The Methane Story – Part 1
Methane (CH_4) vs. Carbon Dioxide (CO_2)

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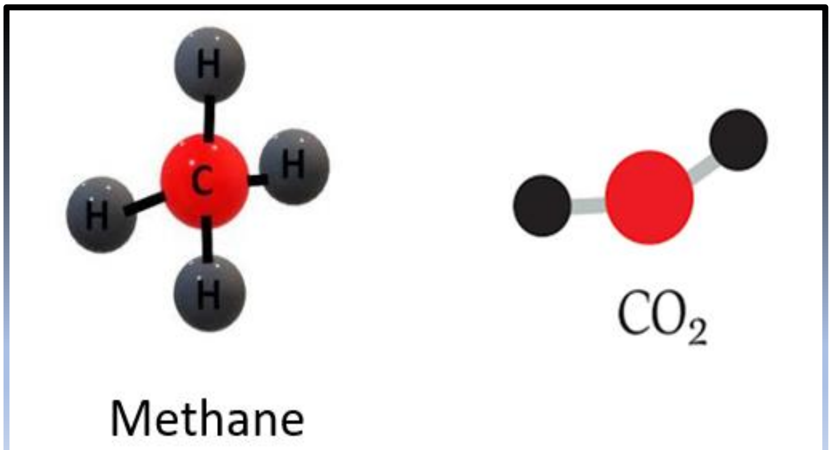

Methane – a Major Greenhouse Gas

Most discussions you will see about climate change and greenhouse gas emissions focus on CO_2 (carbon dioxide). You will see a lot less about methane (CH_4). But that probably should change. An article on the website Vox back in 2021 emphasized that. The article was titled: It's time to freak out about methane emissions (and subtitled: This lesser-known greenhouse gas will make or break a decisive decade for climate change). It also had the following quote: "In the public conversation about climate change, methane has gotten too little attention for too long." Things have changed some since then, but probably not as much as needed.

According to the International Energy Agency (IEA), methane is responsible for around 30% of the rise in global temperatures since the Industrial Revolution, and rapid and sustained reductions in methane emissions are key to limiting near-term global warming and improving air quality.

Methane is a colorless, odorless gas which is produced both naturally (such as in wetlands when plants decompose underwater) and via industrial processes (in fact, natural gas is made mostly of methane). It is the second most significant greenhouse gas after CO_2.

The good news about methane is that there is a lot less of it in the atmosphere – methane is more than 200 times less abundant than CO_2. (According to the EPA, methane is found in the atmosphere at about

1.8 parts per million, while the concentration of carbon dioxide is about 412 parts per million – or 229 times more abundant).

The bad news about methane is that it is considerably more potent than CO_2. How much more? Well, the literature can be very confusing about that. Take these 2 quotes:

> *US Environmental Protection Agency (EPA*): Methane is more than 28 times as potent as carbon dioxide at trapping heat in the atmosphere.
>
> *Environmental Defense Fund (EDF):* Methane has more than 80 times the warming power of carbon dioxide.

Which of these is correct?

The answer is both.

It turns out that part of the good news about methane is that, unlike CO_2 which can last in the atmosphere for hundreds if not thousands of years, methane breaks down and disappears in about 12 years. The 80 times figure that EDF uses is over 20 years. (You will occasionally see the number 100 times – which is measured over 10 years).

The EPA number of 28 – which is probably the most common reference that you will see regarding the difference between methane and CO_2 - is measured over 100 years.

Many experts now agree that it is *not* appropriate to measure over 100 years, since during the period that the methane is in the atmosphere it clearly has a much greater impact – and therefore we should be focusing on the near-term impact. This has become even more significant because of the goals that have been set for reduction in greenhouse gases by 2035 and 2050 – the latter of which is only 26 years away!

So, if methane is 80 times as powerful as CO_2 – and CO_2 is 229 times more prevalent than methane - that would imply that methane is responsible for close to 35% of greenhouse gas emissions – which is a very meaningful number.

There are greenhouse gases out there besides CO_2 and methane. Nitrous oxides, black carbon, and halogenated gases (a category that includes chemicals used for refrigerants) are also contributors to climate change – but to a much lesser extent. This article will focus specifically on methane.

By the way, the other bad news about methane is that, as it decays, the majority of it turns into CO_2 – so even though the methane is no longer in the atmosphere more CO_2 is. (Some argue that this is good news since CO_2 is much less potent than methane, but it would be a lot better if methane just dissolved into thin air).

According to the EPA, over the last two centuries methane concentrations in the atmosphere have more than doubled. While there are some reports that show methane declining[1], most sources show it rising even more quickly. According to the National Oceanic and Atmospheric Administration (NOAA), methane

