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Methane Emissions: A Primer

Methane: The Chemical

Methane is the world's simplest hydrocarbon, with a chemical formula of CH_4 (one atom of carbon and four atoms of hydrogen). It is gaseous under normal atmospheric conditions and is commonly produced through the decomposition of organic materials in the absence of oxygen. It is released into the atmosphere by natural sources such as wetlands, oceans, sediments, termites, volcanoes, and wildfires as well as human activities such as oil and natural gas systems, coal mines, landfills, wastewater treatment facilities, and the raising of livestock.

Methane: The Fuel and Feedstock

Methane is the primary component of natural gas. When extracted from geologic formations or captured by other means, it can be used as either a fuel or as a chemical feedstock for industry.

When used as a fuel, methane has many advantages over other hydrocarbons (e.g., coal and oil). Methane is more versatile: It can heat homes, fuel stoves, run vehicles, fire power plants, and be exported, either as a gas or liquefied, to support the energy needs of U.S. trading partners. Methane is cleaner-burning: It emits, on average, about half as much carbon dioxide (CO_2) as coal and one-quarter less than oil, per unit of energy, when consumed in a typical electric utility plant. Further, its combustion emits no mercury (a persistent, bio-accumulative neurotoxin), virtually no particulate matter or sulfur dioxide (SO_2), and less nitrogen oxides, per unit of energy, than either coal or oil. Recent expansion of natural gas production—primarily as a result of improved technologies (e.g., hydraulic fracturing and directional drilling) used on unconventional resources (e.g., shale, tight sands, and coalbed methane)—has made methane a major component in the energy supply and security of the United States.

When used as a chemical feedstock, methane is a manufacturing component for a wide variety of household and industrial products including plastic, fertilizer, antifreeze, and fabrics. Abundant and economical supplies of methane support the U.S. petrochemical sector, aiding in the creation of domestic jobs and economic development.

For these reasons, many have advocated for the increased production and use of methane (via natural gas extraction or other capture technologies) and have hailed it as a potential "cost-effective bridge" to a less polluting and lower greenhouse gas (GHG)-intensive economy. Many Members of Congress and recent Administrations have supported this position.

Methane: The Pollutant

Methane, however, when vented or leaked into the atmosphere (commonly referred to as "fugitive" emissions), can affect human health and safety and the environment. The U.S. Occupational Safety and Health Administration lists methane as both an asphyxiant and an explosive; increased concentrations in local settings can jeopardize worker safety. Further, the U.S. Environmental Protection Agency (EPA) classifies methane as both a precursor to ground-level ozone formation (commonly referred to as "smog") and a potent GHG, albeit with a shorter atmospheric life than CO_2. Methane's effect on climate change is up to 34 times greater than that of CO_2 when averaged over a 100-year time period, and even greater when considered over the first 20 years after it is emitted. Arguably, any increase in methane emissions may counteract some of the environmental benefits that the U.S. economy has to gain by switching from coal or oil to natural gas. For these reasons, some state governments and the Obama Administration promulgated regulations to limit methane emissions in certain industrial sectors. The Trump Administration, in line with executive orders to promote energy independence and economic growth, revised or rescinded many of those federal regulations. The Biden Administration has sought to reengage federal efforts to address methane emissions.

Typically, air pollution regulations compete against the economic considerations of affected industries. In methane's case, however, its dual nature as a commodity and a pollutant can provide a unique set of incentives. Under certain conditions, the market value of fugitive methane and other byproduct emissions that can be avoided or recovered may be able to offset some of the cost of controls. Further, the value of these avoided or recovered emissions during oil and gas extraction can contribute to increased royalty payments to state and federal governments.

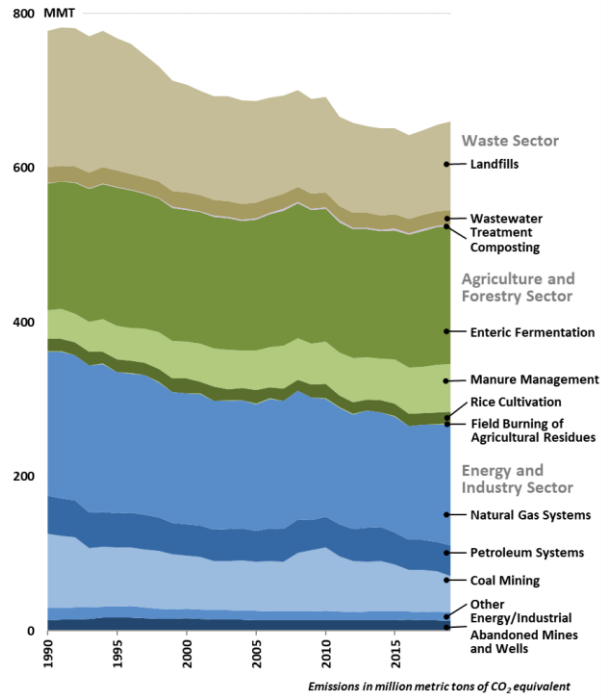
Methane emissions are not always easy to find and capture. Methane, unlike some other pollutants (e.g., SO_2 or CO_2), is not commonly emitted in a concentrated stream from industrial processes. Rather, it is released into the atmosphere through dispersion, leaks, vents, accidents, and ruptures. In this way, methane emissions are most similar to those of other volatile organic compounds, both in manner and control. Efforts to monitor, capture, or abate these emissions are generally more difficult or costly than for other pollutants. Whether the prevention of fugitive methane emissions or their recovery is profitable for producers may depend upon a number of factors, including the nature and extent of the release, the control technology available, and the market price for the avoided or recovered products. In this way, the cost-benefit consideration of methane capture becomes similar to that of energy-efficiency efforts, wherein higher up-front investments and other market barriers have the potential to be offset over time.

