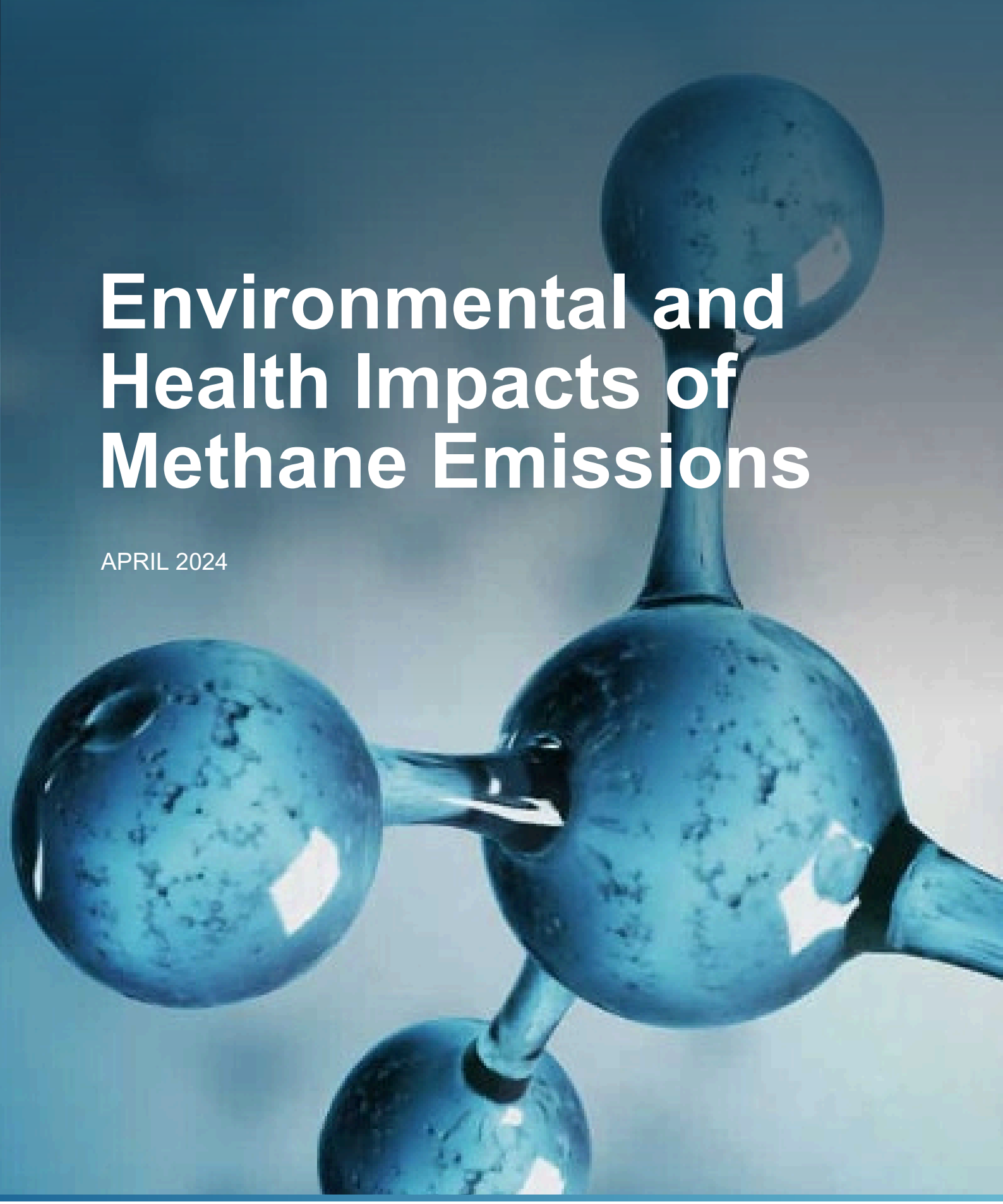

Environmental and Health Impacts of Methane Emissions

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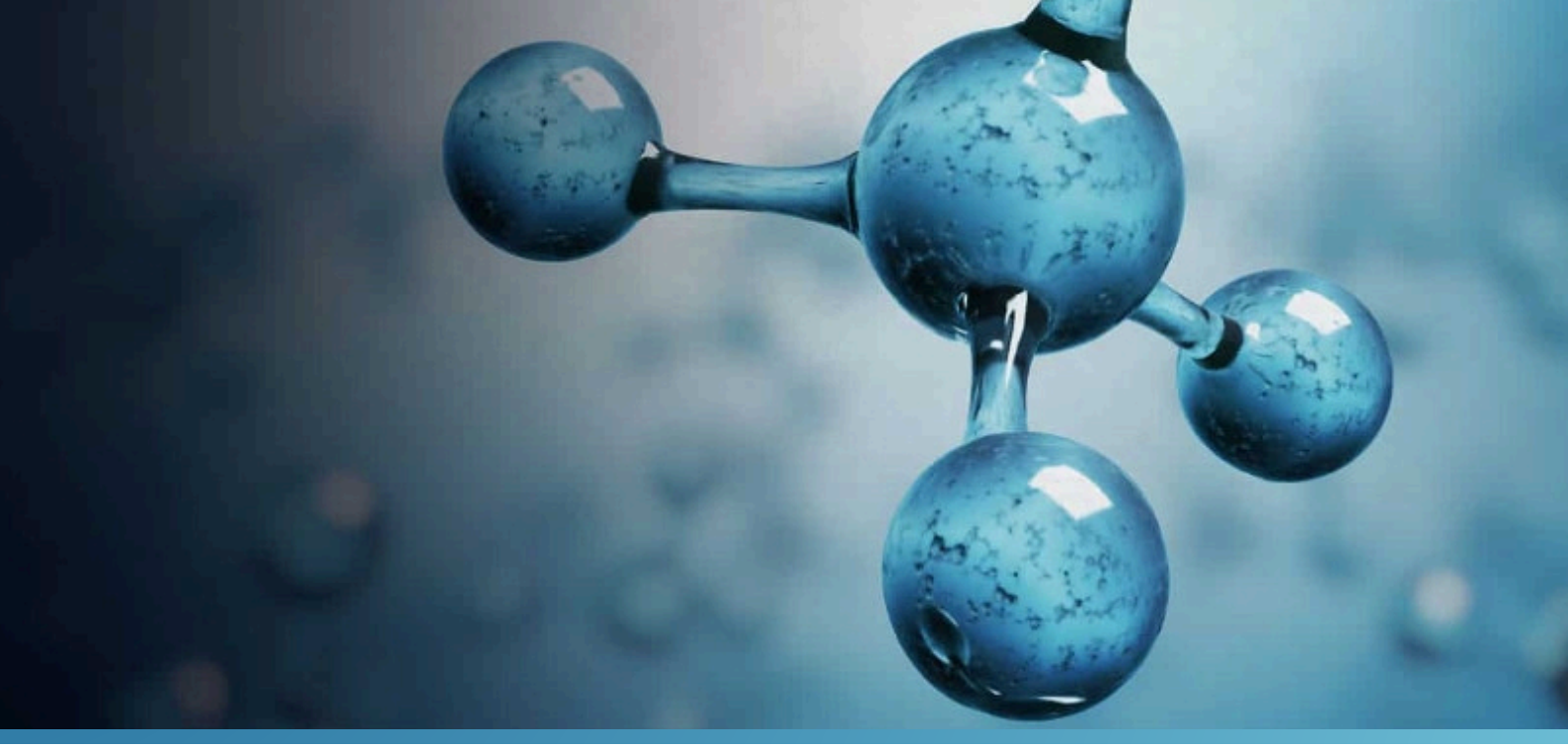
Africa Centre for Energy Policy

With support from TRUSTAFRICA



Environmental and Health Impacts of Methane Emissions

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With support from TRUSTAFRICA

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Design: Derek Kwesi Okai, Derrick Amegatse

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1. Air Pollutants of Climatic and Public Health Importance

The World Health Organization defines air pollution as the presence of harmful substances, including chemical, physical, or biological agents, that alter the natural composition of the indoor or outdoor environment. These pollutants originate from various sources, such as industrial activities, agriculture, vehicle emissions, wildfires, and volcanic eruptions.[1]

Air pollutants pose significant environmental risks; for instance, carbon dioxide and methane contribute to global warming by trapping heat and radiation near the Earth's surface.[2] Additionally, there are health-related impacts; inhaling harmful substances like particulate matter (PM)[2] and nitrogen pollutants can lead to respiratory problems, including asthma, bronchitis, and chronic obstructive pulmonary disease (COPD).

