships, trucks), maintenance routines, and the intrinsic characteristics of the fuel deposits themselves. The level of available data on these variables determines the level of confidence when assessing methane emissions in the energy sector.

Furthermore, there are significant uncertainties about methane emissions from abandoned oil and gas infrastructure, as fugitive methane can leak from these wells, even after they are plugged. There are wide ranging estimates on the number of abandoned wells and their emissions rates. For example, Riddick et al (2019)[19] estimated the potential sources to be between 60.000 and 760.000 in West Virginia, US., with mean leakage rates of 16g/h for more recently abandoned wells and 0.003g/h for wells abandoned before 1993. Another study conducted on 103 wells in the United Kingdom, with ages ranging from 8 to 79 years old since drilling, estimated emissions of 364 ± 677Kg/CO_2eq/well/year based on methane presence on soils, with 27% of probability of them being net methane sinks.[20]

[16] Ari Pottens and Scott Seymour, "Improving Canada's Emissions Inventory: Direct Methane Measurement Makes Its Debut," *EDF Blogs*, 14 June 2024.
[17] National Academies of Sciences, *Improving Characterization of Anthropogenic Methane Emissions in the United States.*
[18] Petrescu et al., "Comparison of Observation- and Inventory-Based Methane Emissions for Eight Large Global Emitters."
[19] Stuart N. Riddick et al., "Measuring Methane Emissions from Abandoned and Active Oil and Gas Wells in West Virginia", *Science of The Total Environment* 651 (February 2019): 1849–56.
[20] I.M. Boothroyd et al., "Fugitive Emissions of Methane from Abandoned, Decommissioned Oil and Gas Wells", *Science of The Total Environment* 547 (March 2016): 461–69.

Agriculture

Variability in agriculture methane emissions can arise from differences in animal diet, livestock species, cultivation practices, and environmental factors – such as conditions that influence microbial activity. Differences in the management of animals, soils, and manure can significantly impact emission rates. In particular, how manure is distributed and managed can either reduce or increase emissions.[21]

When reporting agriculture emissions in inventories, activity data often does not deliver the necessary level of information required to accurately assess methane emissions, given the many sources of variability described above.

Waste

Waste sector emissions are influenced by both the types of waste disposal methods used and the diversity of pollution sources, making them difficult to capture with the simple emission factors often used in national emissions inventories. Waste generation is highly variable in both volume and composition, and local physical conditions—such as temperature and humidity – significantly impact decomposition rates and methane production. For example, Chen et al (2020)[22] found that sewer carbon emissions are highly dependent on sediments, aquatic dissolved organic matter, and sewage sources. However, such detailed data are not available at the national level, making it difficult to accurately assess country level waste – sector emissions.

Attempts to quantify methane emissions from waste, especially at municipal solid waste landfills, have highlighted the role of compounding uncertainties in methane emission calculations. When calculating waste emissions using the default IPCC methodology, total national emissions are estimated based on several parameters. Research has shown that the uncertainty introduced by the parameters can compound, so that a 10% uncertainty in the input parameters may lead to a 20% uncertainty in the final emissions estimates.[23]

Implications of measurement challenges

Uncertainties in methane emissions have wide-ranging implications for climate policy. Reliable data is essential for designing effective policies, evaluating their outcomes, and

[21] National Academies of Sciences, *Improving Characterization of Anthropogenic Methane Emissions in the United States.*

[22] Hao Chen et al., "Variations in CH4 and CO2 Productions and Emissions Driven by Pollution Sources in Municipal Sewers: An Assessment of the Role of Dissolved Organic Matter Components and Microbiota", *Environmental Pollution* 263 (August 2020): 114489.

[23] Mingxi Du et al., "Quantification of Methane Emissions from Municipal Solid Waste Landfills in China during the Past Decade", *Renewable and Sustainable Energy Reviews* 78 (October 2017): 272–79.

tracking emissions reduction progress. When emissions inventories are uncertain, there is a risk of over – or underestimating emissions sources. This can lead to policies that fail to target the most significant sources or are not ambitious enough to meet targets.

Policy implementation is also directly impacted by measurement challenges. For example, mechanisms like carbon markets and methane pricing schemes depend on accurate emissions data to set appropriate prices, allocate allowances, and monitor compliance. If methane cannot be reliably measured, it becomes difficult to enforce these mechanisms, undermining their effectiveness and credibility.

For policy evaluation, measurement uncertainty makes it challenging to assess whether interventions are delivering the intended emissions reductions. This also complicates efforts to track progress towards methane targets. These uncertainties also hinder accountability for both governments and the private sector. Without robust and transparent methane data, it is difficult to hold emitters responsible.

Finally, changes in measurement methodologies further complicate this landscape, especially when comparing old and new emissions inventories. Changes in the methodology need to be communicated clearly to avoid misleading comparisons over time.

Datasets

This initial assessment focuses on bottom-up approaches, drawing on multiple datasets to improve coverage, consistency and cross-validations across countries and sectors. Following extensive research, we included four datasets in this first phase of the project. A summary of the datasets and their methodologies are outlined in Table 1 and the section below.

Summary of datasets

	Full name	Sectors covered	Years covered	Methodology
PRIMAP v2.6 (HISTCR)[24]	PRIMAP-hist Historical Emissions Dataset, version 2.6 (HISTCR)[25]	Agriculture, Energy, Waste and Others	1750-2023	**Harmonized estimates of methane emissions across multiple sectors, primarily relying on country reported national inventories submitted to the UNFCCC**. The harmonization process involves aligning and integrating data from diverse reporting systems to ensure consistency, comparability, and completeness. Key steps include resolving differences in sectoral classifications, units, and reporting years, as well as applying gap-filling techniques and cross-checking with alternative datasets (e.g., EDGAR, EPA, FAOSTAT) when national reports are incomplete or inconsistent.
EDGAR_2024_GHG[26]	Emission Database for Global Atmospheric	Agriculture, Energy and Waste	1970-2023	**Globally harmonized emissions data, integrating both national and international datasets**. It relies on activity data from international databases like FAOSTAT and applies scientific adjustments and estimation techniques to ensure completeness and comparability across countries and years, for missing or underreported data.
CEDS v_2024_04_01[27]	Community Emissions Data System, version 2024/04/01	Energy, Agriculture, Waste and Others	1970-2022	**Methodology framework combining national inventory data with systematic scaling and gap filling techniques, with international sources such as EDGAR**. The framework begins with country-level reported emissions where available, then harmonizes and extends these using proxy activity data and default emission factors to ensure completeness and temporal consistency. In cases of missing, inconsistent, or outdated national data, emissions are scaled to match international datasets or filled using modelled estimates.

[24] Johannes Gütschow et al., "The PRIMAP-Hist National Historical Emissions Time Series (1750-2023) v2.6", version 2.6, Zenodo, 13 September 2024.
[25] PRIMAP also provides a historic dataset that prioritizes third-party sources over country reported data (HISTTP). However, this report uses PRIMAP's HISTCR, which prioritizes country-reported data over third-party sources.
[26] European Commission et al., *GHG Emissions of All World Countries: 2024*, EDGAR Database (Publications Office of the European Union, 2024).
[27] Hoesly, Rachel and Steven Smith, "CEDS V_2024_04_01 Release Emission Data", version v_2024_04_01, Zenodo, 1 April 2024.

	Full name	Sectors covered	Years covered	Methodology
UNFCCC 2025	National Inventory Submissions 2024	Energy, Agriculture, Waste	1990-2023	**Country-reported inventories submitted to the UNFCCC, in accordance with the 2006 IPCC guidelines and its subsequent refinements.** The data are drawn primarily from Biennial Transparency Reports (BTRs), National Inventory Reports (NIRs), and Common Reporting Format (CRF) tables submitted by Parties. These inventories include detailed, sectoral methane (CH_4) emissions estimates compiled using nationally appropriate activity data and country-specific or IPCC-default emission factors.

Table 1: Summary of datasets included in our assessment of historic methane emissions, including sectors covered, years covered, and methodology.

The PRIMAP dataset combines several published datasets to produce a comprehensive time series of annual greenhouse gas emissions for all countries. Its HISTCR scenario prioritizes emissions data officially reported to the UNFCCC, filling gaps – whether for years or sectors – with third-party sources such as the Carbon Dioxide Information Analysis Center (CDIAC), Energy Institute, FAOSTAT, and the Emission Database for Global Atmospheric Research (EDGAR) database.

In contrast, the EDGAR database uses globally harmonized activity data, often derived from international databases like PRIMAP. While PRIMAP (HISTCR)[28] uses more detailed Tier 2 and Tier 3 methodologies – incorporating national emission factors that are reviewed by the UNFCCC and are internally robust – EDGAR applies a Tier 1 approach based on default IPCC emission factors to ensure global consistency. As a result, there can be significant differences between the two, as EDGAR does not use the country-specific emission factors, activity data, and technologies reflected in the higher-tier methodologies used by PRIMAP.

In the Community Emissions Data System (CEDS) methodology, default estimates are firstly sourced from activities involved in key sectors with help of third-party databases, mainly applying energy statistics from the International Energy Agency (IEA) and emission factors derived from (GAINS) for combustion data, EDGAR for non-combustion data, and CDIAC for CO_2.

Sectoral classification and coverage also differ across these datasets. For instance, CEDS often reports higher energy sector values compared to other datasets due to its inclusion of indirect emissions from fossil fuel operations. PRIMAP (HISTCR) reports the lowest emissions, due to its reliance on national inventories, which may underestimate

[28] HISTCR - Historically Country Reported

fugitive emissions from fossil fuel systems. In the waste sector, CEDS's higher estimates come from the inclusion of sub-sectoral or sectoral activities like unmanaged landfills, combustion of waste and handling of non-industrial waste. EDGAR, in contrast, relies on documented landfill sites, and PRIMAP (HISTCR) relies on national inventories. Annex A provides more detail about the differences in sectoral coverage across the four datasets.

Finally, there are also important methodological differences across datasets. For instance, the UNFCCC database compiles greenhouse gas emissions data from the National Greenhouse Gas Inventories (NGHGI), which are submitted by individual countries and then reviewed prior to publication. In contrast, PRIMAP (HISTCR) primarily uses these inventories, but applies harmonization, adjustments, and gap-filling methods to ensure completeness over time. Other datasets, like CEDS and EDGAR have developed their own conventions and apply their own methodology to estimate emissions as mentioned above. These datasets have adopted their own emission factors and methodologies in line with IPCC guidelines and other sources to scale and fill the missing gaps. While these approaches provide complementary perspectives and help in filling data gaps, they result in differences in how emissions are quantified and reported. As a result, discrepancies arise when comparing across datasets, reflecting the variations in methodologies and frameworks adopted by the databases.

Though there are many differences between the datasets, this does not mean they are fully independent. There is considerable overlap between them due to several key factors. First, many global datasets rely on the same or similar primary sources such as IEA energy statistics and IPCC emission factors. National greenhouse gas inventories in contrast, are compiled and reported separately under the UNFCCC framework. Within the UNFCCC reporting system, countries may choose among different methodological tiers (Tier 1, 2, or 3) when estimating emissions. While Tier 1 uses default emission factors, many industrialized countries employ Tier 2 or Tier 3 approaches, which involve more detailed, country- or source-specific emission factors. Regardless of the tier used, all reported estimates are often incorporated into global databases, resulting in overlapping information and a degree of interdependence among datasets. Some datasets, like CEDS and PRIMAP (HISTCR), explicitly incorporate or adjust data from one another, which further reduces their independence. Second, some datasets harmonize with others by using their data to scale and fill gaps. For example, CEDS bases its estimates and emission factors from EDGAR data and aligns with national inventories, while PRIMAP (HISTCR) builds directly on UNFCCC submissions and supplements them with external sources, some of which originate from the datasets mentioned above. Additionally, these datasets often apply comparable frameworks and estimation approaches[29], typically adhering to Tier 1 guidelines as a base for emission estimation. This contributes to alignment in emission estimates despite differences in data sources or processing techniques.

[29] Datasets following IPCC Tier 1 guidelines: CEDS, EDGAR

As a result, observed differences in these datasets, except UNFCCC, often reflect their methodological and harmonization strategies. For comparative analysis, these factors must be carefully considered, as they limit the extent to which differences across datasets can be interpreted or analysed.

Global methane emissions trends

Historical total emissions trends

Global methane emissions have been rising steadily since the beginning of the industrial revolution. Figure 1 shows emissions trends between 1990, the starting point of our time series, and 2022, the last available year, for our three datasets with complete global emissions: CEDS, EDGAR and PRIMAP 2024.

