CLIMATE CENTRAL SOLUTIONS BRIEF: CUTTING METHANE

Part of the Climate Solutions series

November 9, 2022

CLIMATE CENTRAL

INTRODUCTION

Rapidly cutting emissions of methane is increasingly recognized as the most effective strategy for slowing the pace of climate change during the remainder of this decade, buying time for communities to adapt and for additional carbon pollution-reduction measures to be implemented. As a result, governments, businesses, and civil society are focusing heightened attention on curtailing emissions from the largest sources of methane: the energy sector (specifically oil, natural gas, and coal production), the agriculture sector (specifically livestock and rice), and waste management (particularly landfills).

At the same time, remote-sensing data from satellites and aircraft are beginning to provide far more detail on where emissions are coming from: not only which sectors, but also which specific facilities in which particular jurisdictions. Those data can help decisionmakers prioritize and fine-tune reduction strategies. The data can also provide clearer identification of–and thus accountability for–ongoing emissions.

This report explains the role of methane in global warming. It provides a snapshot of global sources of methane emissions with specific focus on the United States, summarizes cost-effective approaches for reducing emissions, and explores how new data can play a key role in enabling rapid reductions.

METHANE: THE BASICS

Greenhouse gases have caused the Earth to warm by 2° Fahrenheit (1.1° Celsius) since pre-industrial times. While carbon dioxide is the biggest contributor to climate change, at least 30% of current warming is due to human-caused emissions of methane.

Methane's significance results from two of its physical properties. First, it is a powerful greenhouse gas, one that traps over 80 times more heat than the same amount of carbon dioxide over a twenty-year period. But it also breaks down far more quickly, with a lifetime in the atmosphere of about a dozen years, as opposed to multiple centuries for carbon dioxide. These two characteristics together mean that reducing methane emissions has a big payoff quickly.

Methane concentrations in the atmosphere have increased markedly since pre-industrial

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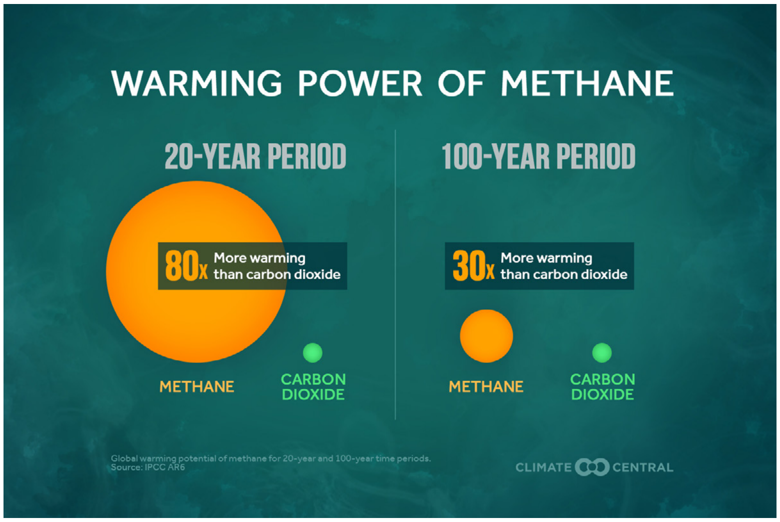
times, rising more than 160% between 1750 and 2021. The pace of that increase has varied over time, with the fastest uptick occurring during the last two years.

QUANTIFYING METHANE: ESTIMATES, MEASUREMENTS, AND THEIR LIMITATIONS

Accurate information on emissions is key for setting priorities and for tracking progress–or lack thereof–in achieving reductions. However, direct measurements of methane emissions are relatively sparse, as collecting data on an odorless, invisible gas requires specialized technology.

As a result, most information on methane emissions comes from estimates rather than based on direct measurements. In many instances, methane estimates are based on "emission factors." Such factors are developed by directly measuring emissions from samples of a particular type of equipment or activity, but these measurements are sometimes decades old and taken in different circumstances. The factor is then multiplied by the number of those items or activities occurring at a facility, then further multiplied by the number of facilities in the relevant jurisdiction. Both the number of items or activities and the number of facilities may themselves be estimates, rather than actual counts. The result of this approach is often referred to as a "bottom-up" estimate.

Estimates provide the core of the national emission inventories prepared by national governments to meet their reporting obligations under the UNFCCC (see Box 1). In the U.S., the inventory integrates information reported by facilities under the Greenhouse Gas Reporting Program (GHGRP). That program, under which more than 8,000 non-agricultural facilities report their estimated emissions of methane and other greenhouse gases, allows use of emission factors established by the U.S. Environmental Protection Agency (EPA).



Box 1. Global Warming Potential: Comparing short-lived and long-lived gases

All greenhouse gases (GHGs) warm the Earth by trapping solar heat in the atmosphere. But each GHG has a different contribution to warming, resulting from two key factors–their capacity to absorb energy (radiative force) and how long it takes them to dissipate in the atmosphere (their lifetime). Because gases behave so differently, it can be difficult to evaluate their impacts on warming compared to one another.

