GAS-FIRED POWER METHANE EMISSIONS

A CALL TO ACTION

GE VERNOVA

EXECUTIVE SUMMARY

Methane is a potent greenhouse gas, trapping ~25X more heat radiated from the earth's surface than carbon dioxide.

According to the International Energy Agency (IEA), about 40 percent of total global methane emissions occur naturally from sources such as wetlands, geologic seepage, permafrost, and animal secretions. The remaining 60 percent of global methane emissions are anthropogenic (man-made), and the largest portion of these come from agricultural production such as raising livestock and rice production. Fossil fuel production, transportation, and use account for approximately 20 percent (~113 million metric tons) of total global methane emissions, and emissions attributable to gas power are about 3% (17 million metric tons) of the global total. Despite gas power being responsible for a relatively small percentage, GE Vernova acknowledges methane emissions reductions across the entire industry are important and should be addressed.

Methane is a potent greenhouse gas, trapping ~25X more heat radiated from the earth's surface than carbon dioxide. Reducing methane emissions is a powerful and cost-effective way to act on climate change, providing an essential complement to action on reducing CO_2.

It's recognized, however, that methane emissions are very difficult to measure and could be significantly higher than estimated. Accurate measurement is a key tool in reducing methane emissions, and improved technology including satellite imagery is being deployed to quantify methane emissions more accurately, but actions can be implemented immediately to contribute to methane emissions abatement.

GE Vernova believes addressing climate change must be an urgent global priority. The oil & gas and power industries have a responsibility, and the technical capability, to take significant steps to quickly reduce methane emissions.

The IEA has identified abatement technologies and practices which could yield significant reductions in methane emissions from the oil & gas sector. They evaluated the potential impact of each to global sector emissions and the associated cost. The agency concluded that in many instances, the abatement technologies cost less than the value of the methane saved. This means such technologies have a positive net present value and pay for themselves because the market value of the captured methane exceeds the cost of the abatement measures. The amount that can be abated at no net cost depends, of course, on the prevailing price of natural gas.

The US is a strong example of how methane emissions can be addressed. Methane emissions from the energy sector in the US have declined despite a massive increase in natural gas production. According to the US Environmental Protection Agency, despite more than a 60 percent increase in natural gas production from 2000 through 2018, largely due to the introduction of hydraulic fracturing techniques, methane emissions have come down by 9 percent overall and 17 percent in the energy sector.

Approximately 40 percent of global natural gas consumption is for the power sector, with the remainder dedicated primarily to home heating, industrial process heating, and use as a chemical feedstock. Gas-fired power generation therefore accounts for approximately 17 million metric tons of methane emissions per year or 3 percent of total global methane emissions.

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SOURCE: IEA METHANE TRACKER 2021

GREENHOUSE GASES – WHAT ARE THEY AND WHERE DO THEY COME FROM?

Greenhouse gases absorb infrared radiation emitted from the earth's surface and reradiate it back to the earth's surface, contributing to global warming. This is similar to how an actual greenhouse works. Greenhouse gases act like the windows of a greenhouse, allowing light through but trapping heat inside.

METHANE
~25X CO_2 equivalent

NITROUS OXIDE
~298X CO_2 equivalent

FLUORINATED GASES
up to 22,800X CO_2 equivalent

Note: 100-year basis

Greenhouse gases are emitted at different rates, with differing levels of intensity with which they absorb and reradiate infrared radiation, and with differing average lifetimes in which they remain in the atmosphere. In order to compare the relative impacts of each gas on global warming, they are often expressed on a CO_2-equivalent basis as shown below. The values shown below are on a 100-year basis and it should be pointed out that on a 20-year basis methane is more than 80X as potent at trapping the earth's heat, meaning it has a more pronounced near-term effect.

Water vapor is the most potent greenhouse gas but its effects can't be significantly modified by human behavior. It is a function of temperature, i.e., the higher the temperature, the more evaporation occurs from the earth's surface, creating higher concentrations of water vapor in the atmosphere. This reradiates more of the earth's radiation back to the earth's surface, which then causes temperatures to rise yet further.