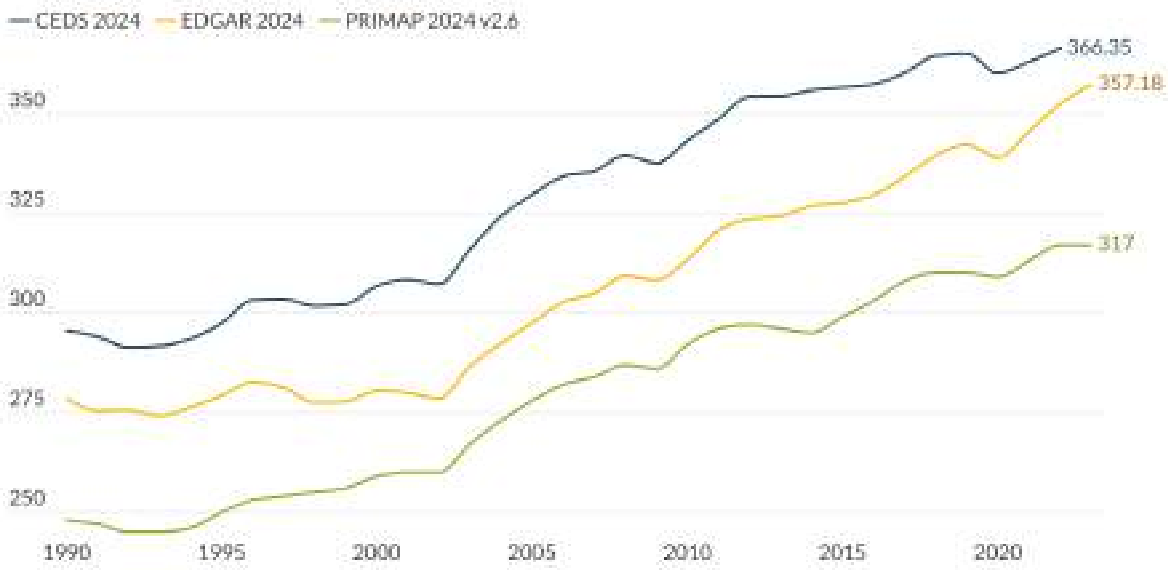
The trends demonstrate a significant increase in global methane emissions, though estimates vary in magnitude. Mean emissions have increased from 274 Mt CH_4 in 1990 to 345 Mt CH_4 in 2022, an increase of 26%, driven by the expansion of fossil fuel extraction, growing demand for agricultural and livestock products, and increased waste generation.

While slightly lower, these numbers align with the Global Methane Budget report, which estimates total methane emissions from bottom-up studies at 372 (345-409) Mt CH_4 in 2020. This persistent rise in emissions has led to a corresponding increase in atmospheric methane concentrations, which, according to the World Meteorological Organization, reached 1943 parts per billion in 2024—an increase of 166% above pre-industrial levels.[30]

[30] World Meteorological Organization, *Carbon Dioxide Levels Increase by Record Amount to New Highs in 2024*, Press release (2025).

Figure 1: Historic trends in global methane emissions

Global CH_4 emissions from different datasets



Annual global emissions of methane (CH_4), measured in megatons of CH_4.

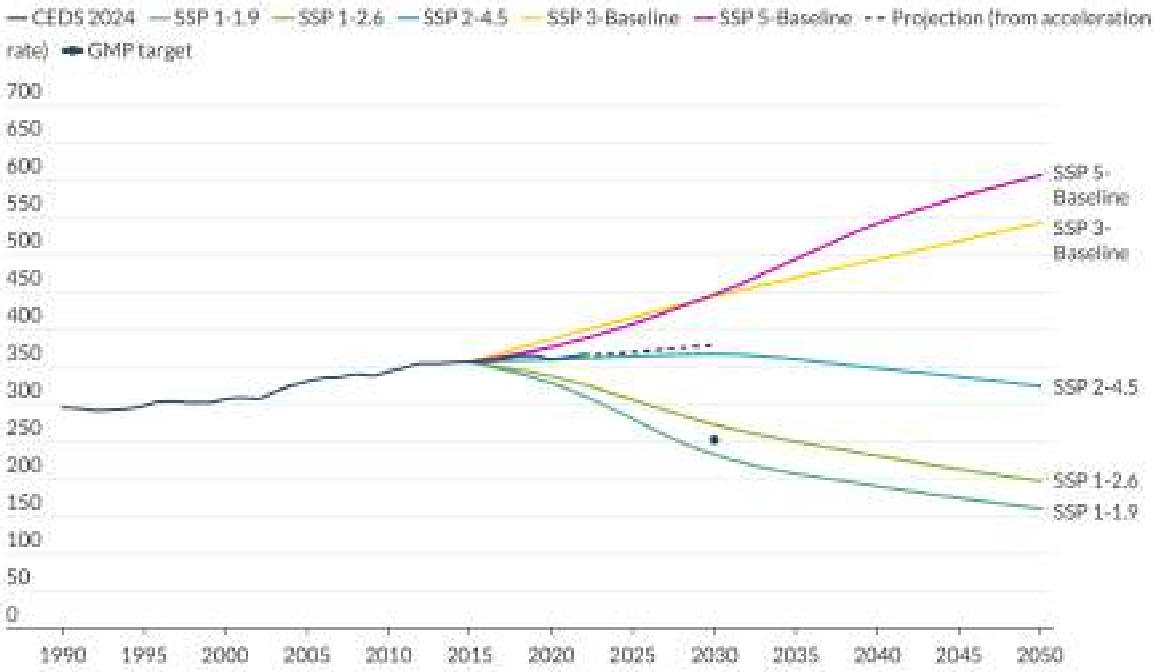
To understand how these historical trends compare with the Global Methane Pledge and with IPCC Shared Socioeconomic Pathways (SSP), we extended the average linear trend between 2012 and 2022 to project emissions through to 2030 (Figure 2). If emissions continue on the same trajectory as the past decade, emissions will increase by 6% by 2030, compared to 2020. This divergence highlights a significant gap, suggesting that, without stronger policy action, the world will be significantly off track from the GMP 2030 goal.

Furthermore, comparing this trend with the methane trajectories from IPCC SSP scenarios shows that historical emissions are closely following the SSP2-4.5 pathway, which results in around 2.7 °C of global warming by the end of the century. This scenario is considered as a middle-of-the-road scenario, where current policies and NDCs are largely maintained.[31] This suggests that current trends remain aligned with intermediate rather than low-emissions futures. It is important to note, however, that methane alone does not determine global temperature outcomes – these projections are shaped by combined trajectories of all major greenhouse gases, notably CO_2, and other gases. However, actions to reduce one gas often also work to reduce another. For example, in the energy sector, switching from fossil fuels to renewables not only reduces CO_2 emissions from combustion, but also cuts methane emissions associated with the extraction, processing, and transport of oil and gas.

[31] Climate Action Tracker, *CAT Thermometer* (2024).

Figure 2: Historic emissions compared with SSP scenarios

Historical emissions from the datasets CEDS, compared with Shared Socioeconomic Pathways harmonised in 2015 with CEDS, in Mt CH_4.



Annual global emissions of methane (CH_4), measured in megatons of CH_4.

Source: ARA Scenarios Database hosted by IIASA, 2022.

As Figure 2 illustrates, the modelled pathway for achieving the 1.5°C target assumes an immediate decline in methane emissions from 2015. However, emissions have continued to rise, creating a growing gap between historic trends and modelled pathways. Differences in historical emissions data across datasets further complicate this picture, as each dataset presents a different baseline and trend over time, which can meaningfully impact how modelled pathways are constructed and evaluated.

As a result, the original pathways may no longer accurately reflect the actual trajectory of methane reductions required, due to a much higher starting point with current emissions levels. This potentially affects the slope of the curve and the timing, pace, and scale of future reductions.

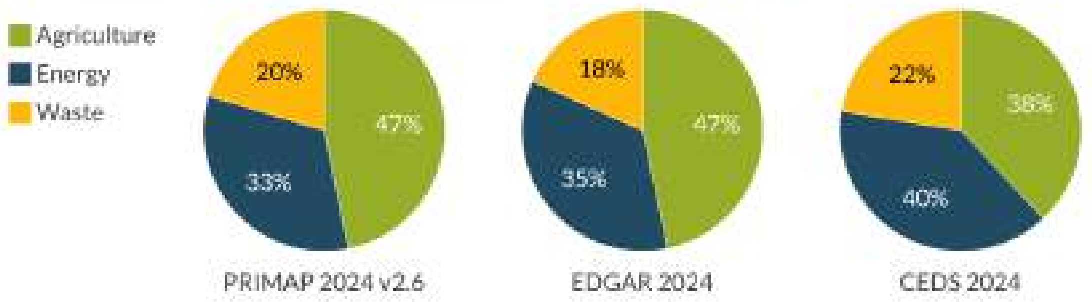
These discrepancies highlight the urgent need for both rapid and sustained methane reductions, as well as for regularly updating methane pathways to accurately reflect the latest emissions data. Only by clearly understanding the current gaps and adjusting pathways accordingly can policymakers and stakeholders understand the pace and scale of action required to limit global warming as close as possible to 1.5°C. We will be addressing these questions in the next phase of this project.

Historical sectoral emissions trajectories

As discussed in previous sections, substantial differences in sector-specific methane emissions arise from how activity levels are quantified and which source-specific emission factors are applied. These methodological differences contribute to large uncertainties across existing inventories, particularly for the energy and agriculture sectors.

Nevertheless, despite differences in the magnitude of emissions reported by each dataset, the overall findings and underlying trends are largely consistent. This consistency provides valuable insights into both the relative contributions of each sector and the patterns of methane emissions over time. For instance, in all datasets, the agriculture sector is by far the largest emitter in 2022, followed by the energy and waste sectors (Figure 3).

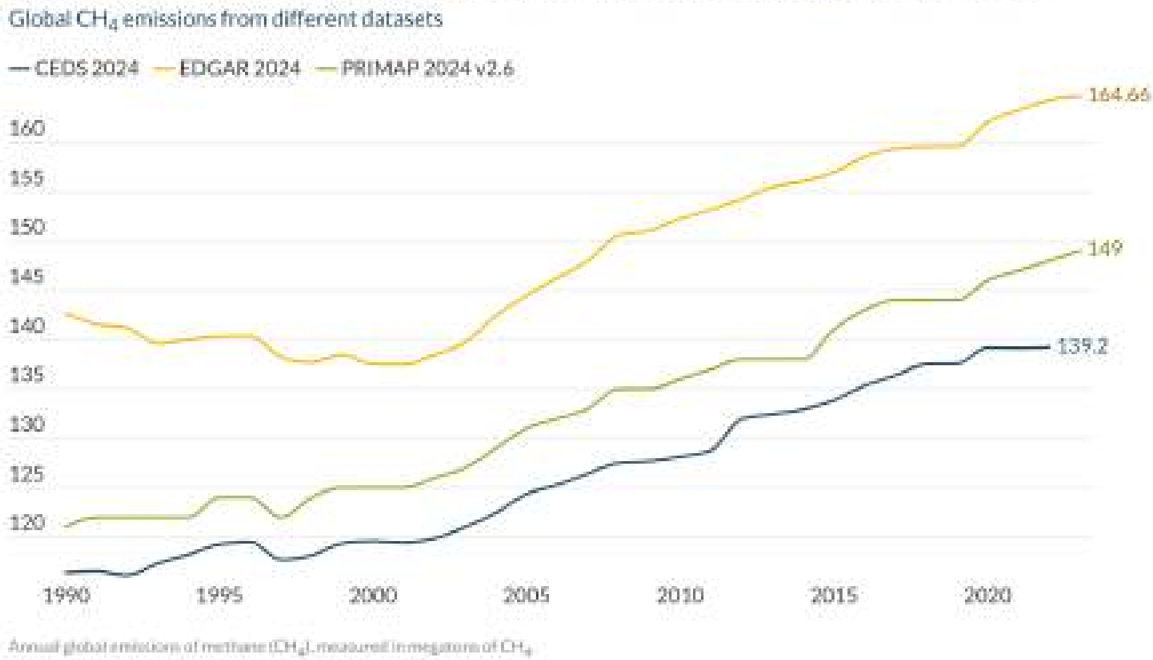
Figure 3: Share of emissions across sector globally



Turning to sectoral trends, Figure 4 illustrates the steady increase in methane emissions from the agriculture sector between 1990 and 2022 across all datasets, with agriculture accounting for 44% of global methane emissions in 2022. We can observe that emissions trends and structure in the last years, after 2015, are very similar between EDGAR and PRIMAP, showing both a similar emissions dip during COVID-19, and clear increase. In 1990, average methane emissions were estimated at 127 Mt CH_4, reflecting lower agricultural activity compared to 2022, where average emissions reached 150 Mt CH_4. This increase over time is driven by population growth, rising food demand and intensification of agricultural practice. This underscores agriculture's growing contribution to global methane emissions.[32]

[32] Xuelei Cheng et al., "Impacts of Production Structure Changes on Global CH4 Emissions: Evidences from Income-Based Accounting and Decomposition Analysis", *Ecological Economics* 213 (November 2023).