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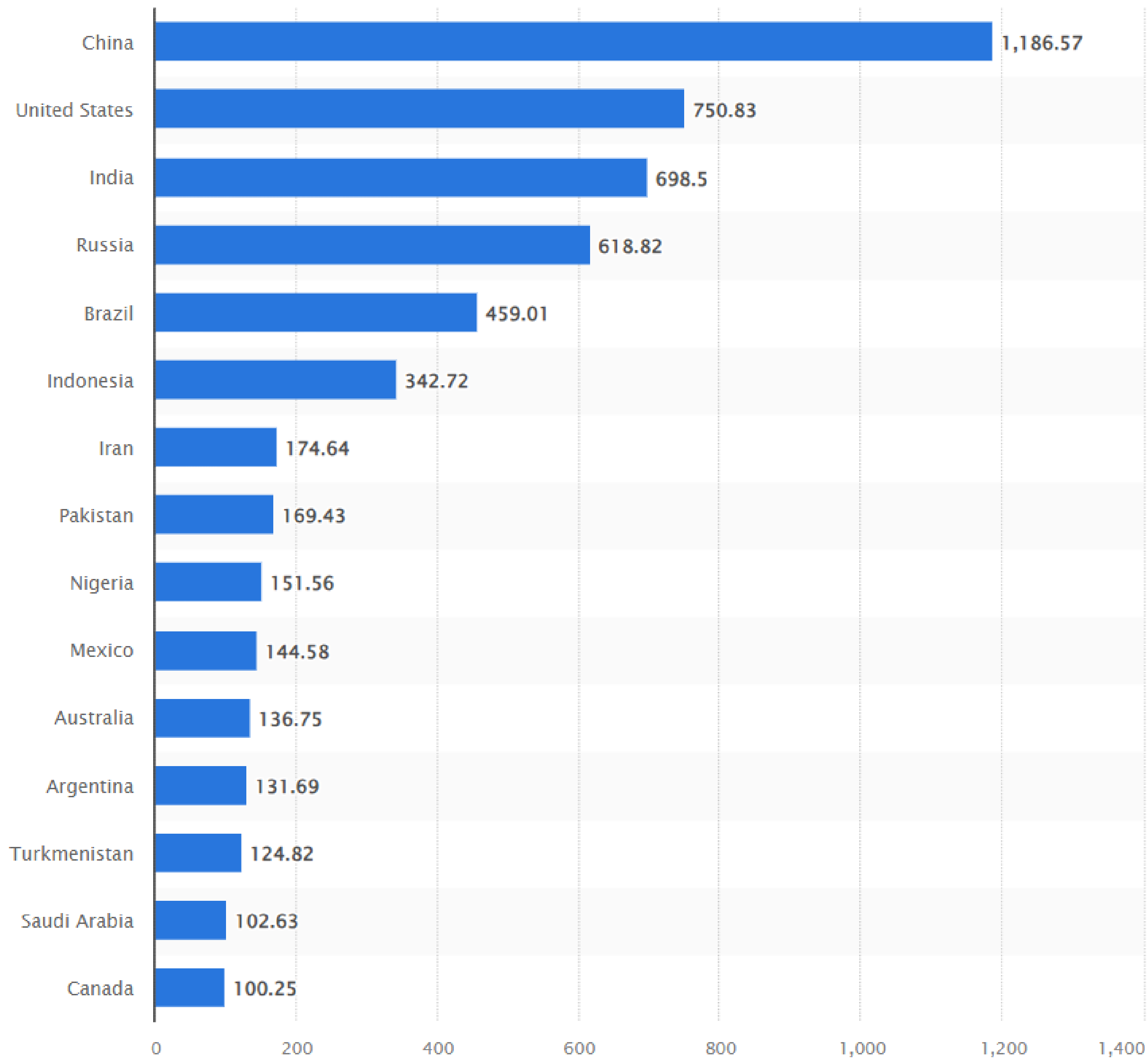
[1] The *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021* stated that methane emissions in the US decreased by 16% between 1990 and 2021

in the atmosphere had its fourth-highest annual increase in 2022 when it rose by 14 parts per billion to 1,912 ppb. It rose slightly faster in 2020 (15.20 ppb) and 2021 (17.75 ppb).

A very recent report from the Rhodium Group indicated that overall greenhouse gas emissions dropped by 1.9% in 2023, but methane leaks, along with the venting and flaring of methane during oil and gas production, limited the overall decrease.

At the country level, the largest methane emitters are as laid out below.



Source: Statista

Before discussing what is being – and can be - done to significantly reduce methane levels, let's first address the question of how methane is generated.

Sources of Methane

Most methane – more than 60% - is created from human actions. The largest source of methane emissions in the US – about 29% - comes from the generation of natural gas and oil, with coal mining accounting for another 6%. The second largest source is what is known as *Enteric Fermentation,* which is the digestive process in which sugars are broken down into simpler molecules for absorption into the bloodstream of animals such as cows, producing methane in the process. A small percentage of methane is also produced in the cow's large intestine and released, and there is also methane released from the animal's manure. These combined are responsible for about 33% of methane emissions.

The third largest methane emitter– at 15% - is landfills. Approximately 60% of landfill methane emissions are generated from food waste.

All other sources of methane combined are responsible for about 31% of methane totals.

Natural sources of methane – referred to as biogenic methane - include wetlands, gas hydrates, termites, oceans, freshwater bodies, and other sources (such as wildfires). But as the planet warms, methane may escape even more from natural sources. A 2021 study from Stanford University found that greenhouse gas emissions have already set in motion natural feedback loops that could cause massive methane releases from permafrost and other sources.

A breakdown of methane sources is shown in the graph below:

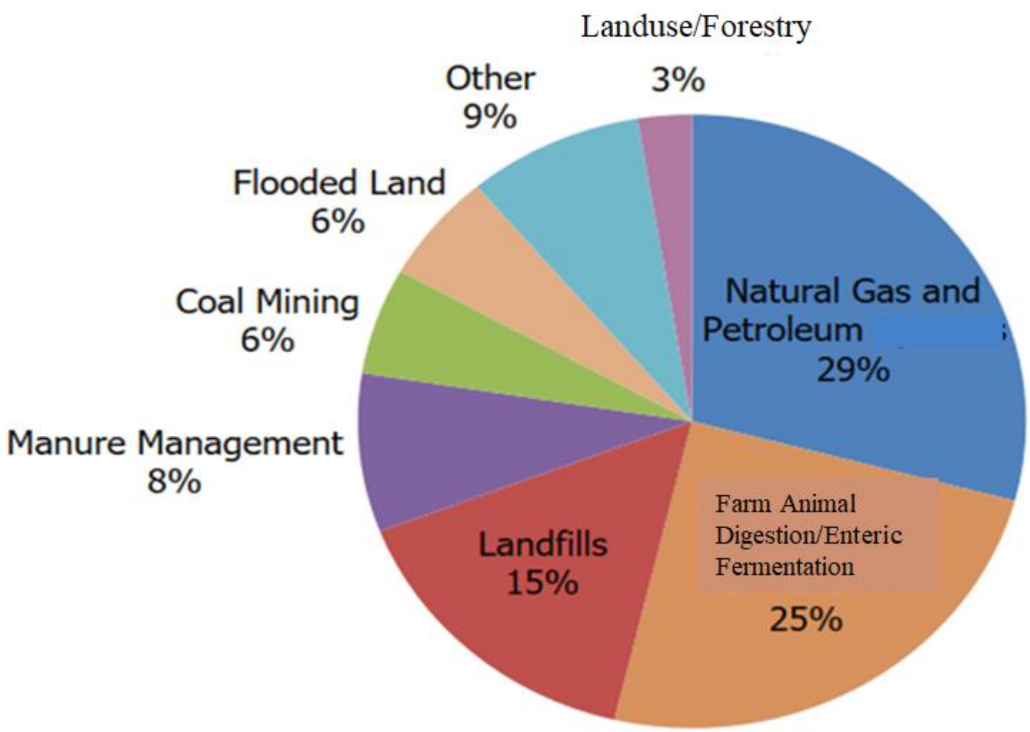


Image Courtesy of EPA

What is Being Done – and Can be Done – to Reduce Methane Emissions?

Even though there is a lot more attention paid to CO_2. than methane, there are steps being taken to reduce methane emissions – but a lot more still needs to be done.

The ***Global Methane Pledge***, spearheaded by the US and the European Union, was launched at COP26 in November 2021 to spur action to reduce methane emissions. Participants joining the Pledge agreed to take voluntary actions as part of a collective effort to reduce *global* methane emissions by at least 30 percent from 2020 levels by 2030. The Pledge now has 155 country participants who together are responsible for more than 50% of global, human-caused methane emissions.

Of the top methane emitters noted above, the only ones that are *not* part of the Global Methane Pledge are China (#1); India (#3); Russia (#4); and Iran (#7). Not many countries, but combined countries that emit just over 50% of the methane emitted by the top 15 emitters represented on the list.

The Global Methane Pledge has brought together both major energy consumers - like the US, the European Union, Japan, and Korea - and major oil and gas producers - such as Iraq and Saudi Arabia. For some countries, the Pledge represents the first significant policy commitment regarding methane, either at the domestic or international level. The text of the Global Methane Pledge states that the participants intend to review progress through annual ministerial meetings. However, the Pledge is non-binding and individual countries are not assigned targets. The US and the European Union asked all Global Methane Pledge participants to develop a national methane reduction action plan by COP27, but that did not happen for most countries.

And while a significant level of emissions occurs in countries that have not joined the Pledge, around 40% of their oil and gas production is *exported* to countries that have joined the Pledge. These importers could encourage reductions through a number of actions, including diplomatic pressure, financing incentives, minimum intensity standards, and more.

At COP28 in 2023, several countries — including the US, Canada, Brazil, and Egypt— announced how they plan to meet their targets, Pledge members announced more than $1 billion in new grant funding to help reduce methane. In addition, a coalition of 50 oil and gas companies announced their commitment to reduce their methane emissions by 80 to 90 percent by 2030

So, how can methane emissions be slashed - and what more can be done to make that happen?

Energy Production

Combined gas, oil, and coal production are responsible for about 35% of methane production (and more than 40% of methane emissions from human activity). Natural gas is the largest part of that - since natural gas is largely composed of methane. Globally, the energy sector was responsible for nearly 135 million tons of methane emissions in 2022 - a slight rise from 2021. The oil and gas industries emit what is sometimes referred to as “fugitive methane” through venting, leaks, and incomplete combustion during flaring

The IEA has estimated that global oil and gas projects continue to leak around 70 megatons of methane each year, or the equivalent of burning almost 2 million pounds of coal. Interestingly, the methane emission intensity of oil and gas operations varies greatly across countries, with the best performing countries having an emission intensity over 100 times lower than the worst performers.

According to the IEA there is a huge opportunity to cut methane emissions from the energy sector. The IEA estimates that methane emissions from fossil fuel operations could be reduced by about 70% with existing technologies. In the oil and gas sector, emissions can be reduced by over 75% by implementing measures such as leak detection and repair programs, installing emissions control devices, and upgrading or replacing leaky equipment. There are also options that could prevent losses in upstream production, including LDAR, equipment electrification or replacement, instrument air systems, and vapor-recovery units. Better methane-sensing technologies would also help make methane-destroying bioreactors more effective solutions for oil and gas companies. These bioreactors work best when fed a stream of gas with a relatively high methane concentration. With better sensing technologies, facilities would be able to pinpoint specific high emissions sources — like pipeline leaks — and “attach” a reactor at that site.

According to the IEA, over 40% of methane emissions from oil and gas operations could be avoided at no net cost, since the outlays for the abatement measures would be less than the market value of the additional gas that is captured.

One negative note: flares, or fires, lit to burn off excess gas or oil that cannot be transported and sold, are a common sight at oil and gas fields around the world. But a study published in the journal *Science* in 2022 found that the process is *not* eliminating nearly as much methane as expected. Flares are intended to eliminate at least 98% of the methane that passes through them. The study concluded that flaring is responsible for *five times more methane* entering the atmosphere than previously thought.

Image Courtesy of Missoula Current

On the good news side, while I was drafting this article – on January 12 to be precise - the Biden administration announced new moves to curb the release of methane from oil and gas facilities. Under the new plan (which follows up on some plans introduced in the 2022 Inflation Reduction Act) oil and gas companies would be required to pay a fee for emitting methane above certain levels to be set by the federal government. The EPA is proposing to charge large energy producers $900 for every ton of methane emissions that exceed these levels, beginning this year. The fee would increase to $1,200 in 2025 and then $1,500 per ton in 2026.