Carbon Dioxide, or CO_2, is the most significant greenhouse gas and one most easily modified by human behavior. CO_2 is naturally present in the atmosphere and can last for thousands of years. Human activities are altering the carbon cycle by adding more CO_2 to the atmosphere and by affecting the ability of natural CO_2 sinks to absorb CO_2.
Methane, or CH_4, or natural gas, is also emitted from both natural and man-made sources. Methane's lifetime in the atmosphere is much shorter (about 12 years) than CO_2, but over a 100-year period its impact pound-for-pound is about 25 times greater than CO_2 due to its efficiency in trapping radiation.

Nitrous Oxide, or N_2O, can be naturally occurring or man-made (e.g., agriculture, fuel combustion, wastewater management). These gases stay in the atmosphere an average of 114 years, and pound-for-pound are almost 300 times the global warming impact of CO_2.

Fluorinated Gases have no natural sources and come only from human-related activities (e.g., refrigerants, aluminum, and semiconductor manufacturing). They last hundreds or even thousands of years in the atmosphere and are tens of thousands times more potent at contributing to global warming than CO_2.

Using the CO_2-equivalent approach over a 100-year period, methane emissions contribute approximately 16 percent of global anthropogenic (i.e., caused by human activity) GHG emissions.

SOURCES OF METHANE EMISSIONS

Of the nearly 600 Million metric tons per year of methane currently emitted globally, approximately 40 percent occurs naturally. The largest single source is natural wetlands, accounting for about one-third of the global total. Methane is produced in wetlands through the anaerobic decomposition of organic material covered by water. Other natural sources, representing about 7 percent of the global total, include methane produced by fresh waters, geologic seepage, wild animals, termites, wildfires, permafrost, and vegetation.

Approximately 350 Million metric tons per year of methane are believed to be anthropogenic. The largest portion of these methane emissions, 25 percent, are from livestock and other agricultural activities, with about 14 percent produced from the digestive process of livestock (i.e., cattle, sheep, goats), and 10 percent produced primarily from rice production utilizing man-made wetlands. Fossil fuels account for 19 percent of total global methane emissions. Sources of these emissions include methane released from the mining or extraction of coal, oil, and natural gas, leakage in the processing or distribution of natural gas along pipelines, and through the flaring of associated gas.

Landfills create an anaerobic environment where bacteria break down organic waste and create landfill gas (of which about 40–60 percent is methane). These gases account for 12 percent of total global methane emissions. Biofuels such as wood, charcoal, agricultural residues, and animal dung contribute methane from activities such as domestic cooking or heating in stoves, boilers, or fireplaces, but mostly in open cooking fires. More than 2 billion people, mostly in developing and emerging countries, use solid biofuels to cook and heat their homes. Biomass burning mainly results in the production of CO_2, but when fires smolder and combustion is incomplete, methane is emitted as well, accounting for about 2 percent of total global methane emissions.