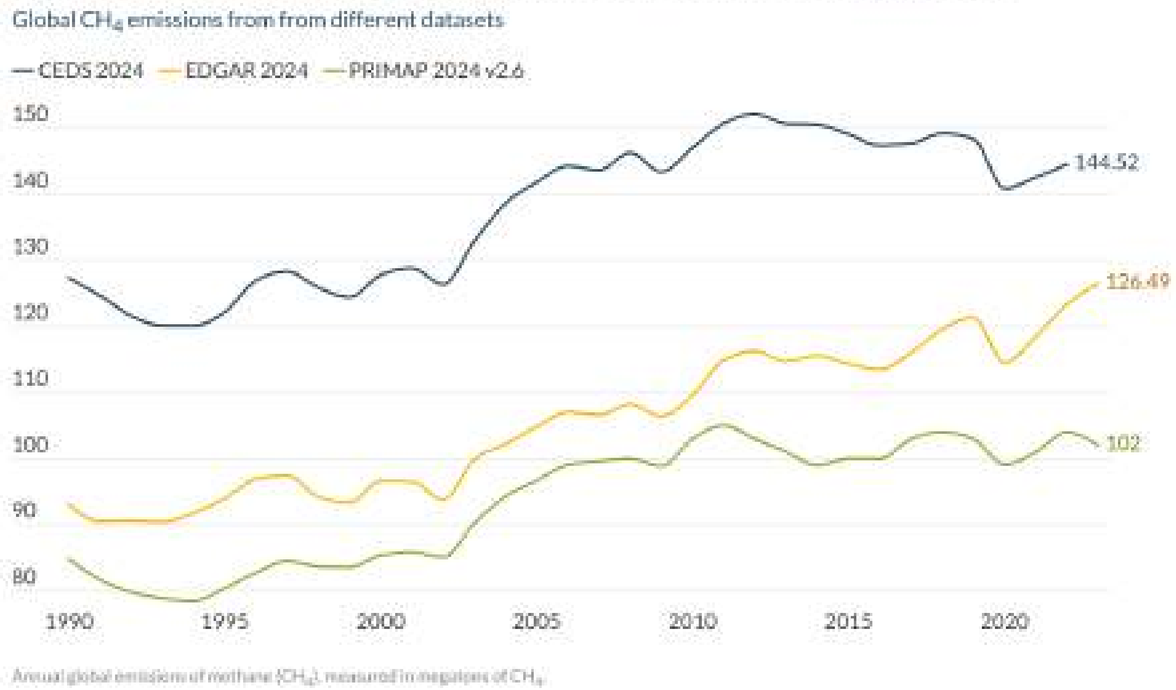
Figure 4: Historic trends in global methane emissions in the agriculture sector



Similarly, global energy-related methane emissions have also increased relative to 1990 levels, though with more fluctuations over time (Figure 5). From 1990 to 2011, all datasets in our analysis show an increase in emissions, followed by a stabilisation period between 2011 to 2022. In 2020, all datasets show a dip in emissions, likely because of the COVID-19 pandemic. In addition, in the last years, we see an increase of emissions from EDGAR and CEDS after the 2020 dip, while PRIMAP remains relatively flat. Overall, the increase of average emissions from 103 Mt CH_4 in 1990 to 126 Mt CH_4 in 2022 is driven by the growth of oil and gas production and coal mining operations.[33]

[33] Zhuangzhou Qi and Rui Feng, "Global Natural and Anthropogenic Methane Emissions with Approaches, Potentials, Economic Costs, and Social Benefits of Reductions: Review and Outlook", *Journal of Environmental Management* 373 (January 2025).

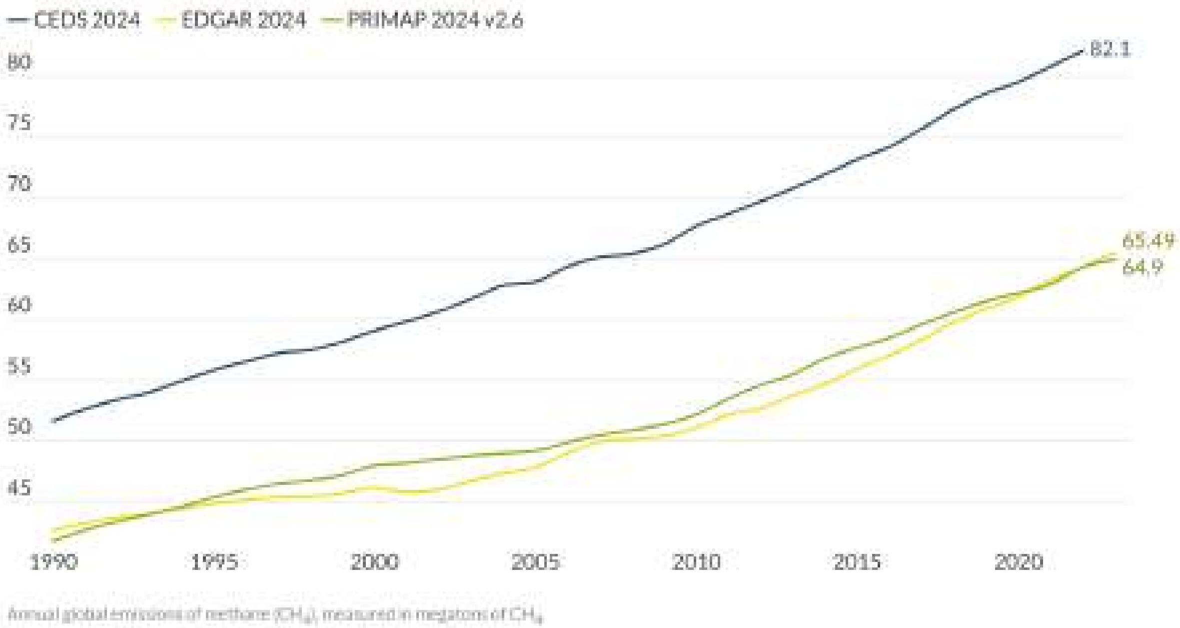
Figure 5: Historic trends in global methane emissions in the energy sector



Finally, methane emissions from the waste sector have also been rising over time, reaching an average of 70 Mt CH_4 in 2022, compared to only 45 Mt CH_4 in 1990. The increase in methane emissions from the waste sector since 1990 can be seen as a consequence of rising global consumption. As economies grow and urban populations expand, the consumption of goods has surged, which leads to a corresponding increase in waste generation.

Figure 6: Historic trends in global methane emissions in the waste sector

Global CH_4 emissions from from different datasets



Country trends

Selection of countries

Global methane emissions are highly concentrated, with a relatively small number of countries responsible for the vast majority of emissions. To ensure comprehensive coverage in our analysis, while balancing feasibility, we opted to focus on countries accounting for 90% of total emissions.

To create this sample, we selected our country list based on three criteria:

1. Inclusion of countries where methane emissions together constitute more than 90% of global methane emissions, in both 2020 (GMP base year) and 2023 (most recent year with widely available data).
2. Inclusion of countries with rapidly growing methane emissions, with an annual average growth rate exceeding 5% over the past 3 to 5 years, for countries falling below the 90% threshold.
3. Inclusion of major fossil fuel producers, defined as the top 10 in each sub sector – oil, gas, and coal.[34]

We applied the two first criteria to the PRIMAP v2.6 (HISTCR) dataset, resulting in an initial list of 64 countries. We then applied the same criteria to the EDGAR database, which resulted in three additional countries, followed by the CEDS database, which

[34] Countries appearing among the top 10 producers of coal, oil, or gas include: Algeria, Australia, Brazil, Canada, China, Germany, India, Indonesia, Iran, Iraq, Kazakhstan, Kuwait, Norway, Poland, Qatar, Russia, Saudi Arabia, South Africa, United Arab Emirates, and the United States.

resulted in two new countries. Applying the first two criteria across the PRIMAP, EDGAR and CEDS datasets results in a list of 69 countries.

Finally, applying the final criteria, we included the United Arab Emirates and Norway to the list, both top 10 fossil fuel producers not captured by our first two criteria, to ensure comprehensive coverage of major energy sector methane sources. The European Union is also included to reflect its role as a single legal party under the Paris Agreement, even though its member states are individually listed.

Our final list of 72 countries is the following:

Afghanistan, Algeria, Angola, Argentina, Australia, Azerbaijan, Bangladesh, Bolivia, Brazil, Cambodia, Cameroon, Canada, Chad, China, Colombia, Ecuador, Egypt, Ethiopia, the European Union, France, Germany, India, Indonesia, Iran, Iraq, Italy, Japan, Kazakhstan, Kenya, Kuwait, Libya, Malaysia, Mali, Mexico, Mongolia, Morocco, Myanmar, Nepal, New Zealand, Niger, Nigeria, Norway, Oman, Pakistan, Paraguay, Peru, Philippines, Poland, Qatar, Republic of Congo, Romania, Russia, Saudi Arabia, Somalia, South Africa, South Korea, South Sudan, Spain, Sudan, Tanzania, Thailand, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Venezuela and Vietnam.

The UNFCCC dataset was excluded from the selection process as it contains significant data gaps, particularly for non-Annex I countries. However, since the HISTCR dataset of PRIMAP is based on UNFCCC submissions, it can therefore be assumed to be a proxy for the UNFCCC dataset (see section 2.2)

In the assessments below, we use average values across the PRIMAP, EDGAR and CEDS datasets, unless stated otherwise.

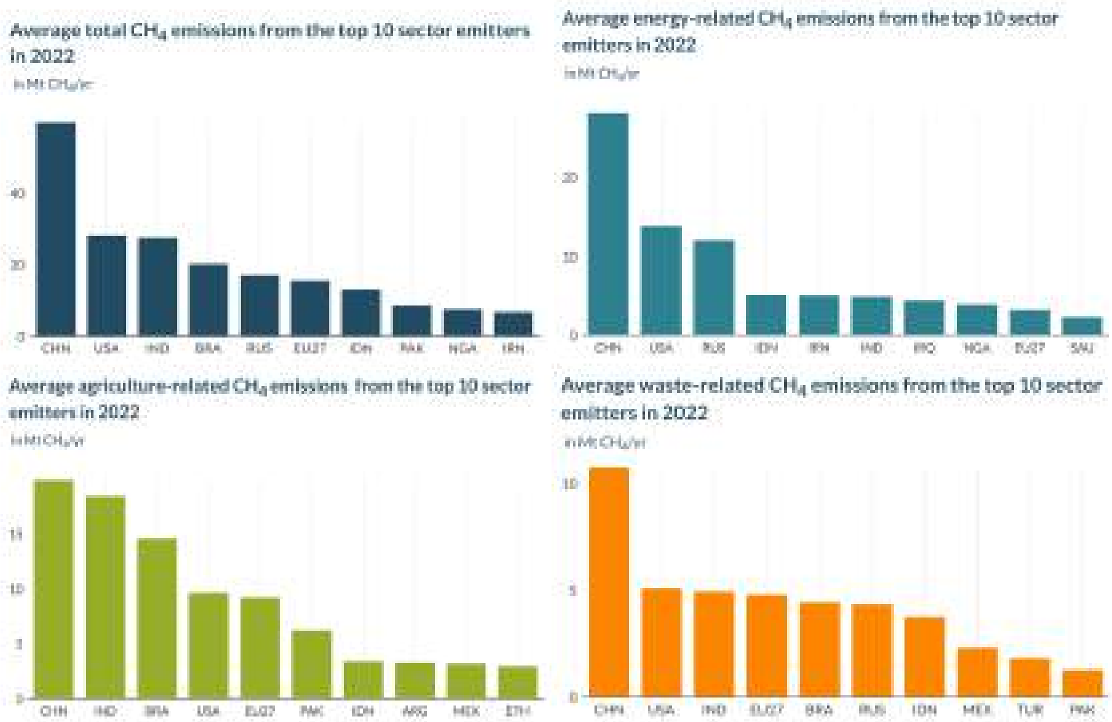
Country analysis

Detailed country-level results for total and sectoral methane emissions over the full historical period are available in our Global Methane Explorer, comparing values from the different datasets for each country from 1990 to 2023. This database also highlights discrepancies with official national inventories submitted to the UNFCCC. In addition to individual countries, the European Union has been included in the analysis as EU27 as legal entity representing 27 member states for its collective responsibility for emissions and targets. The following section focuses on comparing these datasets for countries from the identified list, using the most recent year available, and provides insights into the observed discrepancies and uncertainties across the datasets.

Figure 7 depicts total and sectoral methane emissions for 2022 across the top 10 global emitters, with 2022 selected as the reference year due to lack of data for 2023 in the CEDS database. Based on the average of the three main datasets – PRIMAP, CEDS and

EDGAR – total methane emissions in 2022 are highest in China, with an average of 60 Mt CH_4 followed by the USA (28 Mt CH_4), and India (27 Mt CH^4).

Figure 7: Total and sectoral CH_4 emissions by country in 2022



Fossil fuel-related emissions generally represent a large share of methane emissions in the northern hemisphere, with China's mean energy sector emissions (mainly from coal mining) being the highest at 28 Mt CH_4. The United States and Russia follow, with an average of 13 Mt CH_4 and 11 Mt CH_4 respectively, largely due to oil and gas production and distribution. These top three emitters are followed by Indonesia, Iran, India, Iraq, and Nigeria. Together, these eight countries represent 62% of global energy-related methane emissions in 2022.

