GLOBAL METHANE EMISSIONS AND MERCURY

There is increasing scrutiny of both methane emissions – heavily implicated in global warming – and the mercury content of those emissions, which also impact human health and the environment. This brief, based on a presentation I shared at ICMGP 2022[1], focuses more specifically on methane emissions related to the commercial exploitation of fossil fuels, the mercury content of those emissions, and what can be done about them.

Methane in the atmosphere

Methane, with a relatively short atmospheric lifetime, is capable of warming the planet roughly 80 times more effectively than carbon dioxide over a 20-year period. Moreover, the concentration of methane in the atmosphere has more than doubled since pre-industrial times, to the extent that it is second only to carbon dioxide in driving climate change during the industrial era.

Scientists say that tackling methane emissions isn't only necessary to keep global climate efforts on track, but it would be the fastest way to curb rising temperatures in the near term.[2]

Key methane sources

Methane is emitted by fossil fuels and other anthropogenic activities, as well as through natural processes like the decay of vegetation. According to the International Energy Agency (IEA)[3] the main anthropogenic sources of global methane emissions in 2021 were:

- 40% agriculture, particularly from meat and dairy production[4]
- 35% fossil fuel extraction, pumping, transport
- 20% waste dumps
- 5% other (e.g., bio-energy, biomass burning)

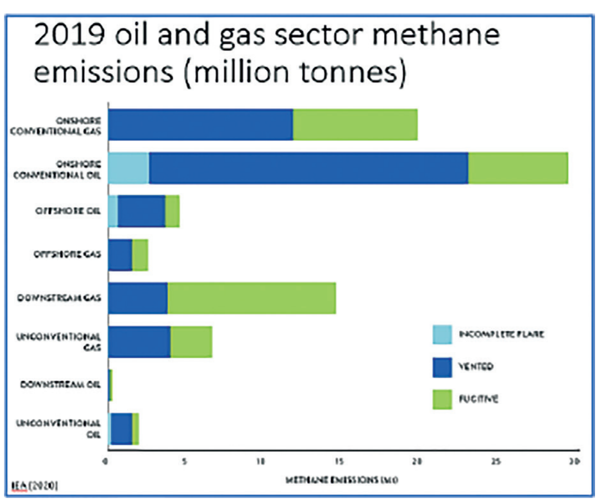
Agriculture is the largest source, but fossil fuel exploitation is not far behind. Moreover, fossil fuel methane emissions have been increasing more rapidly, and most fossil fuels tend to be contaminated with mercury.

Fossil fuel sources of methane

The more obvious sources of methane emissions related to fossil fuels occur during oil and gas extraction, processing and distribution, and from coal mining. Less obvious but closely related are methane emissions during gas flaring and venting, methane emissions from abandoned gas wells and coal mines, and the like.

To take the example of methane emissions from flaring, which is a lower source of emissions than venting and fugitive emissions, the IEA estimates that average flare combustion efficiency (the percentage of gas that is successfully burned off) is roughly 92 percent. Under optimal conditions and proper maintenance, flare combustion efficiency should be around 98%. This "incomplete flaring" gap means that substantial volumes of greenhouse gases such as methane, black soot and nitrogen oxides are unnecessarily released into the atmosphere via this pathway.

Estimates of global methane emissions vary significantly depending on the models and data used to develop those estimates. Nevertheless, among others, the International Energy Agency has developed a comprehensive overview of the relative importance of the various emission sources for oil and gas, as shown in the figure below. It goes without saying, perhaps, that fossil fuel sources of methane emissions have not decreased since this figure was generated from 2019 data.



Non-commercial methane from fossil fuel sources

Based on IEA data and other sources, the World Bank and others have developed estimates of non-commercial methane generated from all fossil fuel sources, including coal mines, as shown below. Note that this figure includes flared methane since flaring still puts the methane's trace mercury contamination into the atmosphere. To put this quantity of non-commercial methane in perspective, 400 billion cubic meters are equivalent to nearly 10% of the quantity of commercial natural gas marketed globally each year.

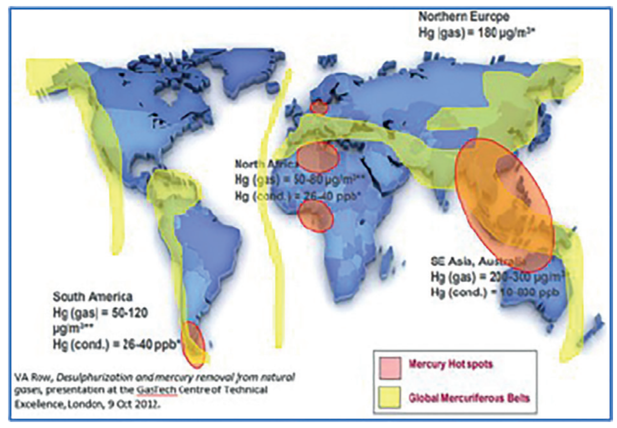
Non-commercial methane emissions from fossil fuel sources