The fee is the second part of new methane restrictions being imposed. Last month, the EPA announced that it would require oil and gas companies, for the first time, to detect and fix leaks of methane from wells, pipelines, and storage facilities, and that it would ban the practice of flaring, except in emergencies. Congress has authorized more than $1 billion in grants and other spending to help companies and communities improve methane monitoring and data collection, and to find and repair leaks.

While fossil fuel groups have largely accepted requirements aimed at detecting and stopping methane leaks, they have indicated that they plan to fight the monetary penalties. The new proposal relies on self-reporting from the energy producers if their methane emissions exceed the levels that are set, with no provision for the government to verify that data. This obviously could lead to significant underreporting.

The proposed regulations will become final following a 45-day public comment period.

Moving on to coal; the vast majority of coal-mine-methane (CMM) emissions emanate from either working or abandoned deep mines. There is a significant challenge in measuring and recovering these emissions. However, established technologies can capture CMM and use it to generate power. Some experts believe that more than 50% of CMM could be cut by leveraging coal mine methane utilization, or by flaring or oxidation technologies, but others believe that is wildly optimistic. Overall**,** tackling methane from coal operations is more challenging than for oil and gas operations.

In the IEA's *Net Zero Emissions by 2050 Scenario,* coal use drops by 55% from 2020 to 2030, and by almost 90% by 2050. This decline would significantly cut methane emissions from coal mines as well as emissions of CO_2 and other air pollutants.

While reducing coal use would go a long way towards reducing emissions, measures are needed in the meantime to address methane leaks from coal operations**.** These could include requirements for operators to capture methane using degasification wells and drainage boreholes prior to the start of production. For mines already in operation, ventilation air methane may already be captured. This can be used as an energy source, for example, to heat mine facilities or for coal drying. These technologies have already been implemented in numerous sites but are still far from being standard industry practice. New policies and regulations could help broaden their use, by creating proper incentives or by directly mandating that mine operators adopt these technologies

Of course, in the end, the most effective way to reduce methane emissions from energy production is to phase out fossil fuels entirely, which is a process that is happening, although not at the pace that many people would like to see.

In the US, the use of fossil fuels for the generation of electricity has declined since the turn of the century. From 2000 to 2020 the use of coal dropped from over 50% to under 20%, while oil dropped from about 3% to close to 0%. Unfortunately, the use of natural gas rose from about 16% to about 40%, so fossil fuels are still responsible for 60% of electricity generation. The better news is that the current pipeline of new renewable energy generation facilities and energy storage facilities is sufficient to totally phase out fossil fuels. The bad news, as I have mentioned in several posts, is that a lot of work needs to be done (and many dollars need to be spent) to upgrade the electric grid to enable it to connect to all of these new potential generation sources, and the wait time (interconnection queue) for getting these new facilities operational continues to climb – along with the cost. But at least we are moving in the right direction.

There is also movement to phase out the use of natural gas for heating and cooking (as well as water heating and clothes drying) in homes and potentially businesses. Recent research has indicated that methane emissions in homes could have health effects. High levels of methane can reduce the amount of oxygen available which can result in slurred speech, vision problems, memory loss, nausea, and headaches. In very severe cases it could lead to what is sometimes called methane gas poisoning, where there may be changes in breathing and heart rate, balance problems, and even unconsciousness. While methane is considered relatively non-toxic, its primary threat is that it functions as an asphyxiant, similar to the threat posed by carbon monoxide exposure.

Many states and cities are moving towards banning the use of natural gas in new buildings - and some are even discussing phasing it out of existing buildings. Significant enhancements to electricity powered heating and cooling equipment - such as heat pumps - (and there are also now several heat pump hot water heaters on the market that are 3-5 times as efficient as standard hot water heaters) and cooking equipment - such as induction ovens – has re-enforced this movement to try to phase out natural gas use in homes and other buildings.

Agriculture

The second largest emitter of methane in the chart above was Farm Animal Digestion/Enteric Fermentation. That is part of Agriculture, as is Manure Management. And some of the other sources are part of Agriculture as well, but those two alone represent 33% - not much less than Energy Production.

Livestock emissions – from manure and gastroenteric releases – account for the bulk but not all of agricultural methane emissions. Another agricultural source is paddy rice cultivation – in which flooded fields prevent oxygen from penetrating the soil – creating ideal conditions for methane-emitting bacteria. Biomass burning also results in methane emissions.

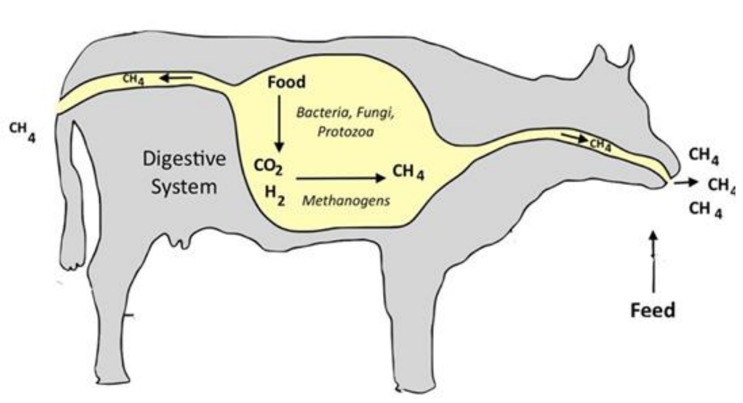


Illustration of Enteric Fermentation: Source – Climable

Modifications to animal feeding practices may reduce emissions from enteric fermentation. Scientists are experimenting with alternative types of feed, as well as feed additives, to reduce the amount of methane produced by cows, and some additives are now available. Methane from manure can be reduced and captured by altering manure management strategies. Experts are looking at ways to manage manure more efficiently by covering it, composting it, or using it to produce biogas. There is also the option of capturing and combusting methane from manure storage. Farmers can provide animals with more nutritious feed so that they are larger and healthier – and therefore lower emissions in relation to the amount of food provided.