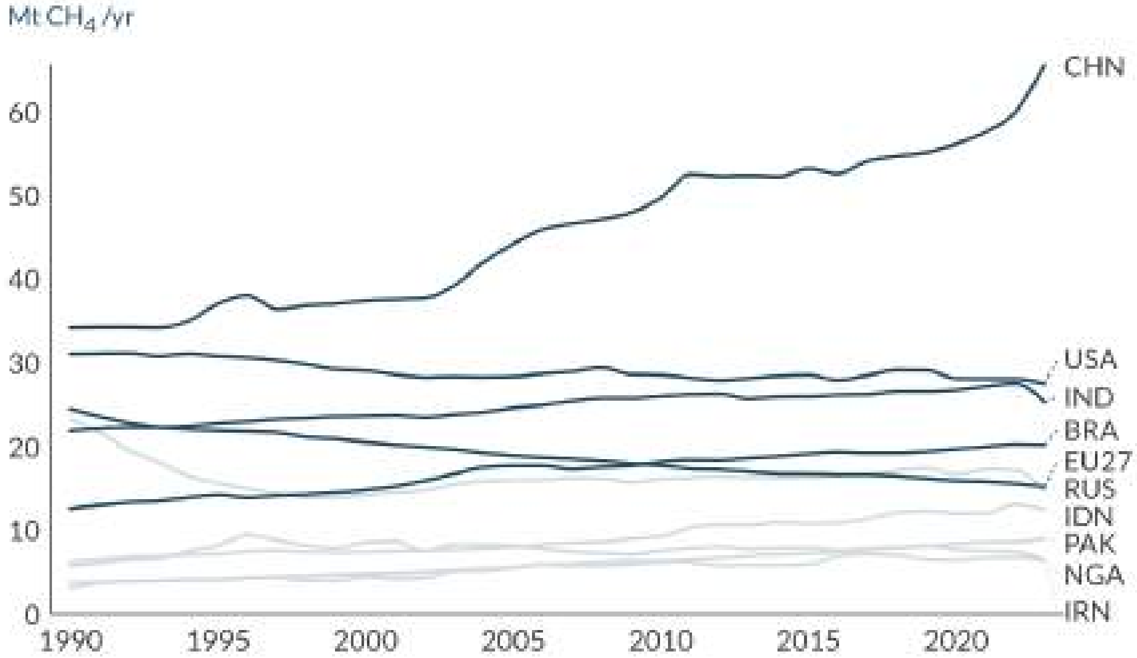
Agriculture-related emissions are particularly concentrated in Asian countries, notably China (20 Mt CH_4) and India (18 Mt CH_4), mainly due to rice cultivation. High emissions are also observed in Latin America, especially in Brazil (15 Mt CH_4), where livestock farming is the primary source of emissions. The USA, European Union, Pakistan, Indonesia, Argentina, Mexico and Ethiopia are also among the largest contributors, with these countries collectively accounting for 59% of global agriculture-related methane emissions in 2022.

Waste-related emissions are also concentrated in a handful of countries. China stands out, accounting for 17% of global methane emissions from the waste sector, followed by the USA, India, Brazil and Russia, each contributing between 6 to 8% of global waste methane emissions.

Across all three sectors, China consistently ranks as the largest methane emitter, underscoring its central role in global efforts to reduce methane. India, the United States, the European Union and Indonesia also appear among the top ten emitters in each sector, highlighting the breadth of their methane emissions. Other countries, such as Brazil, Russia, Indonesia, Pakistan, Nigeria, Iran and Mexico feature in the top ten in specific sectors due to distinct national drivers, such as livestock in Brazil, or oil and gas in Russia and Iran.

While global emissions are rising steadily, this is not necessarily the case for all our top 10 emitters, as – some of these countries have seen emissions level off or even decrease between 1990 and 2022 (Figure 8). China, by far the largest emitter, shows a major increase, with methane emissions – up more than 90% between 1990 and 2022. This increase is largely due to an increase in fossil fuel use in the energy sector. Methane emissions in India and Brazil have increased by 25% and 60% respectively, due to their growing agricultural sectors. In other Asian countries, this trend is even more pronounced, with an increase of over 100% for Indonesia and 135% for Pakistan. In contrast, the European Union has collectively reduced its methane emissions by approximately 37% since 1990, driven by strict environmental regulations, a decline in coal mining, and initiatives such as the European Green Deal that promote cleaner energy and waste management practices. However, recent temporary reopenings of coal plants in some EU member states have raised concerns about sustaining this progress. Alongside the EU, the United States reduced its methane emissions by 9% since 1990, however recent reversals on methane regulations by the Trump administration will likely undermine this progress.

Figure 8: Total methane emissions trends for our top-10 emitters



Mean across sources

In addition to these top 10 emitters, there is a significant increase in methane emissions in countries where fossil fuels are extracted, like Qatar (+490%), Kuwait (+123%), Saudi Arabia (+100%). Similarly, countries with rapid population growth during the last decades have seen an increase in agriculture-related emissions, including Niger (+225%), Mali (+200%) and Uganda (+178%), with the growth in methane emissions being roughly equal to population growth.

When analysing national emissions on a per-capita basis, we observe significant changes in the ranking of the top 10 emitting countries. The largest emitters are now major fossil fuel exporters such as Qatar, Bahrain, and Oman. New Zealand and Australia also appear on the list, mainly due to their large agricultural sectors.

Figure 9: World's top 10 methane emitters per capita in 2022

Uncertainties across datasets

Assessing uncertainty in methane emissions is inherently complex, as it is shaped by a range of factors, including measurement methods, regional differences, and sector-specific characteristics. One way to evaluate uncertainty is by comparing results across multiple datasets and quantifying the differences between them. The following section applies this approach to the datasets used in this assessment. We find that the standard deviation between datasets remains relatively stable over time, ranging between 23-30 Mt CH_4. This suggests that discrepancies reflect consistent methodological differences rather than increasing uncertainty.

At the sectoral level – particularly in agriculture – we observe notable differences in global methane emissions data and trends. EDGAR reports the highest agriculture-related methane emissions, while CEDS reports the lowest. Although PRIMAP and CEDS follow a similar trend over time, EDGAR shows a decline in agricultural emissions until 2000, followed by a strong increase. These differences may stem from methodological differences, including how activity data, emission factors, and regional assumptions are applied, which can vary at the country level. This underscores the importance of understanding the sector-specific methodologies and underlying assumptions from each dataset when interpreting emissions trajectories.

These methodological differences are reflected in the varying levels of uncertainty across sectors. From 1990 to 2023, the energy sector exhibits the highest uncertainty, with standard deviation between datasets ranging from 14 to 23 Mt CH_4. The agriculture sector shows a more moderate range of 9 to 14 Mt CH_4, while the waste sector is lowest at 5 to 10 Mt CH_4. This means that the energy sector contributes most to the overall uncertainty in global CH_4 emissions across the datasets, likely due to differences in methodologies to estimate emissions from sector activities, as explained above. While uncertainty is lower in agriculture and waste, methodological differences remain important and should not be overlooked.

While it is critical to interpret global patterns, these are ultimately shaped by country-level estimates, making it even more important to understand dataset discrepancies at the national scale. As previously discussed, the datasets in this assessment rely on different methodologies, leading to variability in national estimates.

This is especially important in countries such as China, India, and Russia, where gaps between datasets are particularly large (Figure 9). In countries that report to the UNFCCC, PRIMAP tends to align closely with official inventory submissions, especially in 2022[35], reflecting its primary dependence on these national reports. However, PRIMAP and UNFCCC estimates are generally lower than those of EDGAR and CEDS, suggesting potential underreporting in official inventories. Interestingly, China stands out among the top emitters as an exception to this rule, with the PRIMAP dataset reporting significantly higher methane emissions than the other datasets. For 2022, PRIMAP estimates are 24% higher than those from CEDS and 5% higher than EDGAR, as shown below in Figure 10.

Figure 10: Comparison of methane emissions for top emitters across datasets (2022)

This is consistent with Petrescu et al. 2024's paper, which compares top-down and bottom-up methane estimates across individual countries and regions. They show that for many major emitting regions, such as China, the United States, and parts of South

[35] The year 2022 was selected because it is the most recent year for which a complete dataset is available except for non-Annex I countries.

Asia, top-down estimates tend to exceed bottom-up values, indicating that national inventories may systematically underestimate emissions. This comparison shows that discrepancies among bottom-up datasets, as discussed here, mirror deeper structural uncertainties in how national emissions are estimated and reported.

These country-level inconsistencies underscore the value of using multiple datasets with distinct methodological approaches to help identify uncertainties, fill data gaps, and provide a more robust understanding of global and national methane emissions. Future work will further investigate the causes of such divergences – particularly in major emitting countries and sectors – and will explore the potential to integrate top-down emissions estimates from satellites, enabling comparison with independent, observation scientific datasets where feasible.

National commitments and targets

In addition to tracking methane emissions, we also assess government commitments to address them. To do this, we developed a database of methane-related targets, capturing both the inclusion of methane in countries' Nationally Determined Contributions (NDCs) and identifying which countries are setting separate, methane-specific targets.

NDCs outline each country's climate goals under the Paris Agreement and serve as a primary mechanism for national governments to outline their plans to reduce emissions.[36] The outcome of the first Global Stocktake produced at COP28 in Dubai recognizes the need for states to substantially reduce methane emissions by 2030 and calls on Parties to submit NDCs for 2035 aligned with the 1.5°C limit.[37] Including methane in NDCs shows national recognition of its critical role in achieving climate targets and thereby limiting global warming to 1.5°C.[38] Our analysis of the NDCs submitted[39] by the 72 countries in our study, including the European Union, shows that 81% of them address methane emissions, either through overarching emissions reduction targets (covering multiple or all greenhouse gases) or via methane-specific targets.

In our analysis, 75% of countries include methane within broader, economy-wide emissions reduction targets covering multiple gases. This included many of the major emitters in our dataset, notably the United States, India, and the European Union. While this approach is an important step, setting methane-specific reduction targets, either within NDCs or through other government climate plans, creates an even stronger framework for action. Methane-specific, quantitative reduction goals provide clarity about the role of methane in countries' emissions reduction pathways, enhance accountability for delivering results, and enable more effective progress tracking. By emphasizing the role of methane in emissions reduction pathways, these methane-specific targets also encourage public and private sector investment and innovation in methane mitigation.

The GMP commits signatories to a collective 30% reduction in methane emissions from 2020 levels by 2030.[40] However, as of December 2023, only 15 of the then-119[41] GMP signatories had set their own methane-specific reduction target. In our study's subset of 72 countries and the EU bloc (84% of which are signatories to the GMP), only 16% (12

[36] UNFCCC, *The Paris Agreement and NDCs* (n.d.).
[37] UNFCCC, "Outcome of the First Global Stocktake", 2023.
[38] Climate and Clean Air Coalition, *Guidance on Including Methane in NDCs* (CCAC, 2024).
[39] As of November 2024.
[40] Climate and Clean Air Coalition, "Homepage | Global Methane Pledge", 2024.
[41] The number of signatories has since risen to 159 countries, per the Global Methane Pledge.

countries) have adopted methane-specific targets. Methane-specific targets therefore make up only a small share (20%) of the commitments captured in our analysis.

In our analysis, only 28% of the methane-specific targets are economy-wide and cover all sectors. The remainder are sector-specific, with 39% covering energy sector emissions from oil and gas, 17% covering waste sector emissions from landfills and waste treatment plants, and 17% covering agricultural emissions from biogenic sources. 75% of countries in our analysis with methane-specific targets are tackling methane emissions in the country's dominant methane-emitting sector. For example, Malaysia is targeting a 50% reduction in methane emissions across its natural gas supply chain by 2030, while Cameroon aims to install methane capture technologies at 70% of landfills across its major cities by 2035. Malaysia's dominant source of methane emissions is the energy sector, making this a strong example of a well-matched target, but in Cameroon, the majority of methane emissions come from agriculture, leaving this as a missed opportunity.

The Republic of Korea serves as a notable example of a country setting strong, methane-specific targets, with its 2030 Methane Emissions Reduction Roadmap establishing an economy-wide goal of reducing methane emissions by 30% by 2030 compared to 2020 levels. The roadmap further breaks down this 2030 target into sector-specific contributions: a 34.2% reduction in the agriculture sector, a 49% reduction in the waste sector, and a 22.7% reduction in the energy sector. Each sectoral target is supported by tailored policy measures, representing a comprehensive approach to methane mitigation.[42]

In addition to differences in scope – such as whether targets are economy-wide, sector-specific, or embedded within broader greenhouse gas (GHG) targets – countries also vary in the type of methane targets they set. The majority of targets in our database are absolute emissions reduction targets (76%). This pattern holds true for methane-specific targets as well, where 78% are absolute emissions reduction targets, 11% are emissions intensity targets, and a final 11% are emissions capture targets.