Fossil fuel methane source (2019)	2019 methane emissions (billion cubic meters)
Flared methane (90% upstream) from gas & oil	150
Incomplete flaring, venting and fugitive emissions (80% upstream) from gas & oil	120
Active coal mines	110
Abandoned coal mines	25
Total	405

Sources: World Bank GGFR Report, July 2020; Kholod et al., Global methane emissions from coal mining to continue growing even with declining coal production, *Journal of Cleaner Production, Volume 256, 20 May 2020*

Mercury assessment methodology

Having identified the main sources of fossil fuel contributions to global methane emissions, we now focus on the mercury content of those emissions. Our methodology is based on the fact that mercury belts and regional hotspots often coincide with the location of fossil fuel resources. Diverse regions of the world have varying levels of natural mercury contamination, as demonstrated in the figure below.



Mercury emissions from non-commercial methane releases

While fossil fuel resources even in the same region may show varying levels of mercury contamination, empirical data permit rough estimates of the mercury content of non-commercial methane emissions. For this brief, upstream releases of methane are highlighted in particular because downstream releases have typically passed through a mercury removal unit (MRU), and may generally be expected to have a much lower mercury content.

Based on the quantities and types of fossil fuels exploited, and the regions they come from, a reasonable estimate of mercury emissions from non-commercial fossil fuel methane sources would be somewhere between 25 and 50 metric tons of mercury, as summarized in the table below. These are solely mercury emissions to the atmosphere, completely apart from any mercury in solid or liquid waste streams, or recovered by MRUs, etc.

Mercury emissions from non-commercial methane releases

Fossil fuel methane source (2019)	Mercury emissions (metric tons)
Flared methane (90% upstream) from gas & oil	15 - 20
Incomplete flaring, venting and fugitive emissions (80% upstream) from gas & oil	10 - 15
Active coal mines	0 - 12
Abandoned coal mines	0 - 3
Total	25 - 50

Sources: Presentation by P. Maxson at ICMGP-14 (2019), "Mercury in natural gas (and oil)," using regional average mercury contamination of fossil fuel sources; Assume minimal mercury content of downstream methane emissions; Assume 30% of active coal mine gas captured on site.

I would add one comment about the coal sector. It is common knowledge that virtually all coal contains trace mercury; in fact, coal has much higher mercury concentrations than other fossil fuels. It would be reasonable to assume, therefore, that virtually all coal mine methane releases, including from abandoned coal mines, would contain trace mercury. But I could find no scholarly estimates of mercury in methane from coal mines, which explains the figures in the previous table.

Main sources of mercury emissions

The consulting firm Qa³, based on actual on-site studies undertaken over the last 14 years, has identified previously unconsidered pathways of mercury emissions to the environment that occur during the production of natural gas, crude oil and LPG. The table below shows these sources and/or pathways, which Qa³ has estimated are responsible for between 60 and 150 tonnes of typically unrecorded mercury emissions per year. Note also that about half of these sources give rise to atmospheric mercury emissions, which are the main focus of this brief.

Sources of Unconsidered Emission — Qa³ On-site Chemistry

Emission Source	Observed / Estimated % Removal	Common Emission Route
Dehydration - (Glycol Contactor)	OBSERVED 10 – 60%	Venting direct to atmosphere
Dehydration - (Mol Sieve)	OBSERVED 10 – 90%	Via water and possible flaring
Acid Gas Removal - (Amine Contactor)	OBSERVED 10 – 60%	Flaring or contaminated sulphur
Pipework and Equipment	OBSERVED 10 – 99%	Smelting at end of life
Waste Solids and Sludges	OBSERVED 10 – 60%	Hydrocarbon Waste disposal routes
Flaring	OBSERVED 1 – 80%	Direct to atmosphere
CO_2 and N_2 Membranes	ESTIMATED 1 – 5%	Associated with solid wastes
Effluent Water	OBSERVED 0.1 – 2%	Directly into sea / waterway
Venting of Cargo Tanks	ESTIMATED 1 – 2%	Direct to atmosphere

Source: Qa³

Conclusions

Key findings

According to the Intergovernmental Panel on Climate Change (IPPC), today's concentration of methane in the atmosphere is higher than at any time in at least 800 thousand years, and methane has contributed around 30% of observed global warming to date.

Methane releases related to the exploitation of fossil fuels are typically contaminated with mercury, and the resulting mercury emissions to the atmosphere are not insignificant. These 25-50 tonnes of mercury emissions are equivalent to 10-15% of all mercury that is mobilized when oil and gas are extracted from the ground, and are part of the 60-150 tonnes of fossil fuel related mercury that escape to the environment every year.