When it comes to crops like paddy rice, experts are recommending alternate wetting and drying approaches that some believe can reduce methane emissions by as much as 50%. Rather than allowing the continuous flooding of fields, paddies could be irrigated and drained two to three times throughout the growing season, limiting methane production without impacting yield. That process would also require one-third less water.

And, of course, there is a role that people can play, shifting towards plant-rich diets and alternative sources of protein while reducing the amount of meat being eaten – which will reduce the number of cows and other animals that farms need to maintain.

Landfills

As noted above, landfills are responsible for about 15% of methane emissions. Food waste is responsible for about 60% of landfill emissions - and landfills are where almost 50% of food waste ends up. Landfill gas (LFG) is a natural byproduct of the decomposition of organic material in landfills. LFG is composed of roughly 50 percent methane, just under 50 percent CO_2, and a small amount of non-methane organic compounds.

LFG can be extracted from landfills using a series of wells and a blower/flare (or vacuum) system. This system directs the collected gas to a central point where it can be processed and treated depending upon the ultimate use for the gas. From this point, the gas can be flared or used to create energy.

Methane from landfills poses some immediate risks. Spontaneous combustion at disposal sites can occur due to oxygen intrusion from a variety of sources, leading to fire and deadly fumes. Meteorological conditions also increase the risk of landfill fires, often made worse by methane which acts as a fuel. As an example, back in 2022 outside New Delhi, India, firefighters had a huge struggle extinguishing a landfill fire primed by record heat and fueled by methane.

In quite a few countries, particularly developing countries, waste is routinely disposed of at unmanaged land disposal sites. Open dumps are uncovered and uncompacted. Their conditions pose health and safety risks to workers, neighboring residents, and waste pickers who scavenge dumps for potentially usable materials. Left unmanaged, these sites directly emit methane into the atmosphere. But policies can encourage the conversion of open landfills to safer disposal sites. For example, they can incentivize the upgrade of unmanaged dumpsites by requiring remediation efforts and/or conversion to more sanitary landfills. India initiated solid waste management rules back in 2016 that have led to major such improvements.

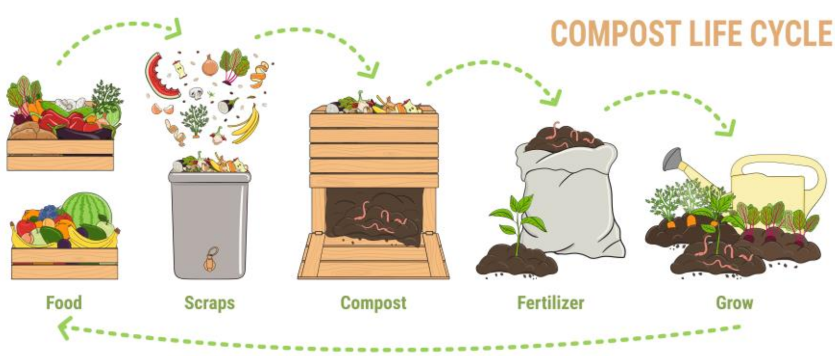
Where sanitary landfills exist — commonly in developed economies — policies should require best practices for methane management during both design and operations, including comprehensive emissions monitoring. Without strong directives, many landfill owners and operators will pursue lowest-cost management practices, which needless to say may not be the optimal methane mitigation solution. Policies and regulations — such as setting methane abatement goals, requiring emissions monitoring, implementing a landfill tax, and creating mitigation incentives — can encourage methane-conscious management in the waste sector.

The Sunshine Canyon landfill in California offers a good example of this. The site, just north of Los Angeles, sought to improve its management practices in reaction to odor complaints and degrading site conditions. The effort began in 2009 when regulators required the landfill operator to institute a non-standard practice of installing a daily cover without peel-back. This unintentionally resulted in the flooding of landfill gas wells and ineffective methane capture. Observation flights over the landfill found significant plumes of methane – showcasing how ineffective regulatory directives can exacerbate emissions.

In 2017, a wider range of methane management practices were rolled out at the landfill. These delivered substantial improvements, in both reducing odor and cutting methane emissions. Follow-up methane monitoring flights confirmed a 55-60% reduction in emissions; this was essentially corroborated by a decline in odor complaints.

Clearly, the fastest way to reduce methane emissions is to reduce the amount of food waste in landfills. That should start with efforts to *reduce* food waste itself. Over a third of all food produced worldwide is wasted - which is about 1.3 billion tons of food. That is enough to feed about 2 billion people - in a world where an estimated 1 billion people do not have sufficient food to eat. So, reducing food waste is a critical issue. There have been steps taken at the country level, and in the US at the state level, to reduce the amount of food waste – although many of these are focused more on reducing the amount of food waste going into landfills. In the US, in addition to programs aimed at educating consumers about how to reduce their food waste, there are a range of both for profit and non-profit companies that are working to get food service and food retail organizations to reduce food waste by donating food that is approaching the end of its shelf-life to non-profits that deliver the food to people that need it.

For the waste that remains, the goal needs to be to make sure that it does not go into landfills. Some food waste – particularly from food manufacturers – is directly converted to animal feed and therefore avoids the landfill. A growing percentage of food waste – now up to over 20% - is being composted, which results in significantly less methane than landfills and is often then used to create fertilizer. More and more cities are setting up composting facilities and collecting food waste from consumers, and there are several companies selling composting units directly to consumers – one of which then collects the compost and converts it to animal feed.