Global Warming Potential (GWP) values were developed to facilitate comparison of impact between gases. The GWP value for each gas is measured against the warming potential of carbon dioxide–specifically how much energy is absorbed by 1 ton of a gas relative to 1 ton of CO2–over a given period of time. The larger the GWP value, the more that gas warms earth in that given timeframe compared to CO2.

Two time frames are typically used for GWP: 100-year and 20-year. The 20-year GWP is particularly useful when considering shorter-lived gases, including methane. Methane's 20-year GWP is 80-83, while its 100-year GWP is 27-30, depending on source type.

Under the UN Framework Convention on Climate Change (the parent body of the Paris Agreement), nations periodically compile and publish inventories of their emissions. While the existing inventory rules require use of 100-year GWPs, some scientists have proposed a paired system in which both the 20-year and 100-year GWPs are presented. They argue this will provide a clearer picture of both the short- and long-term impacts of emission reductions.

By contrast, top-down methods look at the concentration of methane actually present in the atmosphere, through aerial measurements. Methane-sensing equipment takes measurements from tall structures, aircrafts, drones, or satellites. Because wind can quickly spread emissions out over large areas, correctly attributing emissions when multiple sources are within range can be difficult.

When bottom-up estimates are reconciled with top-down ones, striking discrepancies may emerge. For example, a consortium of researchers who compiled top-down measurements on U.S. gas facilities concluded that methane emissions from those facilities were approximately 60% higher than shown in the EPA inventory estimate. This problem is not unique to the United States: the International Energy Agency (IEA) recently concluded that global emissions from the energy sector are about 70% higher than the total reported in national inventories. Notably, the current inventory approach does not effectively ac-

Box 2. More than warming

In addition to its climate impacts, higher concentrations of methane present health and safety risks. These include lung damage and–due to methane's flammability–potential for explosion.

Moreover, methane also mixes with other compounds to form ground-level ozone—a significant air pollutant and primary component of smog. Ozone is linked to an array of health concerns, including respiratory and cardiovascular illness, asthma, and even premature death. Ground-level ozone is also toxic to plants. It reduces yields for a number of important crops, including corn, wheat, and rice. Methane thus provides a double whammy on crop productivity, by contributing both to formation of ground-level ozone, and to more-extreme heat and droughts.

Box 3. Satellites are changing how methane is monitored and measured

A growing array of satellites are gathering methane data. Some provide a global overview, while others map emissions from particular facilities, referred to as point sources. The former generally can only "see" fairly high levels of methane over a broad area, covering the whole globe on a near-daily basis (though clouds can interfere with data collection). By contrast, the point-source mappers can identify methane plumes from specific individual sources, but can only detect relatively high concentrations, and have a narrower field of vision. A third category takes a hybrid approach. An example of a hybrid is MethaneSat, which is expected to launch in early 2023. Emissions data from MethaneSat will be made publicly available in near-real time.

On occasion, satellites created for other purposes may also spot methane emissions. For example, NASA recently announced that its EMIT satellite had identified more than 50 methane "super-emitters" in Central Asia, the Middle East, and the Southwestern United States. The satellite, which was installed on the International Space Station in July 2022, was originally developed to map the prevalence of key minerals in the planet's dust-producing deserts.

Satellite imagery and airborne remote sensing can be used to detect large emissions from any point source in the landscape, such as oil and gas facilities, landfills, or farming operations. Localized remote sensing via aircraft and handheld or airborne infrared cameras can detect smaller plumes, such as fugitive emissions from oil and gas operations.

count for ultra-emitting events–sporadic releases of large amounts of methane during maintenance operations or equipment failures.

On their own, neither bottom-up nor top-down estimates provide a full picture of emission sources. Synthesizing results from both approaches can produce better estimates. The most comprehensive effort to do so to date is the Global Methane Budget, a massive effort in which dozens of scientists examined all available data for 2000-2017.

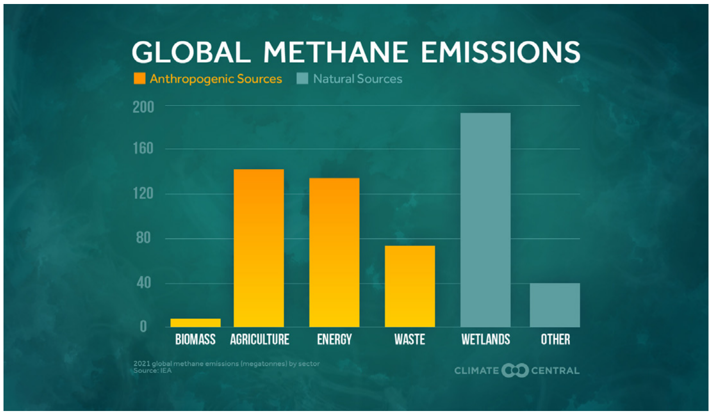
The newly established International Methane Emissions Observatory (IMEO) will collect, gather, and reconcile the various sources of methane data going forward. With an initial focus on fossil fuels, IMEO aims “to establish a global public record of empirically verified methane emissions at an unprecedented level of accuracy and granularity.” IMEO will provide “near-real time, reliable, and granular data on the locations and quantity of methane emissions” in order to catalyze emission-reduction strategies and actions.