1.1. Climate and hazardous air pollutants

The complexity of air pollutants allows them to be categorised in different ways. Air pollutants can be classified based on their physical characteristics, such as gaseous (e.g. CO2, Methane) or particulate forms (e.g. dust, soot, pollen, etc.). They can also be classified based on their source, including transport, industrial processes or agricultural activities. Air pollutants can also be classified based on their environmental or health impacts. This form of classification allows for examining air pollutants that threaten environmental sustainability and drive climate change, and those that pose direct or indirect health risks. This brief discusses two categories based on their environmental and health impacts: climate and hazardous air pollutants.

Climate pollutants are greenhouse gases generated from mainly human activities and have been a critical driver of observed climate change.[4] Major climate pollutants include carbon dioxide (CO_2), primarily released from burning fossil fuels and deforestation. Methane (CH_4) is another potent greenhouse gas produced from agricultural activities, landfills, and fossil fuel extraction. Methane is more potent than CO_2 at trapping heat, although it remains in the atmosphere for a shorter time. Additionally, black carbon, a component of particulate matter released from the combustion of wood, coal, or diesel, absorbs sunlight and contributes to warming.

[1] World Health Organization. (n.d.). Air pollution. Available at https://www.who.int/health-topics/air-pollution#tab=tab_1

[2] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2391 pp. doi:10.1017/9781009157896.

[3] Particulate matter are tiny solid or liquid particles suspended in the air. They emerge from various sources including vehicle exhaust, industrial processes, burning wood or coal, and natural sources such as dust and pollen.

[4] US. Environmental Protection Agency. (2024, May 14). Climate change indicators: Greenhouse gases. Available at https://www.epa.gov/climate-indicators/greenhouse-gases

Whereas climate pollutants contribute to long-term environmental and climatic changes, hazardous air pollutants (toxic air pollutants) can have more localised and immediate environmental effects. Hazardous pollutants are known or suspected to cause cancer, reproductive problems, congenital disabilities, or other serious health issues.[5] These pollutants include gaseous materials such as carbon monoxide, volatile organic compounds (VOCs)[6], ground-level ozone, and metals such as asbestos, lead, cadmium and mercury.

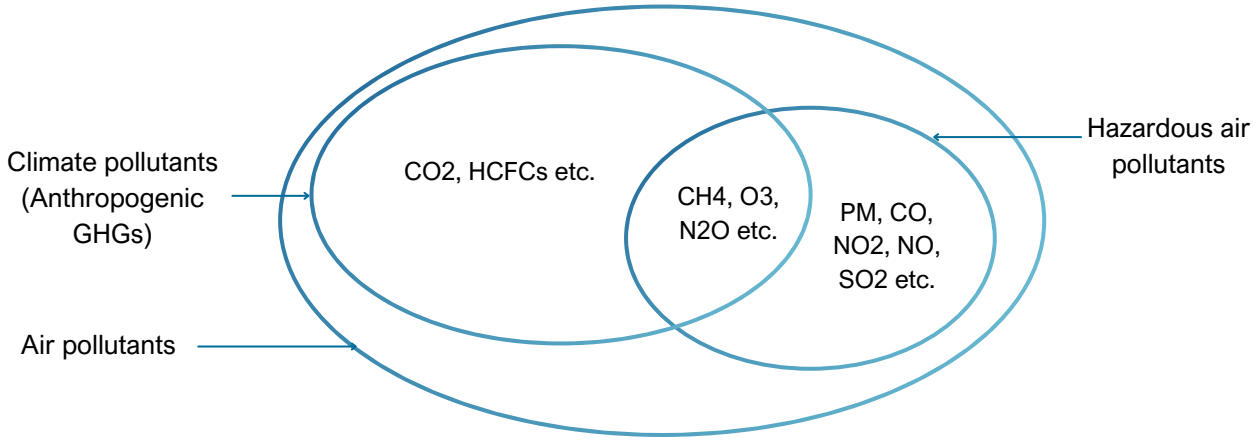

Figure 1: Diagram showing the relationship between climate and hazardous air pollutants.

1.2.Greenhouse effect of increased methane emission

Methane is the second most prevalent greenhouse gas emitted by human activities, following carbon dioxide. It constitutes approximately 16% of global greenhouse gas emissions. Methane poses dual threats: as a hazardous air pollutant and a climate pollutant. As a hazardous air pollutant, methane contributes to the formation of ground-level ozone, a harmful air pollutant that can irritate the respiratory system. As a climate pollutant, methane significantly drives global warming. Over a 20-year timescale, the global warming potential of methane is equivalent to about 82 to 87 times more potent than CO2. When measured over a 100-year timescale, its potential is about 30 times more powerful than CO2.[7]

Atmospheric methane concentrations have doubled over the past two centuries, primarily due to human-induced activities. The increase has accelerated in recent years, with about 40% of emissions originating from natural sources and 60% from human activity (anthropogenic emissions). Some key sources of anthropogenic emissions of methane are provided in Figure 2 below:

[5] US. Environmental Protection Agency. (2023, December 7). What are hazardous air pollutants? Available at https://www.epa.gov/haps/what-are-hazardous-air-pollutants

[6] VOCs are organic substances that readily evaporate into the atmosphere, making them more likely to be inhaled and posing a greater risk of health problems.