Source: City of Alexandria, VA

An alternative to composting that is also growing – and a process that is a little more controversial – is Anaerobic Digestion (AD). Anaerobic Digestion is a process through which bacteria is used to break down organic matter without oxygen. (With methane the material decomposes in the presence of oxygen – which means it is *aerobic*). It typically takes place in a sealed vessel (reactor) which contains complex microbial communities that break down/digest the waste and produce Biogas (which can be purified and used as a renewable alternative fuel) and Digestate (which can be used as animal bedding, nutrient-rich fertilizer, bio-based products (e.g., bioplastics), organic-rich compost, or as a soil enhancer). To increase biogas production, livestock manure may also be combined or "co-digested" into anaerobic digesters

Over 40% of food waste from food manufacturers and processors is sent to anaerobic digesters.

Power Knot, a manufacturer of equipment to address food waste, recently posted an article that identified 6 *disadvantages* of Anaerobic Digestion:

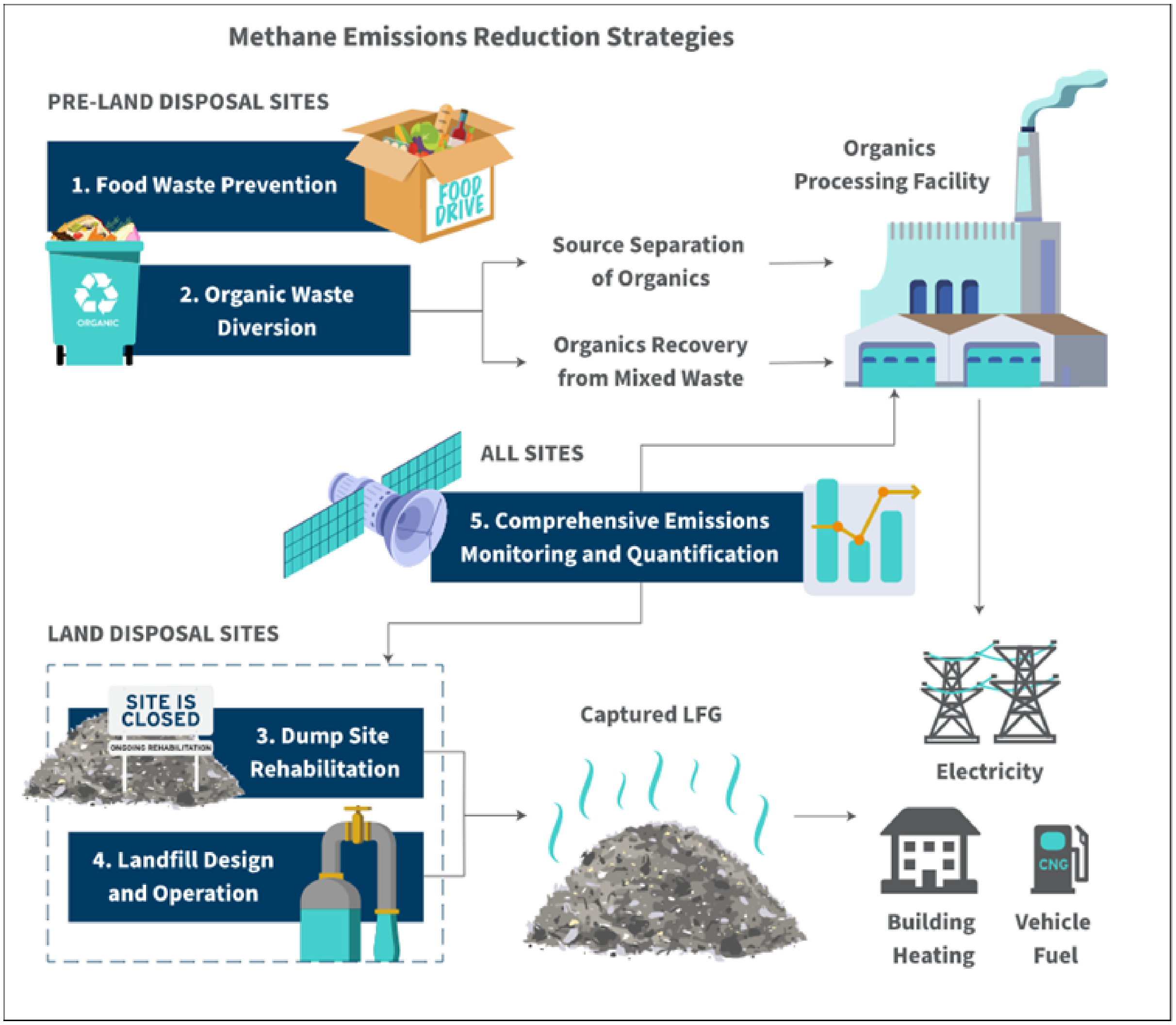
1. Anaerobic digesters still pollute, since the subsequent combustion of the captured gas into usable heat or electricity emits CO, NOx, and SO_2.
2. They increase the risk of toxic spills – and have been responsible for several. The production of highly combustible biogas has also led to explosions, although this is much less common.
3. Odor is another anaerobic output.
4. Anaerobic digesters may require more than food waste to be able to generate power. In some cases, specially grown feedstock has been added.
5. In general, anaerobic digesters require transport of food waste to an off-site facility which is often a long distance from where the waste is generated – resulting in more energy usage and therefore more emissions.
6. Anaerobic digesters are relatively expensive

But in that same article, they go on to state that: "no process is perfect, but Aerobic Digesters can negate the risks of pollution, odor, and explosions". They cite a University of Delaware study that reported that *Aerobic Digesters are across the board better for the environment than alternatives, and increasingly better for the bottom line for organizations trying to reduce the impact of food waste*.