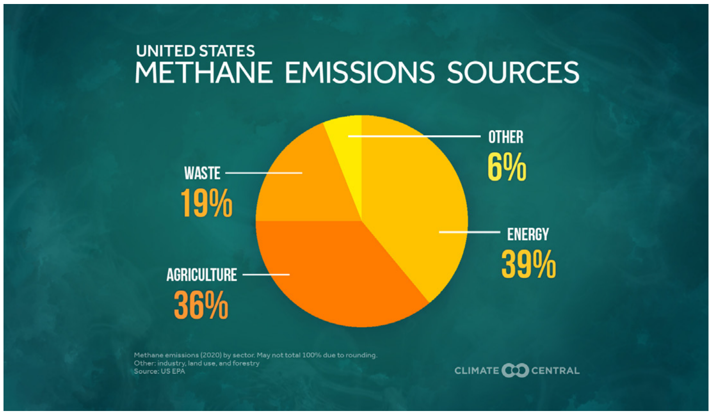
METHANE SOURCES

Most of the methane emitted to the atmosphere–about 60%–results from human activity, with the remaining 40% from natural sources such as wetlands. Globally, about 40% of human-derived methane comes from agriculture, about 35% from the energy sector, and about 20% from waste management.

According to the national inventory for the United States, about 38% U.S. emissions come from fossil fuels, 36% from agriculture, 17% from landfills, and the remaining 9% from a variety of smaller sources. As noted above, national inventories may significantly understate energy-related emissions. Indeed, the IEA estimates that the energy sector contributes 54% of U.S. methane emissions.

On a global basis, the five largest emitters of methane are China, the U.S., Russia, India, and Brazil. In the U.S. the top five states in terms of overall emissions are shown in Box 5; see Appendix 1 for a complete list.





ENERGY SECTOR

Unlike carbon dioxide, which is released when fossil fuels are burned, methane is emitted when natural gas, petroleum, and coal are produced. (When burned, methane itself releases carbon dioxide and other compounds.)

Box 4. Carbon isotopes can tell us the origins of methane

Methane is created either by biological processes (known as biogenic methane) or by geologic activity (known as thermogenic methane). Biogenic methane results when methane-generating bacteria consume organic matter such as vegetation or waste, and thermogenic methane occurs as a result of geologic action deep underground, including in processes that give rise to fossil fuels. Both biogenic and thermogenic methane arise from human as well as natural sources, and affect the climate similarly.

To distinguish between biogenic and thermogenic methane, isotopic signatures provide key insights. Biogenic and thermogenic methane carry different ratios of carbon-12 (the most common form) and its stable isotope, carbon-13. There's an extra neutron in ^{13}C, making it slightly "heavier" than ^{12}C.

Biogenic methane contains less 13C than thermogenic methane, making it "lighter." Researchers can analyze methane samples for the ratio of ^{13}C:^{12}C to determine the relative contribution of biogenic versus thermogenic sources. This information can help indicate whether reduction efforts in various methane-emitting sectors are making progress.

Some evidence indicates that the methane responsible for recent spikes is "lighter" and therefore does not have fossil fuel origins. Some researchers suggest the sources could instead be agriculture, or less likely, wetlands. Other research indicates that the contribution of natural sources has been overestimated.

Natural gas–which is largely composed of methane–is used for multiple purposes. It generates nearly 40% of the U.S.'s electricity. Natural gas, also known as fossil gas, is also widely used for residential heating and cooking, and as a chemical feedstock.

Methane co-occurs in many oilfields, where it can either be a desirable co-product or an unwanted by-product. Whether it is desirable depends largely on the availability of facilities–notably pipelines–to transport the gas to a processing plant.

Underground and surface coal mines both release methane gas, though the quantity of this "coal-bed methane" varies substantially among mines. Underground operations typically vent it to avoid hazards (since methane can be explosive and dangerous to breathe in a confined underground space). Some mining operations also capture the gas.

Methane emissions can occur during any stage of oil and natural gas exploitation. After gas is extracted and captured, it is processed, stored, and distributed, before ultimately being combusted for energy.

As gas moves through the system, there are several ways it is emitted into the atmosphere:

- **Fugitive emissions:** Unintentional or unplanned leaks occur throughout oil and natural gas systems, mainly due to faulty equipment, such loose valves or leaky pipes.

- **Vented emissions:** Methane gas is routinely released intentionally, often for safety or operational reasons (such as venting gas from a pipe for inspection and maintenance). In some cases, venting is part of normal operation due to facility or equipment design. Vented gas makes up the bulk emissions, according to reported data.
- **Incomplete flares:** When it is not cost-effective to capture or process methane at an oilfield, operators dispose of it by flaring, or burning. Not all methane is destroyed by flares and some escapes into the air. The emission factor for flaring is routinely assumed to be 98% destruction efficiency, but recent research suggests the efficiency may be substantially lower and thus flaring may be a much bigger source of methane.