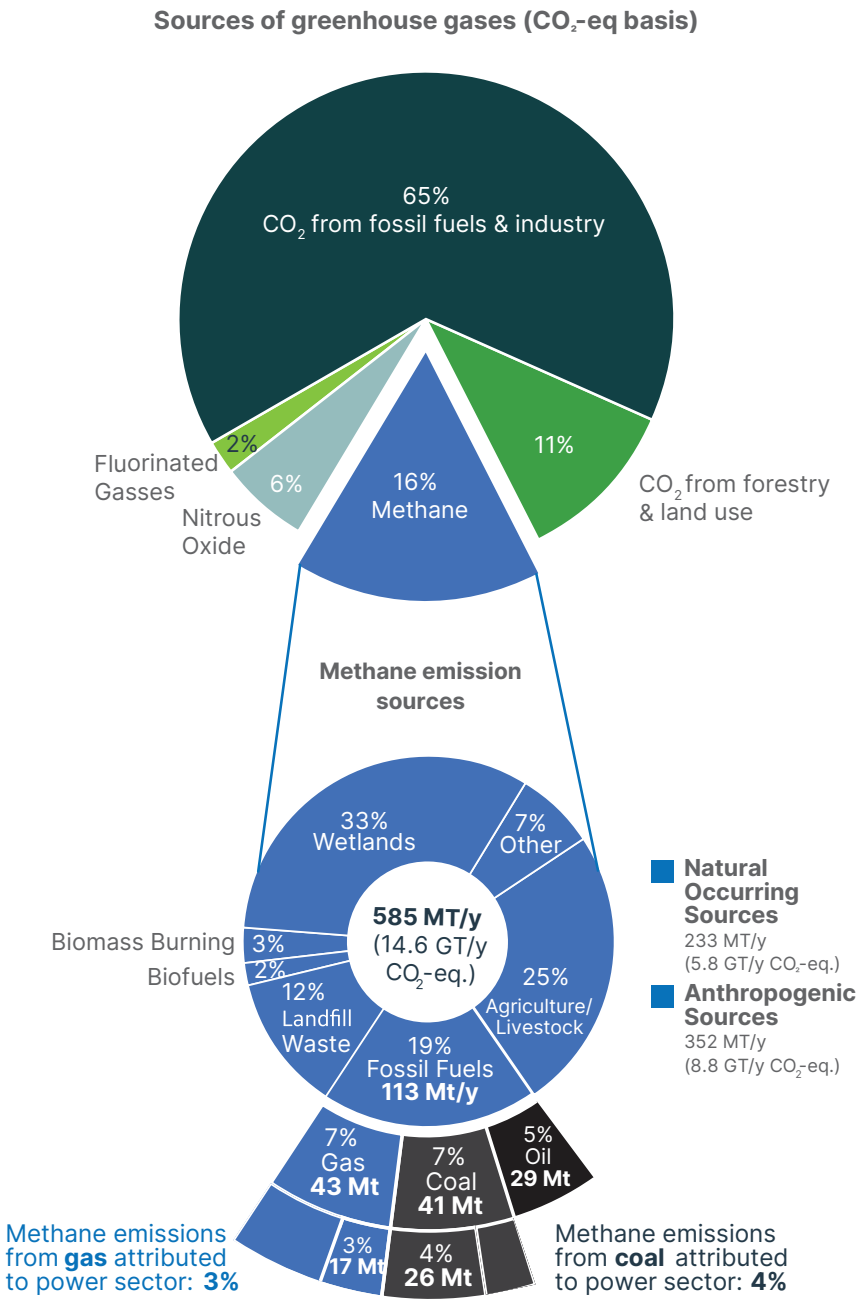

Figure 1: Summary of methane emissions
Sources: US Environmental Protection Agency and International Energy Agency, 2021 Methane Tracker

There is considerable uncertainty around the science of measuring methane emissions. The behavior of methane as a GHG is well understood, but there is less scientific clarity about the sources, or the reasons for recent increases in atmospheric concentrations. This genuine uncertainty can result in a lack of public trust in information on the subject. As a starting point to address this lack of public trust, a commitment to obtain and provide more data through support for scientific research and from more careful direct measurement of methane emissions from industrial equipment is clearly necessary. This is under way, as the industry has much to gain from an increase in knowledge and transparency. In addition to public mistrust, the lack of verifiable data can lead to policy choices that are guided by perception more than facts. Satellite imaging is a powerful tool for identifying sources of methane emissions and satellites such as the Environmental Defense Fund's MethaneSat are advancing the technology of methane leak detection.

METHANE EMISSIONS FROM FOSSIL FUELS

Approximately 110 million metric tons per year of methane are emitted globally due to the extraction, transportation, and use of fossil fuels.

Coal mining releases methane trapped between layers of coal during its formation and methane is released when coal mined, transported, and stored. Coal accounts for about one-third of the methane emissions associated with fossil fuels.

Oil production and processing accounts for about one-quarter of methane emissions from fossil fuels, primarily through intentional venting, fugitive emissions, and flaring of associated gases.

Intentional venting is the release of methane, often for safety reasons, due to the design of the facility, or for inspection and maintenance, and accounts for more than 80 percent of the methane emissions from oil production and processing. This occurs when the gases cannot be recycled in the production process, readily stored/reinjected back into the source, or are a byproduct that lacks a marketable value.

Fugitive emissions are unintentional leaks not caught by a capture system, often due to equipment leaks or evaporative processes. This occurs most frequently when the gases are under pressure and accounts for less than 10 percent of the methane emissions from oil production and processing.