[42] Climate and Clean Air Coalition, *Republic of Korea's 2030 Methane Emissions Reduction Roadmap* (CCAC, 2024).

Methane policy landscape

Overview and approach

While a growing number of countries are setting targets to reduce methane emissions – whether through methane-specific targets or as part of their broader NDCs – targets are only as effective as the policies governments implement to meet them. To assess how governments are translating ambition into action, we developed a comprehensive methane policy database.[43] We applied a multi-stage approach to collect and categorize methane policies in a consistent and comparable manner. We employed a large language model (LLM) for the initial policy identification and classification, followed by a thorough expert review. To ensure consistency, we created a codebook that standardized how policies were categorized across multiple parameters: policy name, jurisdiction, sector, subsector, instrument type, mitigation type, implementation status and date, and whether a policy directly or indirectly targets methane emissions. The complete codebook is included in Annex B. We also developed detailed instructions to train the LLM to effectively identify and classify policies.

This database includes two types of policies: those specifically designed to directly reduce methane emissions in specific sectors (energy, waste, and agriculture), and those with broader objectives that indirectly cover methane within their scope (even if methane is not explicitly mentioned). However, we excluded general climate policies that only incidentally reduce methane emissions, such as renewable energy initiatives, energy efficiency programs, and electrification efforts. We also excluded policies that are expected to increase methane emissions, such as plans to expand fossil fuel infrastructure. Lastly, we excluded policy "objectives" with insufficient detail about the policy instrument, coverage, or implementation timelines. While we expect these excluded policies to impact overall methane emissions, they fall outside our current scope. However, understanding this broader policy landscape remains essential to comprehensively assess progress on methane mitigation.

This database allows us to identify emerging trends, track policy progress, and highlight best practice across countries and sectors. By examining the specific instruments, mitigation approaches, and implementation status of these policies, we can provide insights into effective strategies for accelerating methane reductions at the pace and scale required to align with international goals. We have summarized some of those trends and insights in the sections below.

[43] Policies are current as of March 2025.

Finally, we designed this database as a living resource that is intended to be updated as new policies emerge and existing ones evolve, enabling ongoing tracking of policy implementation progress. The database is accessible online through our Global Methane Explorer, allowing researchers, policymakers, and other stakeholders to explore and analyse methane policies across jurisdictions.

The critical role of broader energy transition policies

While our database does not currently include general energy transition policies, such as renewable energy expansion, energy efficiency improvements, or electrification efforts, it is important to recognize their critical role in reducing methane emissions from the energy sector.

The IPCC[44] emphasizes that scenarios compatible with limiting warming to 1.5°C require deep reductions in fossil fuel production and consumption. In these pathways, stringent methane reductions are directly linked to the deep CO_2 cuts needed by 2030, since a significant share of both methane and CO_2 originate from fossil fuel use. In fact, pathways consistent with the Global Methane Pledge suggest that approximately 60% of methane reductions would be achieved by curbing fossil fuel use.[45] This means that as countries pursue deep decarbonization, the resulting decline in fossil fuel supply chains inherently leads to fewer opportunities for methane to be released.

As a result, many policies and actions that target CO_2 emissions also contribute to methane reductions. For example, the European Union Emissions Trading System (EU ETS) targets CO_2 emissions directly in the electricity and industrial sectors. By incentivizing shifts away from coal and encouraging cleaner energy sources in these sectors, the EU ETS also contributes to methane reductions from the fossil fuel industry.

However, even with a substantial phase-down or phase-out of fossil fuels, some methane emissions will persist from both existing and abandoned infrastructure.[46] Ongoing abatement measures, as discussed in the energy sector section below, will be necessary to address these sources of methane as part of a comprehensive mitigation approach. Taken together, decarbonization and targeted methane abatement provide the most effective strategy for achieving rapid and deep methane reductions.

Sectoral policy analysis

Methane mitigation policies vary across sectors in terms of their number, type, and approach, shaped by the distinct sources, challenges, and opportunities present in energy, waste, and agriculture. Notably, some policies are designed to address methane

[44] IPCC, "Climate Change 2022 - Mitigation of Climate Change" Chapter 6: Energy Systems.
[45] Matthew Gidden et al., *The Global Methane Pledge and 1.5°C* (Climate Analytics, 2021).
[46] IPCC, "Climate Change 2022 - Mitigation of Climate Change" Chapter 6: Energy Systems.

emissions across multiple sectors. This section examines how governments address methane emissions in each sector and highlights the main policy instruments used. Our database identified 260 methane policies in total, with 170 (65%) covering the energy sector, 93 (36%) covering the waste sector, and 57 (22%) targeting agriculture. Because some policies span more than one sector, these counts may overlap and do not sum to the total number of policies. While the database does not capture every policy worldwide, it offers valuable insights into prevailing trends and government priorities across major methane-emitting sectors.

Policy instruments

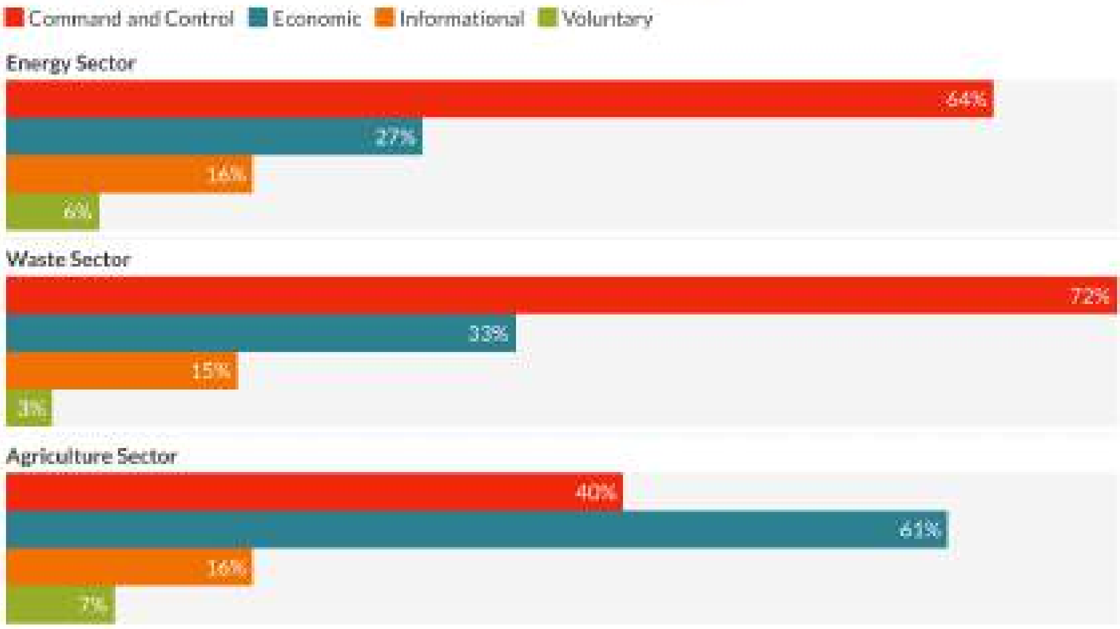
Governments[47] employ a wide range of policy instruments to reduce methane emissions. We categorised these policy instruments into four main types: Command and Control, Economic, Voluntary, and Informational instruments. Figure 10 below summarizes the distribution of instruments in the database, indicating that the most prevalent instruments are Command and Control measures, followed by Economic instruments. Some policies include multiple elements and are therefore categorised as more than one instrument type.[48]

When comparing all three sectors, command and control instruments are the most common in the energy (108 policies or 64% of the sector) and waste (67 policies, 72%) sectors. In contrast, policies targeting the agriculture sector predominantly rely on economic instruments (35 policies or 61% of policies in the sector). While both Command and Control and Economic instruments are used by governments to reduce methane emissions in the agriculture sector, this sector has the most diversity of instruments but the fewest policies.

[47] Our database also includes measures from state-owned energy countries.

[48] Policies with multiple instrument types are counted in each relevant category. For example, a policy that is both informational and voluntary appears in both categories.

Figure 11: Distribution of policies by instrument type



Command and Control instruments, which set legally binding rules or directives, are among the most widely implemented instruments for methane reduction. Sub-categories include emissions standards, technology mandates, restrictions or bans, and leak detection and repair (LDAR) requirements. For example, Canada's Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) mandates Leak Detection and Repair (LDAR) programs and prohibits routine venting and flaring in the oil and gas sector.[49] Similarly, Norway's Petroleum Act requires methane emissions monitoring and the use of best available technologies to minimize emissions during oil and gas production.[50]

Economic instruments leverage financial mechanisms to incentivize behaviours that reduce methane, often by incorporating environmental costs into market dynamics. Subcategories include taxes, subsidies, tradable permit systems, and grants. For example, this year China announced a Certified Emissions Reduction Program, which is a voluntary carbon market mechanism that would allow coal mine operators to earn carbon credits by voluntarily capturing and utilising or destroying methane below

[49] Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector), SOR/2018-66 (Government of Canada, 2018).
[50] Norwegian Petroleum Act, Act 29 November 1996 No. 72 (Norwegian Offshore Directorate, 1996).

regulatory thresholds.[51] In New Zealand, the Waste Minimization Fund provides grants to initiatives that reduce waste generation and increase resource recovery.[52]

Voluntary instruments rely on non-mandatory commitments or agreements, encouraging industries to take action without legal enforcement. Voluntary instruments include certification schemes and voluntary reporting programs such as Ukraine's gradual implementation of Oil and Gas Methane Partnership (OGMP 2.0) Monitoring Standards. This voluntary initiative improves methane emissions measurement, reporting and verification in the oil and gas sector.[53] Although less common in the database, these instruments foster sector collaboration and accountability through transparency.

Informational instruments aim to raise awareness or improve decision-making by providing knowledge, data, or technical support. Subcategories include mandatory emissions reporting, capacity-building, and research funding. For example, Indonesia recently announced a plan to comprehensively measure and quantify methane emissions from upstream oil and gas activities as a first step to developing the technical capacity needed for effective methane management in the sector.[54]

Mitigation strategies

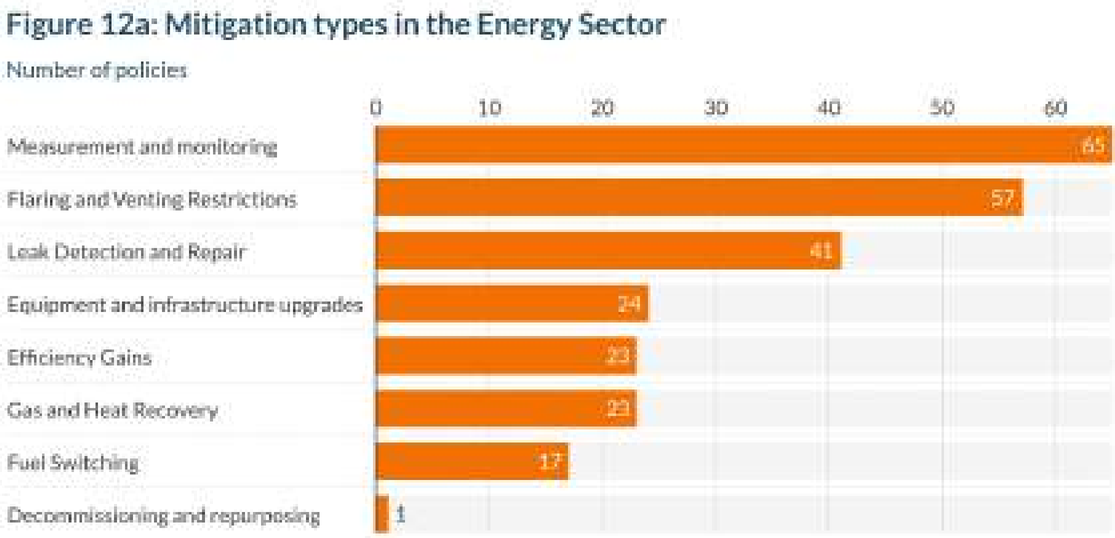
Energy sector

Our database also categorizes policies by the specific strategies, technologies, or practices that governments are deploying to reduce, capture, or prevent methane emissions – what we term "mitigation types". In the energy sector, we track eight distinct mitigation types: leak detection and repair (LDAR), flaring and venting restrictions, fuel switching, efficiency gains, gas and heat recovery, equipment and infrastructure upgrades, decommissioning and repurposing, and measurement and monitoring. Many policies pursue multiple objectives, addressing several mitigation types simultaneously. Figure 11a illustrates how policies are distributed across these eight mitigation types.

The mitigation types captured in our database focus on methane emissions from energy production activities, including upstream (extraction and processing), midstream (transmission and storage) and downstream (distribution) segments of the supply chain.