Fossil fuel operations continue to emit methane long beyond their useful lifetime. Millions of abandoned oil and natural gas wells across the U.S. could be significant sources of methane emissions, according to one recent study. Hundreds of coal mines, too, continue to release gases after they've been abandoned, as well as during their working lives.

Within the U.S., emissions related to the fossil fuel industry vary widely from state to state. See Box 5 for the top-ranked states, and Appendix 1 for a full list.

Box 5. Top-ranked states, emissions by sector (measured in million metric tons of CO2 equivalent based on 100-GWP of 25)

Rank	All sectors	Energy	Agriculture	Waste
1	Texas (92.30)	Texas (49.52)	Texas (25.85)	Texas (13.07)
2	California (47.23)	Pennsylvania (27.82)	California (19.58)	California (11.26)
3	Pennsylvania (36.17)	West Virginia (22.93)	Iowa (13.83)	Florida (7.89)
4	Oklahoma (27.63)	Oklahoma (15.35)	Nebraska (13.10)	Georgia (7.33)
5	West Virginia (24.53)	Colorado (11.31)	Kansas (12.21)	Ohio (6.10)

Source: U.S. Environmental Protection Agency, Greenhouse Gas Inventory Data Explorer

AGRICULTURE

Agriculture is the largest global source of methane from human activity, accounting for roughly 40% of all anthropogenic emissions as noted above. It accounts for about 30% in the United States, making it the second largest source nationally, behind the energy sector.

Livestock production and manure management

Livestock, primarily cows, are the biggest contributor of agricultural methane. This results chiefly from a process known as "enteric fermentation": As feed ferments in the rumen (part of the digestive tract of cows, sheep, and goats), it produces methane that is expelled mainly through belching. Additional methane is released from animal manure, to a greater or lesser degree depending on how the manure is used, stored, or processed.

Rice

Rice cultivation is responsible for around 8% of global anthropogenic methane emissions. In so-called "paddy rice" operations, fields are flooded to cultivate rice, essentially creating more wetlands. Oxygen cannot penetrate the flooded soil, which creates ideal conditions for methane-generating microbes.

As with the energy sector, in the U.S. the quantity of methane emitted from agriculture varies widely by state. See Box 5 for the top-ranked states, and Appendix 1 for a full list.

WASTE MANAGEMENT

Municipal solid waste–everything from food scraps and yard clippings to clothing and paper products–accounts for about 20% of global methane emissions, and for about 15% in the U.S based on estimates from the IEA and the EPA. Methane is also emitted by wastewater treatment plants.

In the U.S. about half of all municipal waste is landfilled. Of that 292 million tons of trash, about a quarter is food and another 7% is yard trimmings. As this organic matter decomposes in the low-oxygen (anaerobic) conditions of a landfill, it releases a combination of gases known collectively as landfill gas (LFG). Methane makes up about 50% of LFG, while most of the rest is carbon dioxide.

In a warming world, climate feedbacks may enhance methane emissions from the waste sector. Warming boosts decomposition, leading to more methane emissions that contribute to further warming.

Box 5 lists the top-ranked states in terms of waste-related emissions; Appendix 1 has a full list.