[7] International Energy Agency (2022), Global Methane Tracker 2024, IEA, Paris https://www.iea.org/reports/global-methane-tracker-2022 , Licence: CC BY 4.0

Energy	Agriculture	Waste
• Oil and gas operations • Coal mining • Bio	• Enteric fermentation among livestock • Rice Cultivation • Manure Management	• Landfills • Wastewater treatment • Biological treatment of solid waste

Figure 2: Methane Emitting Activities from Energy, Agriculture and Waste Sectors

The International Energy Agency estimates that in 2023, the agriculture sector was the largest source of methane emissions, contributing approximately 142 million tonnes globally. The energy sector was the second-largest emitter, releasing about 138 million tonnes of methane. Following these, the waste sector accounted for 71 million tonnes, while biomass burning was responsible for an additional 10 million tonnes of methane emissions. These figures underscore the need for targeted mitigation strategies across all sectors, particularly agriculture and energy, to address their significant contributions to global methane emissions.

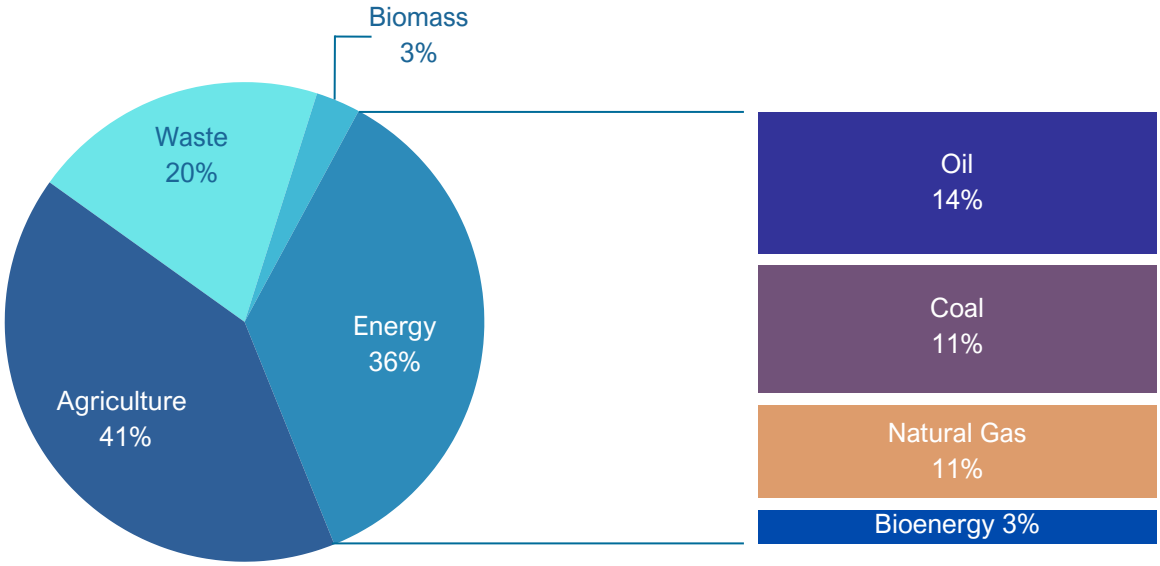

Figure 2: Methane Emitting Activities from Energy, Agriculture and Waste Sectors

Source: International Energy Agency

2. The Climate Crisis is also a Public Health Crisis

Rising temperatures and extreme weather events are expected to lead to an increase in climate-sensitive diseases. Due to its impact on global warming and air quality, methane is a risk factor for climate-sensitive health outcomes and a threat to human health. Methane exposure is relatively non-toxic when experienced at lower concentrations. However, exposure to higher methane concentrations can lead to methane gas poisoning. Methane gas poisoning causes suffocation by displacing the oxygen in the air inhaled, depriving the body of the oxygen it requires.[8]