There are developing technologies aimed at addressing some of the downsides of Anaerobic Digestions. For example, start-up Chomp manufactures and sells community-scale, prefabricated Anaerobic Digestion systems that transform food waste, liquids, and other organic materials into renewable natural gas and biofertilizer with nearly zero waste – being installed in locations that minimize the amount of transportation required.

There are also other approaches to reducing landfill methane emissions. With one such technology, tubes are sent deep into a landfill to collect gas, which is then piped to a central collection area where it can be vented or flared or compressed and purified for use as fuel. *Project Drawdown*, a non-profit focused on stopping climate change, defines their Landfill Methane Capture solution as "the process of capturing methane generated from municipal solid waste in landfills and burning the captured biogas to generate electricity". Some argue that landfill methane capture can achieve 85 percent efficiency or more in closed and engineered landfills. It is least effective in open dumps, where the efficiency is at best 10 percent and capture is typically not seen as economically favorable. As a waste treatment solution, landfill methane capture is generally seen as a last resort. However, it can be part of the program for mitigating greenhouse gases.

The image below illustrates approaches to methane emission reduction from landfills and other dumpsites.



Source: RMI

When you combine food's role in generating methane in landfills and the methane impacts from agriculture, it is clear that food has a major role in methane emissions. There were some efforts made at COP28 to address the climate impact of food, and more time was devoted to agriculture than at past conferences. More than 100 countries agreed to find ways to reduce emissions from food production. Canada introduced incentives for Canadian ranchers to cut methane emissions from their cattle farms. Six of the world's largest dairy producers – Danone, Bel Group, General Mills, Lactalis USA, Kraft Heinz, and Nestle – announced that they will begin reporting their methane emissions by mid-2024 and will create methane action plans by the end of the year. So there clearly was some progress at COP28. But there was minimal interest expressed from countries with high consumption of animal products for reducing the demand for meat and dairy.

Other Methane Sources

While all the other sources of methane emissions account for less than 20% of emissions, it makes sense to try to reduce the emissions there as well. For example, Wastewater does emit a reasonable amount of anthropogenic methane from the breakdown of organic material in wastewater streams. The primary method of reducing methane emissions from Wastewater is to build out modern sanitation infrastructure and technologies; however capital costs could be an issue here. Alternative abatement approaches could include the use of covered lagoons or the application of microalgae to prevent gas formation. Biosolids responsible for producing methane could be collected and sold as fertilizer or bioenergy.

Methane Capture

The prior section, for the most part, discussed reducing the amount of methane released into the atmosphere, although some of discussion mentioned approaches that can be better characterized as methane capture – or removing methane from the atmosphere once it has been released.

Carbon Capture (performed at the site of CO_2 emissions) – and Direct Air Capture (done anywhere) – are considered in many – but not all – sectors as critical ways to reduce CO_2. While not the same as avoiding the release of CO_2 in the first place, they can be used to reduce the amount of CO_2 in the atmosphere. Billions of dollars are being spent on carbon and direct air capture. For example, the Biden administration recently authorized $3.5 billion to develop four regional hubs to accelerate the deployment of Direct Air Capture. The $1 trillion bi-partisan infrastructure bill approved in 2021 earmarked more than $12 billion for carbon capture projects**.**

The field of methane capture lags far behind. Researchers are still grappling with how best to remove methane once emitted. As noted earlier, methane is more than 200 times less abundant in the atmosphere than CO_2. This scarcity makes removing it in large amounts a harder technical challenge.

Capturing methane requires processing a lot of air, which requires a large amount of energy. According to DOE's Advanced Research Products Agency (ARPA) it is also more resistant than CO_2 to conversion into a solid or liquid form. A spokesman for ARPA was quoted as saying: "CO_2 you can capture from the air or you can capture from flue gas because it has a chemical structure that allows you to kind of put a 'hook' on it, but the methane molecule does not — and so capturing methane is very, very difficult."

Most methane removal technologies therefore focus on oxidizing the greenhouse gas rather than grabbing it and pulling it out of the air. For example, porous minerals, called zeolites, can be used to trap methane in their microscopic pores, oxidize the gas, and release it - as CO_2.

Zeolites' potential was overlooked for a very long time because they don't efficiently convert methane into chemicals that have obvious commercial applications, such as methanol. (Stay tuned for the Story pf Methane - Part 2). The minerals are efficient at converting methane to CO_2, which reduces but does not eliminate the global warming impact.

A project at MIT is working on incorporating small pellets of zeolite minerals into a reaction chamber that could be deployed by both the fossil fuel and agriculture sectors to capture methane. The device could work particularly well in coal mines, where methane concentrations are relatively high. Other researchers are developing methane capture technologies that harness the metabolisms of living organisms. In the image below, courtesy of MIT, the zeolite, depicted as the complex structure in the middle, is shown as absorbing the methane that passes through it.

Image Courtesy of MIT

Some bacteria produce enzymes that oxidize methane, trapping it and causing it to undergo a chemical reaction. Researchers hope to build bioreactors that could house those bacteria, oxidizing methane near emission sources.

One example might be hydraulic fracturing sites. Some fracking sites currently trap methane before it enters the atmosphere and transport it to refineries, where it is converted to methanol, which can be used to make a variety of industrial chemicals. But that solution has drawn criticism from environmental groups, as huge volumes of methane can be released during transport. There is work being down to eliminate the risk and expense of transporting captured methane from fracking or other emissions sites by using a bacterial bioreactor to convert the greenhouse gas to useful chemicals on the spot.

A Pennsylvania State University research team has previously demonstrated that its engineered bacteria can convert methane into acetate, an industrial chemical, and polylactate, which can be used to manufacture biodegradable polymers.