Flaring of associated gases that are an unwanted byproduct of oil production creates greenhouse gas emissions in two ways. First, the combusted gases create CO_2 emissions, but additionally, some methane is not fully combusted and escapes directly to the atmosphere. This accounts for about 10 percent of the methane emissions from oil production and processing.

Gas production, processing, and distribution account for 38 percent of methane emissions from fossil fuels. The methane emissions from gas production, processing, and distribution are split between intentional venting (57 percent) and fugitive sources (43 percent). The methane emissions can also be split into upstream (extraction/processing) and downstream (distribution pipelines and conversion to LNG). Upstream accounts for two-thirds of the methane emissions from gas, while downstream accounts for one-third.

Natural gas, or methane, is the cleanest burning fossil fuel for power generation in terms of CO_2, NO_x, SO_x, mercury, and particulate matter emissions. Approximately 40 percent of global natural gas consumption is for the power sector, with the remainder dedicated primarily to home heating, industrial process heating, and use as a chemical feedstock. Gas-fired power generation therefore accounts for approximately 17 million metric tons of methane emissions per year or 3 percent of total global methane emissions. To put this in perspective, man-made wetlands for rice farming are responsible for more than 3X the methane emissions of the gas-fired power industry. Rice feeds an enormous portion of the world's population and methane emissions from rice farming would be very difficult to abate, whereas emissions from fossil fuel use can be largely addressed.

IMMEDIATE AND COST-EFFECTIVE ACTIONS TO REDUCE METHANE EMISSIONS ARE AVAILABLE TODAY

The IEA has identified abatement technologies and practices which could yield significant reductions in methane emissions. These solutions mainly apply to exploration, production, and transportation in the oil & gas sector. The IEA evaluated the potential impact of each to global sector emissions and the associated net costs to deploy the abatement actions. In many instances, the actions cost less than the value of the methane saved, so they pay for themselves. The specific amount that can be abated with no net cost depends, of course, on the prevailing price of natural gas. See Figure 2, which according to the IEA is based on the unusually low gas prices in 2020 due to the COVID 19 pandemic. Recommended abatement technologies or actions include:

Leak Detection and Repair (LDARs) –
This is the process of locating and repairing fugitive upstream and/or downstream leaks, sometimes using infrared cameras to make leaks visible.

Installing Flares –
Flaring, while not ideal, is preferable to direct venting of methane gas when absolutely necessary for safety reasons. Flares can be installed at oil & gas production sites, and components expected to emit methane can be routed to these devices.

Vapor Recovery Units (VRUs) –
These are small compressors designed to capture emissions that build up in pieces of equipment. VRUs can pull off gases that accumulate in oil storage tanks and are otherwise periodically vented to the atmosphere to prevent explosion.

Electric Motors –
Replace gas-powered devices with electric motors to minimize possibility of leaks.

Replace Pumps and Instrument Air Systems –
Emissions can be eliminated by replacing pumps and controllers pressurized by natural gas with those that are powered by instrument air systems or electricity.

Early Replacement of Devices –
Replace primarily "high bleed" pneumatic devices used throughout production sites and compression facilities with "low bleed" devices.

Replace Compressor Seals or Rods –
Use improved technology to reduce leaks from compressors that are used throughout the oil & gas supply chain. Installing Plungers – Install plunger lifts to more efficiently extract liquids and limit the escape of methane.

Blowdown Capture –
Blowdowns can be triggered by emergency signals or routine start up or shut down procedures. Emissions are mitigated when excess gas is recovered and used on site or sent to market, instead of being vented or flared.

Other –
Includes techniques such as capturing unburned methane from gas burning engines and turbines using a catalyst, deploying small prime movers that locally use associated gas, improved pipe/system blowdown practices, conducting a pipeline pumpdown before maintenance, and "green" completions that capture gases normally released when reworking or completing a well.

The IEA notes that the cost of abatement measures and the value of the captured methane will vary by location and prevailing natural gas prices. The IEA analyzed the relationship between abatement costs and the value of the capture methane across more than 70 countries in their 2021 Methane Tracker.