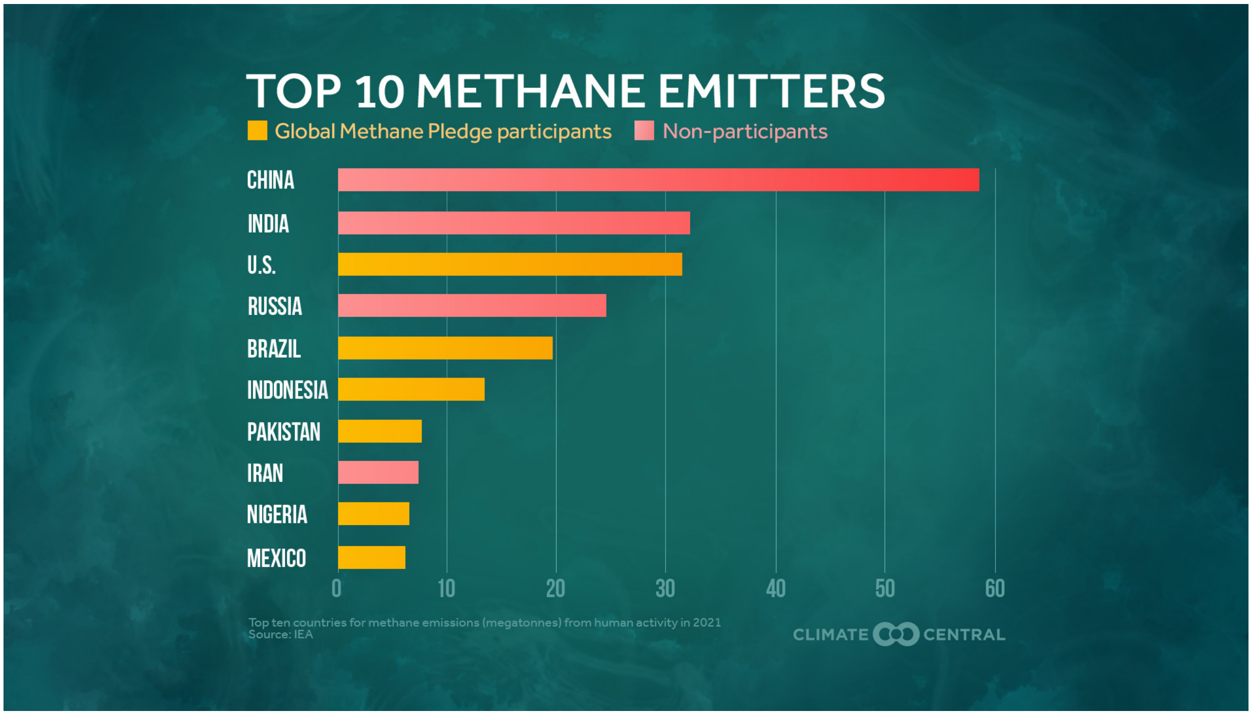
REDUCING METHANE EMISSIONS

KEY INITIATIVES

As the importance of reducing methane emissions to limit near-term warming has become better understood, efforts to spur such reductions have multiplied. In addition to the sector-specific initiatives mentioned below, major players include:

- UNEP's International Methane Emissions Observatory (IMEO, described above). In addition to its data role, IMEO manages industry partnerships to connect data to action.
- The Global Methane Initiative, an international public-private partnership focused on "reducing barriers to the recovery and use of methane."
- The Climate and Clean Air Coalition (CCAC), whose 150+ governments, businesses and civil society organizations work together to simultaneously benefit air quality and climate. CCAC's 2021

Global Methane Assessment integrates information on such benefits for a variety of specific emission-reduction strategies.



Also in 2021, two additional efforts were launched: the Global Methane Hub, a philanthropy-led effort to provide and coordinate funding for emission reduction efforts; and the Global Methane Pledge, through which 125 nations have agreed to take voluntary actions to collectively reduce global methane emissions at least 30 percent across all sectors from 2020 levels by 2030. In addition, the EPA's 2019 report, Global Non-CO2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050, provides technical and economic feasibility estimates for reducing methane (and other non-CO2 warming gases) from anthropogenic sources for 195 countries.

All of these initiatives focus on the three main emitting sectors discussed above, namely agriculture, energy, and waste management. Many observers regard energy–specifically oil and gas production–as the sector with the best opportunity for significantly reducing emissions in the near term. In part, that is because there are fewer decisionmakers: the number of oil and gas plant managers and executives is far smaller than the number of farmers or municipal-landfill operators. Moreover, natural gas–composed mainly of methane–is already a commercial product for this industry. By contrast, methane is an unwanted by-product for the agriculture and waste sectors; though as discussed later in this report, there are efforts underway to capture and use methane from these sources, too.

CUTTING EMISSIONS IN THE ENERGY SECTOR

There is tremendous potential for cutting methane emissions from the fossil fuel industry. Technical solutions exist across the supply chain, and many options are zero or low net-cost because implementation costs are offset by the value of captured gas. Although advanced technology can support comprehensive initiatives, even simple fixes can achieve meaningful reductions.

An analysis by IEA looked at relative costs and impact of implementing well-established technologies and practices (including leak detection and repair, technology standards, and limits on venting) across countries already committed to methane reduction. Adoption of these practices and policies could potentially cut nearly 15% of global methane emissions from fossil fuel production. IEA's analysis concludes that it is technically possible to reduce the sector's methane emissions by 75%. Nearly half could be implemented at no net cost, taking into account the value of the gas saved.

UNEP's Oil/Gas Methane Partnership 2.0 (OGMP 2.0)–which includes governments and nongovernmental organizations, as well as more than 80 oil and gas companies–provides a detailed framework through which participating companies quantify and work to reduce their emissions. OGMP 2.0 companies commit to reporting measurement-based (rather than estimate-based) data for their facilities–including, crucially, facilities in which they have a financial stake but do not directly operate.

Separately, the Oil and Gas Climate Initiative–an industry-only coalition of oil/gas companies–in 2022 launched Aiming for Zero, based on the principle that "virtually all methane emissions from the [oil and gas] industry can and should be avoided." Among the companies are Chevron, ExxonMobil, and Occidental. Participants have pledged to reach "near-zero methane emissions" from their facilities by 2030, and to encourage others in the industry to do likewise.

Leak detection and repair

Leak detection and repair (LDAR) refers to methods, equipment, and technology used to locate and repair fugitive leaks along the oil and natural gas supply chain. Fugitive emissions can escape from leaky seals or gaskets on valves, fittings, and compressors.

In the U.S., a set of LDAR regulations apply to the oil and gas industry. Operators are required to monitor and inspect equipment for leaks, and repair or replace leaking equipment in a timely manner. Repairs for these leaks can be relatively simple and cost-effective.