Methane Emissions

According to EPA, methane is the second-most-prevalent GHG emitted in the United States (behind CO_2), and in 2019 it accounted for 660 million metric tons of CO_2 equivalent, or approximately 10% of all domestically produced GHG emissions from human activities. Some academic and other government studies put these emissions higher. Of the total methane emissions in 2019, 40% were emitted from sources in the energy and industrial sector, 40% from sources in the agricultural sector, and 20% from sources in the waste sector. Between 1990 and 2019, EPA data indicate U.S. methane emissions decreased by 15%. Still, trends have fluctuated over the past decade, with increases reported in some years, including 2017-2019. Since 1990, emissions from sources associated with agriculture have increased, while emissions from sources associated with waste management, energy, and industrial processes have decreased (**Figure 1**). (CRS chose to analyze EPA's data for 2019 instead of its data for 2020 due to the atypical effects of the Coronavirus Disease 2019 [COVID-19] pandemic on emissions.)

Economic and technical issues pose challenges to making a comprehensive national inventory of methane emissions. Unlike CO_2, whose emissions are reported using well-tracked energy statistics, methane is emitted to the atmosphere primarily through fugitive releases. Thus, it is challenging to acquire comprehensive and consistent observational data. For this reason, methodologies for quantifying methane emissions are under near-constant revision and debate. Concurrently, new techniques and technologies to measure and report emissions (e.g., from aircraft and satellites) continue to be developed.

Figure 1. U.S. Methane Emissions: Historical Trends



Source: CRS, with data from the U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019*, 430-R-21-005, April 14, 2021, Table 2.1.

Issues for Congress

Through the years, the federal government has sought policies (legislative and regulatory) to control methane emissions while balancing several goals, including

- promoting domestic energy production and security,
- protecting the property rights of mineral owners (including federal resource rights and royalties),
- assuring the operational safety of employees who work with or near significant emission sources, and
- safeguarding the general population from the impacts of air pollution and GHG emissions.

Some stakeholders raise concerns over federal controls. They argue that more stringent standards on emissions would not provide cost-effective health and environmental benefits. Some industries contend that they are already doing everything feasible to prevent, capture, and reuse methane emissions (for economic and safety reasons). Others note that state and local authorities are better equipped to oversee and enforce emission reduction efforts.

Federal Actions

On November 2, 2021, the Biden Administration released the "U.S. Methane Emissions Reduction Action Plan," a set of policies to increase efforts across the federal government to reduce methane emissions. These include the following:

- EPA-proposed performance standards for methane emissions from new oil and natural gas sources and first-time emissions guidelines for states on existing oil and natural gas sources (86 *Federal Register* 63110).
- EPA initiatives to reduce methane emissions at municipal solid waste landfills through (1) a program to reduce food loss and waste and (2) a voluntary outreach program for emissions capture. These initiatives would complement existing performance standards (81 *Federal Register* 59332) and emissions guidelines for states (81 *Federal Register* 59276) from 2016.
- Department of the Interior-proposed standards for waste prevention during the venting and flaring of methane from oil and natural gas operations and well closures on public lands and waters.
- Pipeline and Hazardous Materials Safety Administration (PHMSA) rules, pursuant to the implementation of the PIPES Acts of 2016 and 2020 (P.L. 114-183 and P.L. 116-260, Division R), that would, among other things, require operators to address methane leaks.
- Department of Agriculture programs that include (1) a voluntary, incentive-based "climate-smart" agriculture program to reward farmers and ranchers for methane reductions; (2) a climate-smart partnership initiative targeting commodities' supply chains; and (3) a public-private partnership to promote biogas programs.

Further, on November 5, 2021, Congress enacted the Infrastructure Investment and Jobs Act (P.L. 117-58) that authorized, among other items, $4.7 billion for programs to plug, remediate, and reclaim abandoned oil and natural gas wells, and $1.0 billion for a new grant program at PHMSA aimed at reducing methane leaks from antiquated pipes.

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