[51] IEA, *Coalbed Methane (Coal Mine Gas) Emission Standard (China)*, IEA Policies Database (International Energy Agency, 2024).
[52] Ministry for the Environment, *Te Pūtea Whakamauru Para | Waste Minimisation Fund* (Government of New Zealand, 2025).
[53] DiXi Group, *Ukraine's Efforts and Plans to Reduce Methane Emissions Were Discussed at the Ukrainian Pavilion at COP29* (2024).
[54] Study to be conducted jointly by Japan Organization for Metals and Energy Security (JOGMEC), Indonesian National Oil Company, PT PERTAMINA (Persero) and its affiliates. See *JOGMEC, Pertamina, PEP and JOB Tomori Signed Joint Study Agreement on Methane Emission Measurement and Quantification: For Low-Carbon LNG Value Chain* (JOGMEC, 2024).

End-use emissions, such as methane leaks from household gas appliances, as well as general energy transition policies that reduce fossil fuel use, are excluded.



Most policies in our database tackle the main challenges of energy sector methane mitigation: uncertainty in methane estimates, intentional releases, and fugitive leaks.

The challenges of emissions underreporting and the lack of measurement-based data, as discussed in Section 2, are receiving increasing policy attention. Measurement and reporting requirements are the most common mitigation type in our database, featured in 65 energy-related policies (about 40%). This emphasis on robust measurement and reporting systems highlights governments' growing recognition of the need for accurate, timely emissions data to enable effective methane mitigation, improve accountability, and track progress.

A significant share of policies in the database also target the largest sources of methane emissions in the energy sector: intentional releases of methane through gas venting and flaring, and fugitive emissions through equipment leaks across the value chain. Flaring and venting restrictions are the second most common approach, appearing in 57 policies (about 34%). These policies aim to limit or eliminate the intentional release of methane by setting strict limits on when venting or flaring is allowed, including by prohibiting routing releases except in emergency situations. Leak detection and repair (LDAR) programs, which address the unintentional leaks of methane during fossil fuel production, transport, and storage, represent the third most prevalent mitigation type, included in 41 policies (approximately 24%). LDAR programs mandate regular inspections with specialized equipment to detect leaks and prompt timely repairs and reporting, thereby helping to prevent future methane emissions from those sources.

Box 1: Upstream Command and Control regulations in major fossil fuel producing countries

Command and Control regulations, if enforced, are a highly effective instrument to deliver deep, sustained methane reductions in the upstream segments of the fossil fuel supply chain – primarily targeting extraction, production, processing, and transportation of fossil fuel products. Unlike voluntary actions or economic instruments (such as subsidies or emissions pricing), Command and Control measures set clear, legally binding requirements for industry behaviour and emissions performance. This approach provides greater certainty of outcomes and can drive rapid, sector-wide improvements – especially in contexts where market incentives or voluntary commitments alone may be insufficient to achieve ambitious methane reductions.

Many major fossil fuel producing countries are implementing methane regulations through various mechanisms, including emissions standards, technology mandates, performance-based requirements, outright bans on high-emitting practices, conditional permitting, and mandatory Leak Detection and Repair (LDAR) programs. The European Union's landmark Methane Regulation (2023) exemplifies this approach, mandating quarterly LDAR surveys across all oil and gas infrastructure, prohibiting routine venting and flaring, and requiring operators to repair detected leaks within specific timeframes. Critically, the EU regulation extends its reach beyond domestic operations through a first-of-its-kind import standard.

We identified a list of 20 countries representing the top 10 producers of oil, gas, and coal.[55] Of those 20 countries, our policy review suggests that 15 (**75**%) have some form of Command and Control regulation targeting the energy sector.

Waste sector

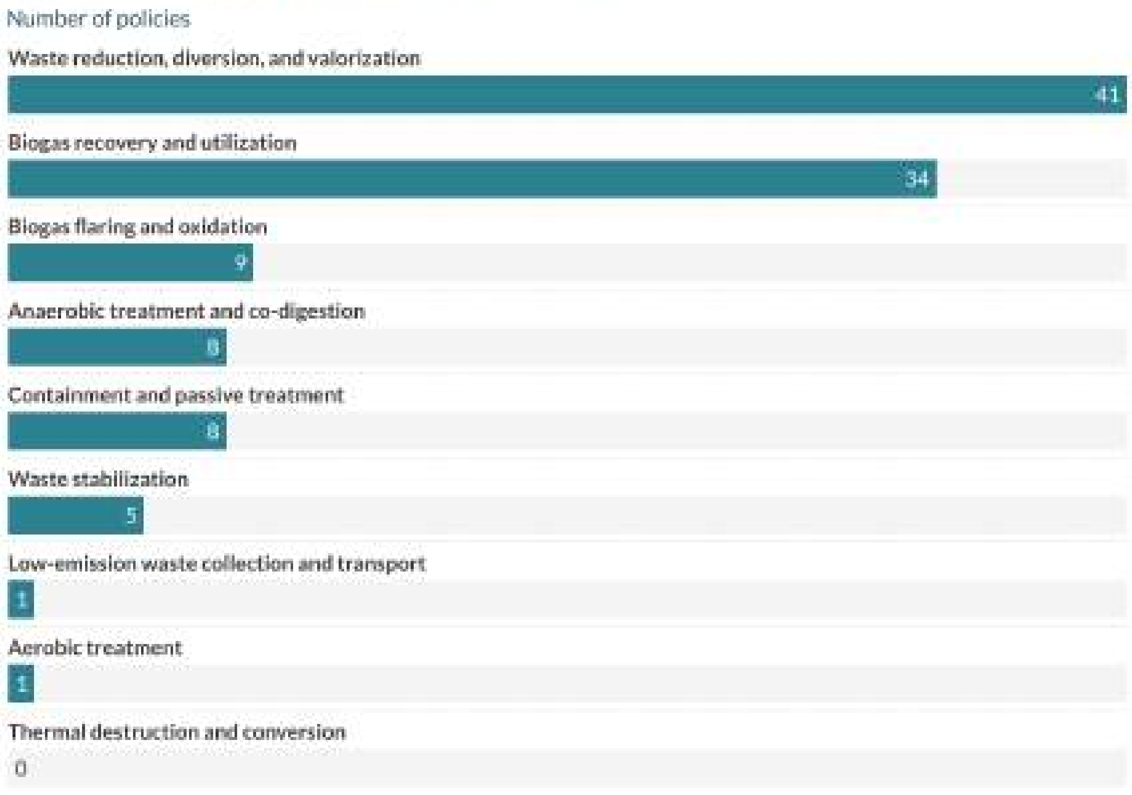
In the waste sector, we track 10 mitigation types: waste reduction, diversion, and valorisation; low-emission waste collection and transport; aerobic treatment; anaerobic

[55] Countries appearing among the top 10 producers of coal, oil, or gas include: Algeria, Australia, Brazil,
Canada, China, Germany, India, Indonesia, Iran, Iraq, Kazakhstan, Kuwait, Norway, Poland, Qatar, Russia, Saudi Arabia, South Africa, United Arab Emirates, and the United States.

treatment and co-digestion; biogas recovery and utilization; waste stabilization; biogas flaring and oxidation; thermal destruction and conversion; containment and passive treatment; and measurement and monitoring. Figure 12b illustrates how policies are distributed across these 10 mitigation types. Broader approaches to reducing waste such as circular economy strategies are reflected here, but categorized by the specific mitigation measures they implement, rather than as a general category.

Policies targeting the waste sector show a clear preference for certain mitigation strategies. Waste reduction, diversion, and valorisation is the most common approach, featured in 49 policies (or about 53% of all the waste policies in our database). These policies prioritize reducing the volume of organic waste generated and diverting it from landfills where it would otherwise produce methane emissions. Biogas recovery and utilization is the second most common approach, with 34 policies focused on capturing methane from waste processes and using it as an energy source. Measurement and monitoring ranks third, with 26 policies aimed at improving methane emissions quantification.

Figure 12b: Mitigation types in the Waste Sector



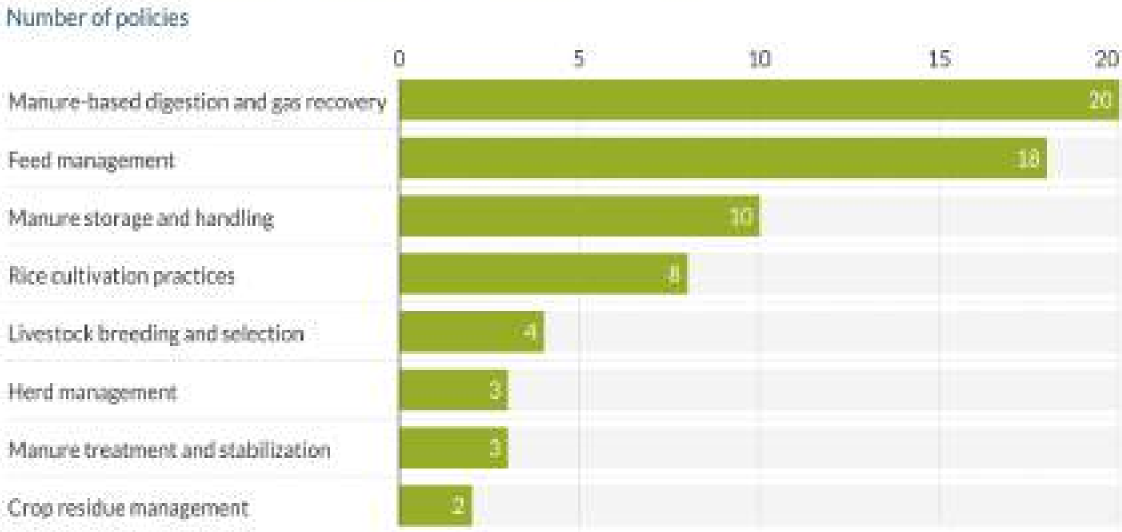
Less common approaches include biogas flaring and oxidation (9), containment and passive treatment (8), waste stabilization (5), and low-emission waste collection and transport (1).

This distribution suggests that countries are prioritizing strategies that not only reduce methane emissions by reducing the amount of waste generated but also create new value from waste, representing a "circular economy" approach to waste management.

Agriculture

In the Agriculture sector, we track nine mitigation types, namely rice cultivation practices, feed management, livestock breeding and selection, herd management, manure storage and handling, manure treatment and stabilization, manure-based digestion and gas recovery and crop residue management. Figure 12c illustrates the distribution of policies across these nine mitigation types.

Figure 12c: Mitigation types in the Agriculture Sector



While methane emissions from rice cultivation are significant, rice can only be grown under particular environmental conditions, limiting this source of agricultural methane to certain countries and regions. Reducing the methane intensity of rice cultivation is critical to limiting warming to 1.5°C and can involve measures such as intermittent irrigation (alternate wetting and drying) or using rice varieties that emit less methane.

By contrast, livestock farming is common worldwide, which helps explain why policies addressing emissions from manure and enteric fermentation are more common in our dataset.

In the agriculture sector, most policies in our database focus on manure-based digestion and gas recovery efforts (20), feed management (18), and manure storage and handling (10). These approaches reflect the significant contribution of ruminant digestion and manure management to global methane emissions.

Although policies focused on manure and feed are most common, our database also identifies a few less-common mitigation approaches, including livestock breeding and selection (4), herd management (3), and crop residue management (2). The relatively lower representation of approaches like livestock breeding and selection may be due to the fact that the technologies required to genetically modify livestock to produce less methane are still emerging.

The state of policy implementation

Reducing methane emissions from the energy, waste, and agriculture sectors at the pace and scale required to align with 1.5°C pathways requires quick and effective policy implementation. Our policy database is designed to systematically assess and track progress of methane-related policies across jurisdictions, providing a comprehensive framework for monitoring their development and implementation.