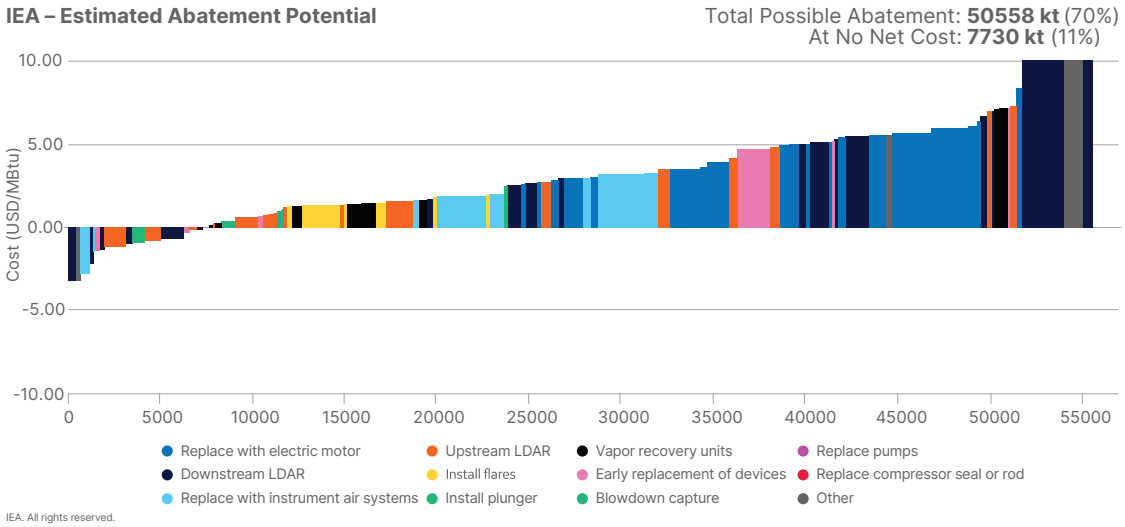

Figure 2: Oil & Gas Industry Global Abatement Oppoertunity.[6]

US: NATURAL GAS PRODUCTION UP, METHANE EMISSIONS DOWN

The three largest producers of natural gas in the world are the US, Russia, and Iran. These three countries are also the largest emitters of methane from oil and gas production, but the methane emissions intensity (i.e., the amount of methane emitted per unit of oil and gas produced) of the US is less than half that of Iran and more than 50 percent lower than in Russia. The wide range of methane emissions intensity is an indication that there is an opportunity to share best practices with the goal of reducing total emissions. In fact, in the US according to the US Energy Information Administration and the Environmental Protection Agency, despite more than a 60 percent increase in natural gas production from 2000 through 2018, largely due to the introduction of hydraulic fracturing techniques, methane emissions have come down by 9 percent overall and 17 percent in the energy sector. See Figure 3. Agriculture and land use are the only sectors with increased methane emissions over this time period, demonstrating the difficulty in abating emissions in these sectors and the ability to abate emissions across all other sectors of the economy. As noted previously, measuring methane emissions is very difficult and actual methane emissions from all sectors may be considerably higher.

Methane emissions from the US energy sector have come down 17% for the period 2000 through 2018