In November 2021, EPA proposed additional methane regulations that broaden the scope of existing requirements. The proposal includes performance standards for particular types of equipment known to be leak-prone, as well as monitoring provisions to enhance leak detection. The Inflation Reduction Act, which was signed into law in August 2022, places a modest fee on methane emissions; the fee is inapplicable if regulations take effect and result in reductions at least as great as those proposed. The Act also provides funding for methane-reducing equipment and processes.

Venting and inefficient flaring

Venting gas occurs as a planned part of operations in oil and gas production, so changes to standard practices and procedures are necessary to reduce these emissions.

Flaring the "associated" gas that is an unwanted byproduct of oil production is often used as an alternative to venting methane.

Box 6. Cutting gas at home

Households across the U.S. have appliances and heating systems fueled by methane-rich natural gas. Transitioning these devices and systems to electricity can reduce demand for natural gas production and distribution, thus reducing emissions from this sector. In addition, recent research has found that nontrivial amounts of methane leak from natural gas stoves that are present in around 40 million American homes, even when the stoves are not in use. Learn more about electrifying households from Rewiring America and Climate Central's report on climate-friendly homes.

Flaring the gas combusts it so that carbon dioxide rather than methane reaches the atmosphere (as noted above, methane traps more than 80 times as much heat as carbon dioxide over a 20-year period). But the efficiency of flaring varies significantly: while some well-operated flares destroy 98% of methane, others only achieve 60% destruction. And when a flare is extinguished or never properly ignited–as researchers have found happens with an estimated 3-5% of U.S. flares–methane flows directly into the atmosphere.

Operations can avoid use of non-emergency venting and inefficient flaring. Paired with the implementation of gas capture systems, there can be both emission cuts and financial benefits.

Coal mines
Because coal typically co-occurs with methane, disturbing a coal seam–whether through surface mining or underground–releases methane. Various technologies allow capture of methane from underground mines, at which point it can be used to power operations on-site or, where natural gas pipeline systems are nearby, sold as a commercial product.

Coal mines can produce significant quantities of methane even after mining ends. Methane emission from abandoned coal mines will steadily increase as more mines are closed across the globe. Abandoned mine methane can be recovered and utilized. The EPA Coalbed Methane Program maintains a database of "gassy" abandoned mines that can be developed for gas recovery opportunities

CUTTING EMISSIONS IN AGRICULTURE

As the global population continues to grow, so does demand for food. High-emission agricultural activities like raising livestock and cultivating rice are projected to expand in coming years. Targeting these activities for cost-effective GHG reductions can have significant impact. Changes in consumer preferences that reduce consumption of livestock products and rice would also reduce these emissions, but relatively little is known about how people make dietary choices or what influences them.

Alternative feed for cows
Scientists are experimenting with alternative feeds and additives–known as methanogenesis inhibitors—that could reduce the amount of methane that ruminants produce during digestion and later expel. These additives range from natural supplements to synthetic chemicals.

One feed supplement for cows that has gotten a lot of attention (partly because it's effective and partly because it's unexpected) is seaweed. A study published in 2021 found that adding small quantities of red algae (Asparagopsis taxiformis) to the diet of beef cattle reduced methane from digestion in cows by 80%. Another potential additive is 3-nitrooxypropanol, which one study shows reduced methane from cows by 30% on average.

But methane-reducing feed additives are not yet widely commercialized. Researchers and farmers need to collect additional data on effectiveness, health and nutrition implications, and other ecosystem or productivity impacts. Some are still experimental and don't have regulatory approval (though 3-nitrooxypropanol has been approved in Brazil, the world's largest beef exporter). Others are expensive or difficult to administer to a whole herd, such as those not kept in a central location like a barn or feedlot.

Changing practices in rice cultivation
Historically, most of the world's rice has been grown by flooding rice paddy fields throughout the

growing season. The standing water creates low-oxygen conditions that are ideal for methane-producing microbes. Studies show that alternating between irrigating and draining paddies during the growing season can both conserve water and reduce methane emissions by as much as 70%. Farmers in China have successfully used a similar practice of alternate wetting and drying since the 1980s, with measurable cuts to methane emissions.

Implementing this practice more widely is one of the most promising strategies for cutting methane emissions from rice cultivation. However, some researchers have found that it may not be suitable in all settings or conditions. The practice requires control over water input, and not all farmers have the sustained access to irrigation that is necessary. Heavy rainfalls–which climate change is making increasingly common–also make draining more difficult, potentially hampering the use of wet/dry strategies.

CROSS-CUTTING SOLUTION: BIOGAS

Biogas–which is about 50% methane–is produced as microbes break down organic matter in the low-oxygen conditions often found in manure lagoons and landfills. Thus, biogas management is a cross-cutting strategy for both the agricultural sector and the waste-management sector. Biogas systems extract and process gases released from both types of facilities, though with differences in facility design.

Once biogas is collected and processed, it can either be burned in its original form or transmitted for energy or transportation uses. Biogas can also be processed as renewable natural gas, wherein other gases are removed and the concentration of methane increases to upwards of 90%. Renewable natural gas has broader application than raw biogas.