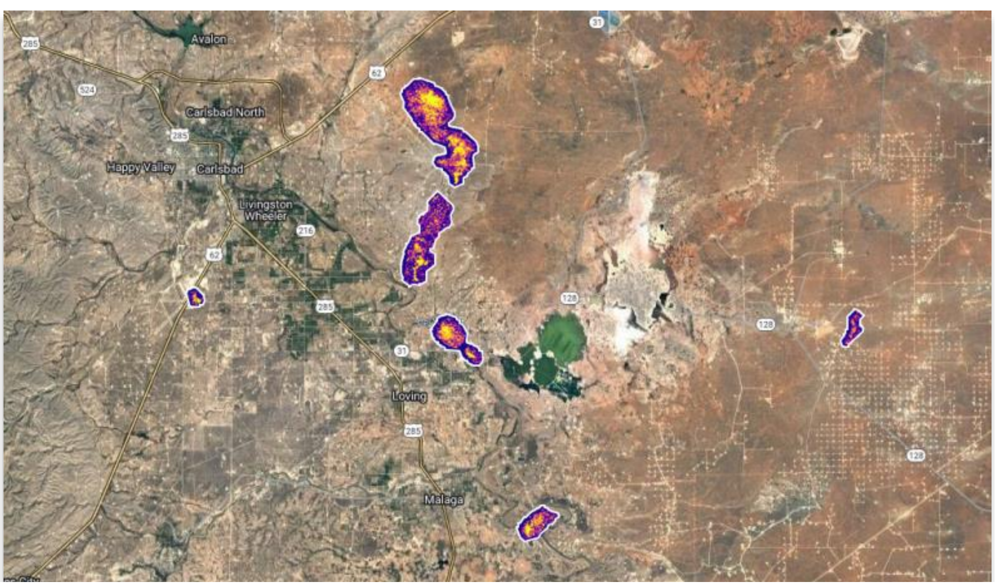
Where do we go From Here?

Methane is a smaller contributor to climate change than CO_2 – but a much larger contributor than most people are aware of. Generating more attention to methane is probably a good idea.

As noted throughout the article, there are steps being taken to reduce the amount of methane being emitted into the atmosphere, just as there are for reducing CO_2. There are also steps being taken to capture methane once it has been emitted; but a lot fewer steps than are being taken with CO2.

Improving the transparency in emissions data is another potential step towards significantly reducing methane. The European Union has committed to several efforts in this regard, including funding the *International Methane Emissions Observatory*, actively supporting the *Oil and Gas Methane Partnership 2.0*, and proposing to collect and make public information collected from operators and importers under [its recently proposed methane regulations](). These measures may encourage the uptake of measurement and reporting standards and help companies and countries identify abatement opportunities.

Satellite technology in particular has the potential to drive significant reductions. Satellites can detect and quantify large leaks over a wide geographic area and are already providing a picture of methane emissions that greatly increases both government and corporate knowledge about emissions. In 2022, more than 500 super-emitting events were detected by satellites from oil and gas operations and a further 100 were seen at coal mines. But a lot of work is happening to improve the ability to accurately monitor methane – including the use of Artificial Intelligence (AI).



Methane emissions observed by satellite over New Mexico. *Source: NASA/JPL-Caltech. Image Courtesy of Bloomberg*

For example, University of Oxford researchers have developed a tool to automatically detect methane plumes on Earth from orbit using machine learning with hyperspectral data. These detect narrower bands than more common multispectral satellites, making it easier to locate the methane and filter out noise. Overall, the model has an accuracy of over 80% for detecting large methane plumes and was more than 20% more accurate than the previous most accurate approach. The method also had a significantly improved false positive detection rate, lowering it by more than 40% in comparison with the previous approach.

In 2022, the utility Duke Energy launched a methane monitoring platform that uses satellites, ground-level sensors, AI, and cloud computing to detect leaks and measure methane emissions from its natural gas distribution system in "near real-time." The project was done in collaboration with Accenture and Microsoft and received $1 million from DOE to extend the platform to the Transco pipeline owned by Duke Energy supplier Williams.

In early 2024, a new satellite known as *MethaneSAT*, launched by EDF, will beam its first set of data to scientists who plan to use machine learning and advanced modeling in order to pinpoint and measure emissions from leaking oil and gas production sites worldwide. Around the same time, a group led by the non-profit *Carbon Mapper* project will launch the first of two satellites whose missions are to capture high-resolution images of methane escaping from oil and gas facilities, as well as landfills and agricultural operations. Carbon Mapper's data is intended to be used to enable actions to reduce methane emissions as well as support initiatives like Climate TRACE, a collaboration of academic and private-sector players who are training artificial intelligence to analyze and calculate greenhouse gas emission sources.

And as one final example; *Climate Change AI (CCAI)*, another organization composed of volunteers from academia and industry who believe that tackling climate change requires concerted societal action, announced a new application last year called *MethaNet* – which is an AI-driven approach to quantifying methane point-source emission from high-resolution 2-D plume imagery

Having this type of data could address the issue noted earlier that the proposed new US regulations imposing fees on oil and gas producers who exceed methane emission levels provided no basis for government to monitor those levels.

So, there is definite progress being made to address methane emissions from all sources, as well as to enhance what is being done across the board. Accelerating this process starts with building more awareness of the issues.

In the end, phasing out the use of fossil fuels is what needs to be done – but that will take time. Significantly reducing food waste will also have a major impact on methane emissions – and that can happen on a much more rapid timetable. But there are also a lot of other activities needed to try to eliminate methane emissions. Getting awareness of the issues is just a starting point.

And, speaking of issues associated with methane, stay tuned for The Story of Methane - Part 2, which should be posted next week.