Methane monitoring and reporting

It is widely agreed that we need to greatly improve methane emissions measurement, reporting and verification. In most countries reporting has been based on generic factors, which may have missed 60-70 percent of the actual emissions.

With a better understanding of the scope of the problem, we can better set targets and priorities for reducing these emissions. While the path forward will be different in each region, and sometimes for each operator, there is a clear need for stronger collaboration between private and public organizations, as well as improved availability of working capital. Fortunately, the tools now exist to monitor and measure methane emissions quite accurately.

Methane reduction measures

There are well established technologies to capture and commercialize vented, fugitive and flared gas. Even at oil and gas prices significantly below where they are at present, cost-effective abatement solutions exist for 60–80 percent of oil and gas methane emissions, and for 55–98 percent of coal methane emissions These technologies fall under the following major categories:

• Phase out (replace with electrical or mechanical devices) or upgrade pneumatic equipment powered with natural gas

• Improve LDAR (leak detection and repair) activities

• Halt routine flaring and venting

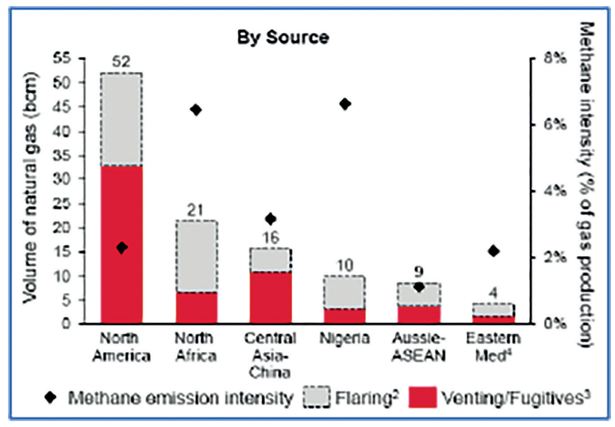
• Clean up orphaned oil & gas wells

• Re-design systems, where possible, to avoid potential sources of methane leaks

Incentives and rewards

The 27 countries of the European Union have agreed on a binding goal for the EU as a whole to be climate neutral by 2050, and methane emissions are covered by this pledge. Despite their attractiveness, the existing economic incentives have not yet motivated oil and gas operators to make significant changes, although recently some companies in the energy sector have voluntarily committed to methane reductions. As a further incentive in the European Union, the European Commission unveiled its methane emissions strategy in 2020, followed by its support for the Global Methane Pledge launched at climate COP-26. New proposals that the European Commission elaborated in 2022 have a wide ranging set of implications for oil and gas companies, and may be adopted before the end of 2023.

According to a recent report by S&P Global,[5] more than 70% of 112 billion cubic meters (bcm) of potential natural gas supply lost due to flaring and venting/fugitives, could be captured with a positive return on the required investment, as summarized in the following figure.



Additional gas supply from capturing flared, vented and fugitive methane (2021). Source: S&P Global

While attention to other pathways of mercury emissions and releases from fossil fuel exploitation is also important, reducing non-commercial methane releases is one of the best ways to achieve near-term benefits for global warming, as well as reduced fossil fuel related mercury emissions.

References

1. P Maxson, "Global methane emissions and mercury," presentation to the International Conference on Mercury as a Global Pollutant (ICMGP 15), Cape Town, South Africa, July 2022.

2. Methane: A crucial opportunity in the climate fight <https://www.edf.org/climate/methane-crucial-opportunity-climate-fight>

3. Global Methane Tracker 2022, International Energy Agency, Paris <https://www.iea.org/reports/global-methane-tracker-2022>

4. Ivanovich, C.C., Sun, T., Gordon, D.R. et al. Future warming from global food consumption. Nat. Clim. Chang. 13, 297–302 (2023). <https://doi.org/10.1038/s41558-023-01605-8>

5. Levers for capturing methane emissions to improve gas availability, S&P Global Commodity Insights, 2022.

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About the Author

Mr. Maxson is the Director of a Brussels-based consultancy, and has university degrees in engineering and business administration. For more than 20 years he has focused most of his research and publications on mercury related issues for clients including the European Commission's DG Environment, the U.S. EPA, the World Bank, UNEP and other UN agencies, NGOs such as the Zero Mercury Working Group, the European Environmental Bureau, the Artisanal Gold Council, and others. His work has been most widely referenced with regard to global mercury sources, mercury uses in products and processes, and mercury trade.

Mr. Maxson contributed significantly to the development of the Minamata Convention on Mercury, and continues to support a range of efforts to improve its implementation and broaden its scope. His current projects include research and policy measures on legal and illegal mercury trade especially for use in ASGM, developing safe mercury management procedures for countries with limited resources, phasing out the use of dental amalgam, eliminating the use of mercury in skin-lightening creams, etc.