Biogas offers a double benefit: it both directly prevents methane from escaping into the atmosphere, while also reducing use of other fossil-fuel energy sources.

Manure biogas
Dairy cattle, beef cattle, and hogs all produce copious amounts of manure. On large livestock operations, manure is commonly collected and stored in liquid manure management systems, or lagoons. The slurry of manure and water in lagoons creates anaerobic conditions that favor methane production.

Farmers can cover lagoons and capture the biogas generated as manure decomposes. Anaerobic digestor systems further “digest” the waste and generate more methane. Food and other agricultural waste can also be added to digestors for processing.

As of 2021, 331 manure-based anaerobic digestion systems were operating across the U.S. Although biogas can provide income, these systems can be complex and expensive to install and operate, so they may not be viable for smaller operations.

Landfill gas energy projects
Methane is also created under low-oxygen conditions in landfills, as microbes feed on organic matter such as food and yard waste. A system of wells and vacuums or blowers can be installed at landfills to extract landfill gas and direct it to a central point, where it is contained and processed. At this point, the gas is either flared, used, or transmitted.

Across the U.S., there are 538 operational landfill gas projects and hundreds more potential candidates. Each project can potentially capture 60-90% of the methane emissions from the landfill, depending on project design and efficiency. Projects can generate revenue from the sale of biogas, making them economically as well as environmentally beneficial.

The Landfill Methane Outreach Program (LMOP), managed by the EPA, is a program through which stakeholders and officials can voluntarily engage to reduce or avoid methane emissions from waste management. LMOP and the International Solid Waste Association collaboratively produced the International Best Practices Guide for LFGE Projects to connect stakeholders with information and resources to inform project development.

CROSS-CUTTING SOLUTION: REDUCING FOOD WASTE

Food waste and loss occurs across the supply chain, from harvest on the farm to household kitchens. In the U.S., up to 40% of the food supply is never eaten. Food waste made up more than 21% of garbage in U.S. landfills in 2018. Reducing food waste sent to landfills lessens the organic matter available to feed methane-producing microbes.

In 2015, the U.S. Department of Agriculture (USDA) and EPA jointly announced a goal of cutting food loss and waste in half by the year 2030. More than 45 corporations have joined the initiative, submitting annual updates on their progress. USDA and EPA compile those updates, but to date have not quantified overall progress toward the 2030 national goal.

Composting is one way to divert waste from landfills. EPA reports that around 25 million tons of waste were composted in 2018. About 90% was from yard trimmings, with most of the remainder being food waste. Additionally, nearly 18 million tons of food was managed through other landfill alternatives, including anaerobic digestion, donation, and animal feed.

The USDA administers Composting and Food Waste Reduction cooperative agreements to help local governments establish compost and food waste reduction plans. These local programs can divert food waste from landfills and create scalable solutions to waste management, in addition to creating fertilizer for farmers.

CONCLUSION: KEY BARRIERS TO CUTTING METHANE

The technology and capacity to reduce methane emissions in the U.S. and elsewhere in the developed world is well established for the oil and gas sector, with a growing array of options also available for agriculture and waste management. But lack of publicly available high-quality data on methane emissions by sector and individual facility has hindered priority-setting and accountability. In developing countries, lack of access to technology, training, and finance further complicates the problem.

Policy, regulation, and voluntary industry initiatives all play important roles in seizing the opportunity presented by methane reductions to slow the pace of warming in the current decade. Accurate data that enables priority-setting and accountability is one key to making the rapid progress needed.

KEY GOVERNMENT ACTIONS ON METHANE

Global Methane Pledge
Key action: U.S.-led international commitment aims to achieve 30% reductions in global methane emissions by 2030

United States Methane Reduction Action Plan
Key action: Outlines how the U.S. will tackle super-emitting events

Inflation Reduction Act
Key action: Includes a methane emissions charge for industry, and provides grant funding for reduction technology

USEFUL LINKS

- Carbon Mapper
- Carbon Monitoring System
- Emissions Database for Global Atmospheric Research
- Environmental Defense Fund
- Global Methane Assessment, 2021
- Global Methane Budget
- International Energy Agency
- International Methane Emissions Observatory
- Inventory of U.S. Greenhouse Gas Emissions and Sinks
- Kayrros
- MethaneSat
- Oil and Gas Methane Partnership 2.0
- Primer on Cutting Methane
- TROPOspheric Monitoring Instrument (TROPOMI)
- United Nations Framework Convention on Climate Change

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APPENDIX 1– U.S. methane emissions by sector, ranked by state (2020)

Methane emissions measured in million metric tons of CO2 equivalent based on 100-GWP of 25
Other includes: Industry and Land-use, Land-use Change, and Forestry (LULUCF)
State totals in Agriculture do not add up to the overall U.S. total.