Source: US EPA

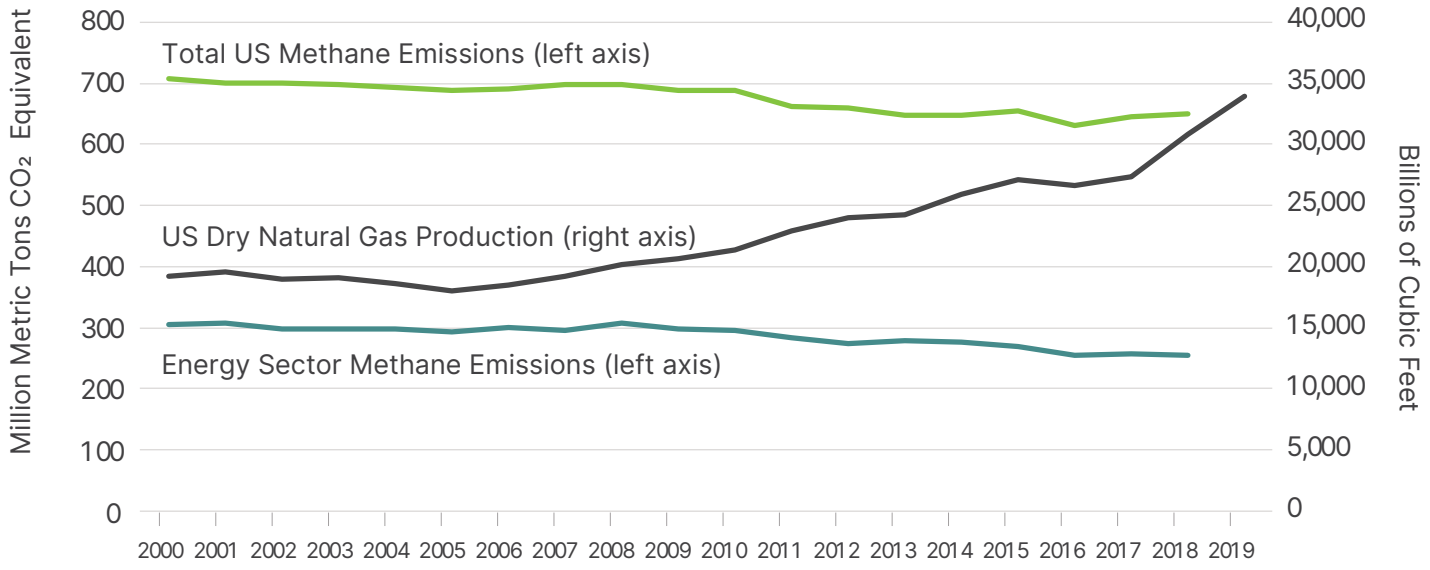

Figure 3: US Methane Emission and Dry Natural Gas Production.[7]

CONCLUSION

Despite this, methane is a powerful greenhouse and any comprehensive strategy to reduce greenhouse gas emissions must address methane emissions as well as CO_2 emissions.

Although approximately 40 percent of global methane emissions are naturally occurring from sources such as wetlands, geologic seepage, and wild animal emissions, the remaining 60 percent are anthropogenic. Accordingly, measures should be taken to reduce them. Fortunately, cost-effective abatement measures are available to significantly reduce emissions from the oil & gas sector in the near term.

GE Vernova believes addressing climate change is an urgent global priority. The oil & gas and power industries have a responsibility and the technical capability to take significant steps quickly to reduce greenhouse gas emissions, and GE Vernova supports measures to require producers and users of methane to employ the best available technology to both measure and prevent methane emissions.

The Oil & Gas Methane Partnership developed a framework for reporting methane emissions that should provide the public with assurance that methane emissions from member companies are being managed responsibly.

Given the urgency of the climate crisis, it's important that policies not be delayed until more detailed measurement and reporting data are available. That said, it is clear that more comprehensive and accurate data are required to ensure that the problem is fully identified and that solutions to address it are effective. Satellite imaging is a powerful tool for identifying sources of methane emissions and satellites such as the Environmental Defense Fund's MethaneSat are advancing the technology of methane leak detection. Significant actions should be taken immediately to address known sources of methane emissions while a more comprehensive policy framework and suitable measurement tools for each country are developed.

Reducing methane emissions from oil & gas operations is among the most cost-effective and impactful actions that governments can take to achieve global climate goals.

*Source: IEA Report: **Driving down methane leaks from the oil & gas industry**, a regulatory roadmap and toolkit, January 2021*

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REFERENCES

[1] US Environmental Protection Agency, Overview of Greenhouse Gas Emissions, https://www.epa.gov/ghgemissions/overview-greenhouse-gases

[2] Inventory Data Explorer, https://cfpub.epa.gov/ghgdata/inventoryexplorer/#iallsectors/methane/inventsect/current; US Energy Information Agency, Natural Gas Data, https://www.eia.gov/dnav/ng/hist/n9070us2A.htm

[3, 5, 6.] International Energy Agency Methane Tracker 2021 https://www.iea.org/reports/methanetracker-2021

[4] International Energy Agency, World Energy Outlook 2021

[7] US Environmental Protection Agency, Greenhouse Gas Inventory Data Explorer, https://cfpub.epa.gov/ghgdata/inventoryexplorer/#iallsectors/methane/inventsect/current; US Energy Information Agency, Natural Gas Data, https://www.eia.gov/dnav/ng/hist/n9070us2A.htm

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