The database categorizes policies into three distinct stages of implementation: announced, adopted, and active. Policies classified as "announced" represent official communications by governments or relevant authorities that signal an intent to introduce a policy. For example, at COP28, Brazil committed to develop and implement regulations to reduce methane emissions from the oil and gas sector but has yet to establish the guidelines.[56] The "adopted" category includes policies that have been formally approved but are not yet operational, indicating that implementation has not yet begun. An example of an "adopted" policy would be regulations requiring oil and gas operators to implement LDAR programs, where the law has been finalized, but its implementation and enforcement are scheduled to begin at a future date.[57] Finally, policies categorized as "active" are those currently in effect and implemented, with enforcement mechanisms (if applicable) operational. For example, in 2024, China introduced an amended emission standard for coalbed methane, which came into effect for new facilities on April 1, 2025.[58]

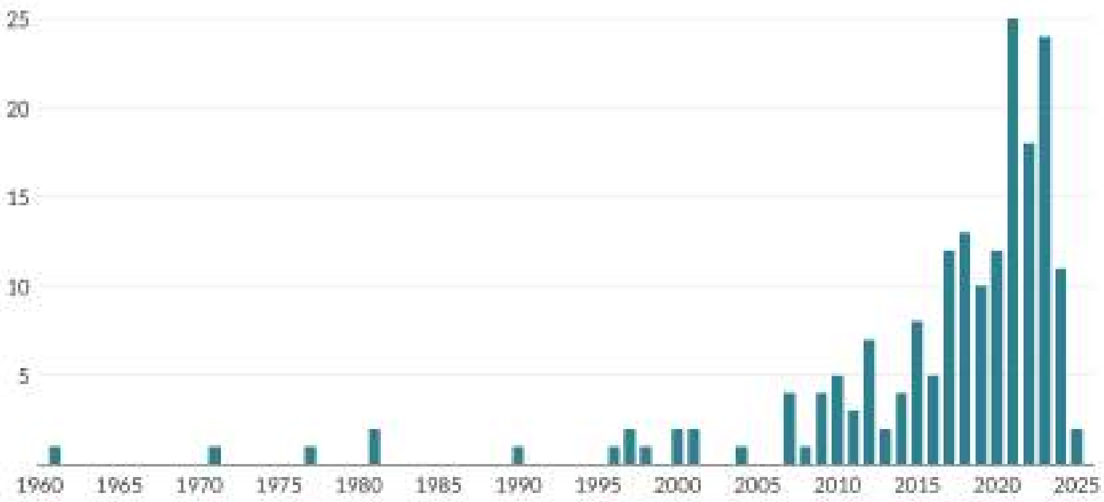
It is important to note that the database excludes general policy statements or objectives from governments – in other words, policies that lack clear information on the policy design specifics such as instrument type, policy coverage and stringency, or implementation timelines. For example, a broad government statement about capturing and utilizing methane from oil and gas operations, without specifying how or when the policy would be implemented, would be excluded. This ensures the database remains focused on actionable, well-defined, and measurable policies.

[56] Argus Media, *COP: Brazil Eyes Methane Reduction Regulation by 2025* (2023).
[57] Currently, no policies collected in our database fall under the "adopted" category.
[58] *IGSD, China Strengthens Coal Mine Methane-Emission Requirements* (Institute for Governance & Sustainable Development, 2024).

Of the 260 policies in our database, the majority (89%) are currently active, reflecting both recent progress in methane mitigation efforts and the fact that active policies are generally easier to identify and track than those that are only announced. While some policies date back decades – such as Colombia's 1961 law prohibiting gas flaring – policy implementation has notably accelerated since the late 2000s, with the majority of policies being implemented in the past 10 years (Figure 13).

Figure 13: Trends in policy implementation over time

Number of policies implemented per year



Despite this progress, key policies, such as oil and gas methane regulations in Canada, Brazil, and Egypt, remain stalled in the announced phase. In other cases, governments are repealing policies, as seen in the United States, where the Trump administration eliminated the methane fee on oil and gas operations, dismantling a central methane policy of the Biden administration's Inflation Reduction Act.[59]

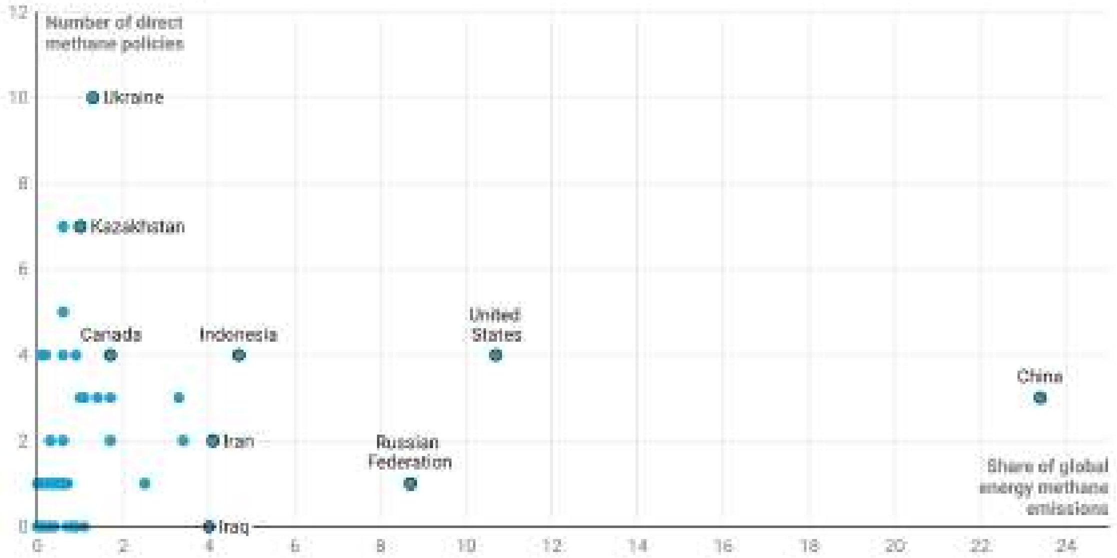
Figures 14a through 14c visualize the relationship between the number of methane-specific policies adopted by each country and that country's share of global methane emissions across the energy, waste, and agriculture sectors. While the number of policies does not directly determine policy effectiveness – since a single, well-designed policy may deliver more emissions reductions than several overlapping or poorly enforced ones – the distribution of policy action can nonetheless reveal important trends in governments' emphasis on methane mitigation.

In the energy sector (Figure 14a), a notable number of countries with substantial methane emissions have adopted few or no direct policies. For example, Iraq, which accounts for around 4% of global energy methane emissions, has no direct methane mitigation policies in the sector. Russia, which is responsible for about 8% of sector

[59] Sabin Center for Climate Change Law, *President Trump Signs Joint Resolution to Disapprove EPA Rule on Methane Emissions* (Columbia Law School, 2025).

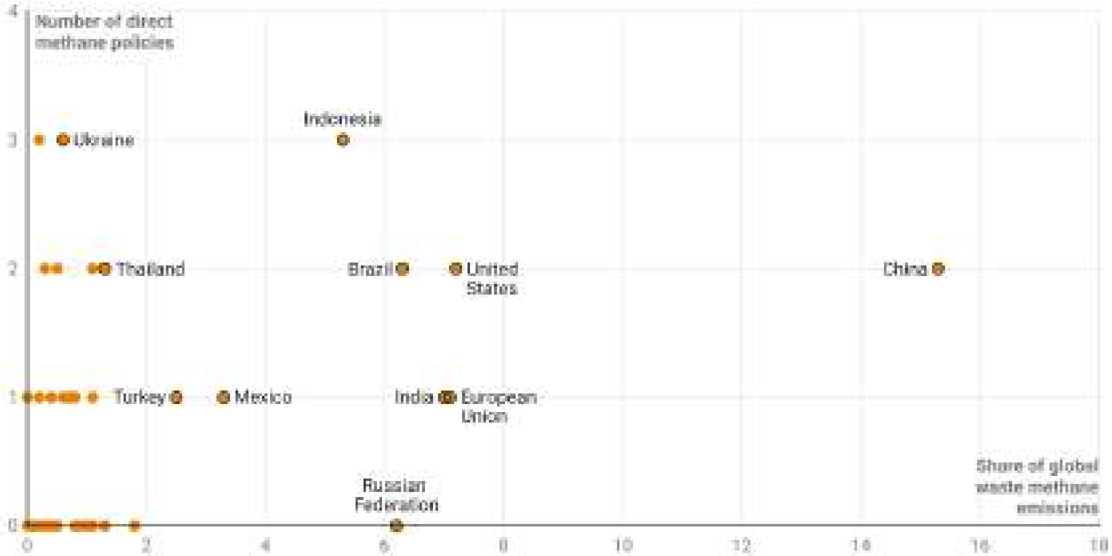
emissions has only a single direct policy. In contrast, Ukraine and Kazakhstan have implemented or announced a relatively high number of policies – ten and six, respectively – despite their smaller emissions shares.

Figure 14a: National methane policies in the energy sector vs. share of global energy methane emissions



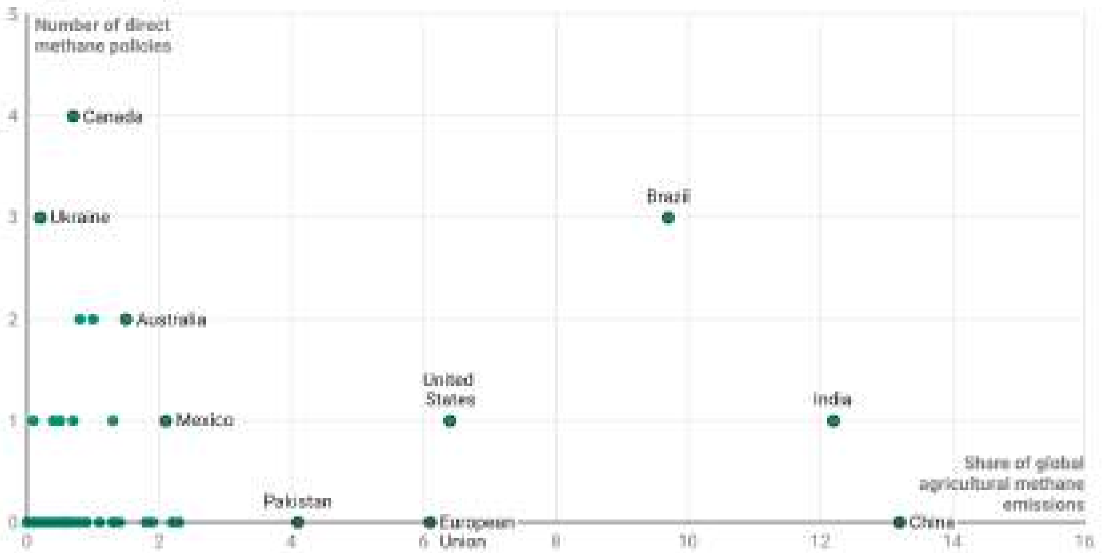
Turning to the waste sector (Figure 14b), policy action similarly does not increase in step with emissions – several of the largest emitters have implemented few, if any, direct policies. Russia stands out here as well, representing 6.2% of global waste methane emissions but with zero direct methane policies targeting the sector. China, which is responsible for over 15% of global waste methane emissions, has only two policies. The European Union, despite accounting for 7.1% of global waste methane emissions, has only one EU-level policy directly targeting the sector; however, several member states (including Germany and Italy) have their own national policies addressing waste methane. At the same time, countries like Ukraine and New Zealand have three policies each, despite the lower share of global methane emissions.

Figure 14b: National methane policies in the waste sector vs. share of global waste methane emissions



The agriculture sector (Figure 14c) shows a similar disconnect between emissions and policy action. China is the largest agricultural methane emitter, responsible for approximately 13% of global methane emissions in this sector, yet it has no direct policies in place. India, which accounts for approximately 12% of global agricultural methane emissions, has only one policy targeting the sector. The European Union, despite accounting for 6.1% of global agricultural methane emissions, has no EU-level policies directly targeting agricultural methane. However, some member states, included France and Poland, have their own national policies. Conversely, countries like Canada and Ukraine have implemented more policies despite representing a much smaller share of agricultural methane emissions.

Figure 14c: National methane policies in the agriculture sector vs. share of global agricultural methane emissions



Overall, these figures highlight that some of the world's largest methane emitters in each sector have either very few or no direct methane mitigation policies. In short, there is no consistent relationship between a country's emissions share and the number of policies in place. In many cases, countries responsible for fewer emissions have more robust policy frameworks, while major emitters have little or no policy engagement. This highlights the need not just for broader adoption of methane policies, but also for increased ambition and effort where it is currently lacking, particularly among countries with high emissions but relatively fewer policy initiatives.

Achieving the methane reductions needed to align with 1.5°C pathways requires not only faster implementation of existing policies but also more ambitious measures across all countries to close the gap. Governments must expand and strengthen methane mitigation efforts, introduce new policies, and avoid policy rollbacks to deliver rapid and sustained progress. Future project activities will assess select countries to quantify emissions reductions from existing targets and policies and evaluate alignment with 1.5°C pathways.

Conclusion

Rapidly reducing methane emissions represents a critical opportunity to limit near-term warming and meet international climate commitments. Our analysis of emissions data, national targets, and policies across 72 countries accounting for 90% of global methane emissions reveals both concerning trends and signs of progress.

Across all datasets we examined, methane emissions continue to rise, putting the world on a dangerous path associated with approximately 2.7°C of warming by the end of the century – far exceeding the Paris Agreement's 1.5°C limit. Reversing this trend requires increased government ambition and concrete action to deliver deep, sustained methane reductions. While the Global Methane Pledge has garnered 159 signatories, very few countries have set their own national methane reduction targets, leaving uncertainty on how methane fits into national emissions reduction pathways. Our policy database shows encouraging signs of acceleration in policy implementation, with many governments enacting strong command and control regulations and strengthening emissions monitoring requirements. However, several major policies are stalled, and current efforts fall well short of delivering the pace and scale of methane reductions needed this decade.