Source: U.S. Environmental Protection Agency, Greenhouse Gas Inventory Data Explorer

	Energy	Energy %	Agriculture	Agriculture %	Waste	Waste %	Other	Other %	State Total
Alabama	8.295	51%	2.543	16%	4.851	30%	0.578	4%	16.268
Alaska	1.251	71%	0.039	2%	0.448	25%	0.019	1%	1.757
Arizona	1.402	22%	2.852	45%	1.61	25%	0.512	8%	6.376
Arkansas	3.537	39%	3.049	34%	1.952	22%	0.535	6%	9.074
California	8.634	18%	19.581	41%	11.255	24%	7.758	16%	47.229
Colorado	11.307	55%	6.597	32%	1.736	8%	0.919	4%	20.56
Connecti-cut	0.418	42%	0.195	20%	0.319	32%	0.064	6%	0.996
Delaware	0.138	17%	0.073	9%	0.532	67%	0.049	6%	0.791
DC	0.053	65%	0	0%	0.025	30%	0.004	5%	0.082
Florida	1.839	12%	3.828	25%	7.887	52%	1.703	11%	15.258
Georgia	1.58	12%	2.87	22%	7.33	57%	1.095	9%	12.875
Hawaii	0.034	5%	0.263	39%	0.373	56%	0	0%	0.67
Idaho	0.479	5%	8.2	83%	0.659	7%	0.512	5%	9.85
Illinois	6.375	40%	3.875	25%	5.211	33%	0.302	2%	15.762
Indiana	5.045	43%	3.416	29%	3.126	27%	0.094	1%	11.681
Iowa	1.574	9%	13.826	78%	2.211	12%	0.176	1%	17.786
Kansas	9.386	39%	12.208	51%	1.84	8%	0.365	2%	23.799
Kentucky	5.138	40%	3.832	29%	3.721	29%	0.305	2%	12.996
Louisiana	10.725	57%	1.549	8%	3.084	16%	3.491	19%	18.849
Maine	0.298	23%	0.265	20%	0.41	31%	0.331	25%	1.304
Maryland	0.619	21%	0.556	19%	1.476	50%	0.329	11%	2.98
Massachu-setts	0.943	47%	0.091	5%	0.858	43%	0.098	5%	1.99
Michigan	4.28	29%	4.616	32%	5.449	38%	0.183	1%	14.529
Minnesota	1.475	13%	7.307	66%	1.565	14%	0.672	6%	11.02
Mississippi	2.372	36%	1.914	29%	1.879	28%	0.511	8%	6.677
Missouri	1.301	11%	8.354	68%	2.098	17%	0.445	4%	12.199
Montana	2.65	30%	5.35	60%	0.43	5%	0.422	5%	8.853
Nebraska	1.204	8%	13.104	82%	1.516	10%	0.116	1%	15.94
Nevada	0.579	21%	1.162	42%	0.532	19%	0.517	19%	2.789
New Hamp-shire	0.197	21%	0.102	11%	0.56	60%	0.078	8%	0.937
New Jersey	1.226	39%	0.089	3%	1.738	55%	0.11	3%	3.163

	Energy	Energy %	Agriculture	Agriculture %	Waste	Waste %	Other	Other %	State Total
New Mexico	10.406	66%	4.223	27%	0.83	5%	0.248	2%	15.707
New York	3.732	27%	5.885	42%	3.958	28%	0.322	2%	13.897
North Carolina	1.279	9%	6.556	47%	5.314	38%	0.936	7%	14.086
North Dakota	3.039	42%	3.46	48%	0.403	6%	0.301	4%	7.202
Ohio	9.057	47%	4.11	21%	6.098	31%	0.16	1%	19.425
Oklahoma	15.353	56%	9.28	34%	2.273	8%	0.724	3%	27.629
Oregon	0.881	9%	2.882	28%	1.531	15%	4.947	48%	10.241
Pennsylvania	27.821	77%	4.842	13%	3.347	9%	0.156	0%	36.166
Rhode Island	0.15	51%	0.011	4%	0.103	35%	0.031	11%	0.295
South Carolina	0.796	17%	0.881	19%	2.147	46%	0.891	19%	4.715
South Dakota	0.354	4%	8.246	89%	0.39	4%	0.244	3%	9.234
Tennessee	1.554	19%	3.256	41%	2.705	34%	0.47	6%	7.985
Texas	49.524	54%	25.847	28%	13.071	14%	3.858	4%	92.301
Utah	3.306	45%	2.406	33%	0.96	13%	0.647	9%	7.319
Vermont	0.145	11%	0.93	71%	0.184	14%	0.049	4%	1.308
Virginia	6.134	46%	2.758	21%	3.71	28%	0.59	4%	13.193
Washington	1.021	13%	3.754	49%	2.082	27%	0.841	11%	7.699
West Virginia	22.925	93%	0.706	3%	0.837	3%	0.066	0%	24.534
Wisconsin	1.514	10%	10.656	72%	2.453	16%	0.268	2%	14.89
Wyoming	10.694	76%	2.775	20%	0.16	1%	0.4	3%	14.029
Territories	5.108	87%	0	0%	0.78	13%	0	0%	5.887
U.S. Total	269.148	39%	250.91	36%	130.019	19%	38.397	6%	688.474