Looking ahead, our project will continue to build on this foundation through several key activities. We will identify global, sectoral, and country-level methane reduction pathways and assess the gaps between current emissions, targets, and policies, and what's required to align with 1.5°C pathways. By evaluating these gaps and highlighting successful approaches, we aim to provide stakeholders with the evidence and tools needed to develop, advocate for, and implement stronger methane policies required to keep the 1.5°C goal within reach.

Annex A: Sector coverage across our three datasets

Sector	UNFCCC	PRIMAP	EDGAR
Energy	CRF 1A (fuel combustion), CRF 1B (fugitive emissions)	Combustion and fugitive emissions (based on UNFCCC CRF categories)	Fuel combustion (power, industry, transport, buildings), fugitive emissions (coal mining, oil & gas extraction, transmission, distribution)
Agriculture	CRF 3A (enteric fermentation), 3B (manure management), 3C (rice cultivation), 3D (agricultural soils)	Enteric fermentation, manure management, rice cultivation, agricultural soils	Enteric fermentation, manure management, rice cultivation; activity data primarily from FAO
Waste	CRF 5A (solid waste disposal), 5B (biological treatment), 5C (incineration), 5D (wastewater treatment)	Solid waste disposal, wastewater treatment	Solid waste disposal, wastewater treatment, waste incineration

Annex B: Policy codebook

1. **Policy name**

   Definition: The official title of the policy, program or regulation as they appear on government websites and documents.

2. **Jurisdiction**

   Definition: The country responsible for implementing the policy. Include only federal/national policies. Excludes provincial or state policies (including policies under equivalency agreements). The European Union is included. State-owned energy companies are included.

3. **Sector**

   Definition: The broad economic sector targeted by the policy. Policies can target multiple categories.

   Options:

   - Energy
   - Waste
   - Agriculture

4. **Subsector**

   Definition: A more specific economic category within the sector. Policies can target multiple subsectors.

5.

   Options:

Sector	Subsectors
Energy	Upstream oil and gas Liquified natural gas Midstream/downstream oil and gas Coal mining
Waste	Solid waste disposal Wastewater treatment and discharge Incineration and open burning of waste Waste diversion and treatment
Agriculture	Rice cultivation Livestock management Manure management Residue management

5. **Instrument type**

Definition: The mechanism or approach used to implement the policy. Commitments and strategies are not policies and should be excluded from the database. Policies can be coded as multiple instrument types, with the primary instrument listed first. Use only the options provided in the Instrument Type column.

Options:

Instrument type	Definition
Command and Control	A legally binding rule or directive imposed by a government authority to control or restrict certain activities, enforce compliance, or establish mandatory standards.
Economic	Instruments that use financial incentives or market-based mechanisms, such as taxes, subsidies, tradable permits, or grants to influence behaviour by incorporating environmental or social costs into the market.
Voluntary	A policy approach that relies on non-mandatory commitments, agreements, or actions by individuals, businesses, or organizations to achieve policy objectives without legal enforcement, or punitive measures in the event of failure to comply or achieve commitments.
Information	Provides knowledge, data, or guidance to influence behaviour, raise awareness, or improve decision-making.

6. **Instrument subcategory**

Definition: Specifies the particular type of instrument used within each broader category. Use only the options provided in the Instrument Subcategory column.

Instrument Type	Instrument Subcategory	Definition
Command and Control	Emissions standards	Establishes a maximum allowable methane emissions level.
	Technology mandates	Requires the adoption of specific methane reduction technologies.
	Performance-based regulations	Sets methane reduction targets that regulated entities must meet but allows flexibility in compliance.
	Restrictions or bans	Prohibits certain high-emitting practices, like routine venting or flaring.
	Permitting and licensing rules	Permits for energy projects are conditional on compliance with methane reduction measures.
	Leak Detection and Repair (LDAR) requirements	Mandates regular inspections and repairs of methane leaks
	Emission monitoring and verification standards	Requires standardized methods for measuring and verifying emissions.
Economic	Taxes or fees	Imposes a charge on methane emissions to incentivize reductions or raise cost of business-as-usual emissions.
	Subsidies	Provides financial incentives to support methane mitigation efforts.
	Financing instruments	Financing options, either repayable (loans) or through capital raised from investors (bonds), for methane reduction efforts.
	Tradable permit systems	Establishes a cap on methane emissions with tradable allowances.
	Grants and direct payment	Offers government funding for methane reduction projects.
	Tax credits and incentives	Provides tax benefits for methane reduction investments.
	Performance-based incentives	Provides financial rewards or penalties based on measured methane or emissions intensity.
Voluntary	Voluntary reporting programs	A program where companies voluntarily, and publicly, disclose methane emissions and reduction efforts to improve transparency and benchmarking.
	Certification or labelling schemes	Recognizes companies that meet specific methane reduction standards (i.e. a public disclosure requirement).
	Credit mechanism	Creates a system where entities can earn and trade credits for implementing emissions reduction projects.
Informational	Mandatory emissions reporting	Requires companies to disclose methane emissions data
	Capacity-building and technical assistances	Provides training, tools, and support to help companies reduce methane emissions.
	Research and development funding	Funds innovation and technology development for methane mitigation

7. Mitigation type

Definition: The specific strategy, technology, or practice used to directly or indirectly reduce, capture, or prevent methane emissions

Options:

Sector	Mitigation type	Definition
Energy	Leak Detection and Repair	Policies that seek to reduce fugitive emissions, which are unintentional releases of methane during the production, transportation, or storage of fossil fuels.
	Flaring and venting restrictions	Policies that aim to reduce or eliminate the flaring and/or venting of un-combusted methane into the atmosphere.
	Fuel switching	Policies that mandate or incentivize a switch from high-emission fuels to lower-carbon alternatives.
	Efficiency gains	Policies that mandate or incentivize improvements in energy conversion, transmission, or end-use efficiency to reduce fuel consumption and associated methane emissions. This includes upgrading thermal power plants (e.g., converting gas-fired plants to combined-cycle), reducing methane slip in engines, improving pipeline efficiency, and enhancing flare combustion efficiency in oil & gas operations.
	Gas and heat recovery	Policies that mandate or incentivize the capture and reuse of methane from energy production to generate electricity, provide heating, or serve as a fuel source. Recovered methane can include residual gas from oil and gas operations or coal mine methane.
	Equipment and infrastructure upgrades	Policies that mandate or incentivize the replacement, upgrade, or maintenance of equipment to reduce methane leaks (e.g. pipeline replacements, compressor upgrades, valve replacements).
	Decommissioning and repurposing	Policies that mandate or incentivize the closure of polluting energy facilities, such as oil and gas plants and coal mines, or mitigate their long-term environmental impact through repurposing.
	Measurement and monitoring	Policies focused on improving methane emissions, quantification, continuous monitoring systems, or remote sensing technologies.
Waste	Waste reduction, diversion, and valorisation	Policies that aim to reduce the volume of organic waste generated, increase diversion of organic waste from landfills, or produce useful byproducts from organic waste, such as biofuels, bioplastics, or biofertilizers.
	Low-emission waste collection and transport	Policies that aim to reduce or minimize methane emissions during the collection, transport, or transfer of organic waste or wastewater sludge.
	Aerobic treatment	Policies promoting treatment processes that stabilize organic waste through aerobic decomposition and bio-drying, preventing methane generation under anaerobic conditions.
	Anaerobic treatment and co-digestion	Policies that promote the treatment of organic waste in sealed, oxygen-free systems (anaerobic digesters), where decomposition is controlled to reduce emissions from methane-rich sources like

		landfills or open lagoons. This includes both single-stream anaerobic digestion and co-digestion, where multiple types of organic waste (such as food waste and sewage sludge) are processed together.
	Biogas recovery and utilization	Policies to regulate or incentivize the capture and productive use of methane gas from waste processes.
	Waste stabilization	Policies that reduce methane generation by altering the physical, chemical, or biological conditions within waste to suppress anaerobic decomposition. These approaches inhibit methanogenic activity by treating waste either before or during processing.
	Biogas flaring and oxidation	Policies that require or regulate the controlled combustion or oxidation of methane gas captured from waste systems to prevent its release into the atmosphere. These methods destroy methane after it forms, typically at landfills, digesters, or lagoons.
	Thermal destruction and conversion	Policies that promote the high-temperature destruction or irreversible transformation of residual solid or liquid waste to prevent methane generation. These processes typically occur at the final stage of waste treatment or disposal and aim to either destroy methane-generating material or convert waste into more chemically stable byproducts.
	Containment and passive treatment	Policies that reduce methane emissions by physically containing waste, preventing gas escape, or enabling passive biological treatment (e.g., oxidation by microbes in the soil). This category includes landfill covers, lagoon covers, and other systems that prevent uncontrolled methane release without requiring active gas collection or combustion.
	Measurement and monitoring	Policies focused on improving methane emissions quantification, continuous monitoring systems, or remote sensing technologies.
Agriculture	Rice cultivation practices	Policies that reduce methane emissions from rice cultivation by promoting water, crop, and soil management strategies that limit methane production. This includes encouraging the use or development of rice cultivars with traits that suppress methane formation, as well as promoting practices such as intermittent or alternate wetting and drying (AWD) that reduce anaerobic conditions in paddies and thereby suppress methanogenic microbial activity. It also includes strategies that modify soil chemistry or microbial activity to inhibit methane formation in flooded conditions.
	Feed management	Policies that reduce enteric methane emissions by improving livestock nutrition and directly targeting rumen methanogenesis. This includes strategies to enhance the nutritional quality or digestibility of livestock feed, as well as promoting the use of feed additives that inhibit methane production or alter the rumen's microbiome.

	Livestock breeding and selection	Policies that reduce methane emissions by promoting the breeding or selection of livestock with lower methane intensity per unit of output. This can involve selecting animals with traits such as higher feed efficiency, beneficial rumen microbial profiles, or improved dairy productivity – traits that naturally reduce methane production while maintaining or improving productivity.
	Herd management	Policies that reduce methane emissions by managing herd structure, grazing intensity, reproduction, and lifecycle turnover to increase productivity and reduce emissions per unit of output. This includes optimizing the proportion of productive vs. non-productive animals, improving fertility and offspring survival, and shortening the time from birth to productive output or slaughter. These strategies reduce a farm's "methane overhead"—methane produced by animals that are not actively contributing to milk, meat, or offspring production.
	Manure storage and handling	Policies that reduce methane emissions from manure management by avoiding or disrupting anaerobic conditions during collection, storage, or handling. This includes shifting away from wet storage systems, shortening storage duration, or improving system design to limit methane formation.
	Manure treatment and stabilization	Policies that reduce methane emissions by chemically, biologically, or thermally treating manure to inhibit methane-forming bacteria or stabilize organic material before storage.
	Manure-based digestion and gas recovery	Policies that reduce methane emissions by promoting the controlled anaerobic digestion of manure, paired with recovery and either use or destruction of biogas.
	Crop residue management	Policies that address methane emissions from agricultural residues by restricting burning and instead promoting productive use or aerobic treatment. This includes the collection and reuse of crop residues, in-field composting of residue under aerobic conditions, and restrictions on open-field burning.

8. **Status**

   Definition: The current stage of the policy's implementation.
   Options:
   a. Announced: Officially communicated by the government or relevant authority but not yet formally approved or in effect. Represents the initial public declaration of policy intent.
   b. Adopted: Formally approved but not yet operational. The policy has completed the approval process, but implementation has not yet begun.
   c. Active: Currently in effect and being implemented. Enforcement mechanisms (if included in the policy) are operational.

9. **Date**

Definition: The year the policy was either announced or implemented, depending on the “status”. In cases where a policy is finalized in one year, but comes into force in another, the date the policy was finalized should be noted, with detailed on implementation in brackets. E.g. “2018 (phased implementation 2020 to 2023)”

10. Policy description

Definition: A concise (maximum 5 sentence) summary including details about the following categories (where applicable), prioritizing quantitative information where available:

- Purpose: Primary objective of the policy
- Coverage: Sectors, activities, or entities affected
- Key requirements: Main obligations or incentives
- Stringency: Emissions reduction targets or compliance thresholds
- Funding: Financial resources allocated
- Timeline: Implementation schedule, phase-in period, or key dates
- Enforcement mechanism: how compliance is monitored and enforced
- Enforcement level: who is subject to the policy, e,g, individual companies, industry sectors, facility operators, national governments, subnational governments, etc.
- Estimated impact: Projected emissions reductions

11. References

Definition: A list of the key sources consulted to populate the columns of the table.

12. Link

Definition: A link to the primary source of the information. Preference should be given to official government websites/documents.

13. Direct or Indirect

Definition: Indicates whether a policy explicitly targets methane emissions reductions as its primary objective or achieves methane reductions as a secondary benefit.

Options:

- **Direct:** Policies explicitly designed to reduce methane emissions, with methane reduction as an explicit, primary goal. A policy should be classified as "Direct" if "methane" is explicitly mentioned in the policy title or objectives.
- **Indirect:** Policies that result in methane emissions reductions but primarily target other objectives. Broader climate policies that include methane alongside other GHGs should be classified as "Indirect" unless they contain specific, dedicated provisions for methane.

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