Exposure to methane gas can lead to a variety of immediate symptoms, ranging from mild to severe. Early signs of methane poisoning often include changes in mood, such as irritability, and physical symptoms like slurred speech, blurry vision, and memory loss. Individuals may also experience nausea, vomiting, facial flushing, and headaches. In more severe cases, exposure can cause more serious health issues, including irregular breathing, changes in heart rate, dizziness, and difficulty maintaining balance. As the poisoning worsens, it can lead to numbness, loss of consciousness, and in extreme cases, death due to respiratory or cardiovascular failure.[9]

2.1 The combination of methane and other pollutants is detrimental to human health

Methane emissions from oil, gas, and waste sectors are often accompanied by the release of other harmful air pollutants, creating both climate and public health concerns. Methane contributes to the chemical reactions in the atmosphere that produce tropospheric (ground-level) ozone, a harmful air pollutant. Some studies indicate that methane is responsible for about 35% of the current levels of ground-level ozone.[10] The effects of ozone exposure on human health are well documented. Both short-term and prolonged exposure to ozone are linked to severe health risks and premature deaths.
Short-term exposure to ozone is associated with an increased risk of contracting chronic obstructive pulmonary disease (COPD). COPD is a progressive lung condition characterised by airflow obstruction.[11] COPD includes two main problems: chronic bronchitis, which causes a lot of coughing and mucus, and emphysema, which damages the air sacs in the lungs. Symptoms include coughing, shortness of breath, wheezing,

[8] De-Giorgio, F., Grassi, V. M., Vetrugno, G., Rossi, R., Fucci, N., d'Aloja, E., & Pascali, V. L. (2012). Homicide by methane gas. Forensic science international, 221(1-3), e1-e3.
[9] Snyder, J. (2020, June 10). The dangers of methane gas poisoning and exposure. NevadaNano. Retrieved June 24, 2024, from https://nevadanano.com/methane-gas-poisoning-and-exposure/; Public Health England. (2019). Protecting and improving the nation's health: Compendium of chemical hazards - methane. https://assets.publishing.service.gov.uk/media/5c34c0b240f0b6445ac3e198/Methane_PHE_general_information__070119.pdf
[10] Butler, T., Lupascu, A., & Nalam, A. (2020). Attribution of ground-level ozone to anthropogenic and natural sources of NOx and reactive carbon in a global chemical transport model. Atmospheric Chemistry and Physics Discussions, 2020, 1-41.
[11] Mar, K. A., Unger, C., Walderdorff, L., & Butler, T. (2022). Beyond CO2 equivalence: The impacts of methane on climate, ecosystems, and health. Environmental science & policy, 134, 127-136.

and getting lung infections often. There is limited evidence on the health effects of long-term exposure to ozone. However, recent studies have shown that long-term ozone exposure contributes to deaths caused by diseases that affect the respiratory system (e.g. asthma, pneumonia) and the circulatory system (e.g. heart failure).[12]

Oil and gas operations that release methane are also responsible for emitting a range of harmful air pollutants (Health-Damaging Air Pollutants or HDAPs). These pollutants pose serious health risks, even at low concentrations. Key pollutants and their associated health impacts include:

- **Black carbon:** Contributes to respiratory issues, cardiovascular disease, and exacerbates asthma.
- **Hydrogen sulfide:** Can irritate the lungs and eyes, leading to chronic respiratory problems and neurological effects.
- **Toluene:** Exposure may cause dizziness, headaches, and long-term damage to the nervous system.
- **Xylene:** Can lead to headaches, dizziness, and liver or kidney damage with prolonged exposure.
- **Benzene:** Known to be carcinogenic, benzene exposure is linked to leukemia and other cancers.
- **Nitrogen oxides:** Aggravate respiratory conditions like asthma and contribute to the formation of ground-level ozone.
- **Sulfur dioxide:** Causes throat and lung irritation, contributing to respiratory diseases and heart conditions.

2.2 Populations at Risk

Certain populations are more vulnerable to the health impacts of methane exposure due to factors such as age, pre-existing health conditions, and environmental circumstances. These groups may face greater risks from methane, whether through household activities, occupational settings, or living near methane-emitting sources. The following outlines key sources of methane exposure for these vulnerable populations:

1. Household exposure: Methane is typically present in the air at low concentrations. However, direct exposure, albeit low, can occur in households using natural gas products through gas leakages. Additionally, people in communities that rely on solid fuels (such as wood, charcoal, or biomass) or inefficient cooking stoves, especially in poorly ventilated spaces, are at increased risk of exposure to methane and other pollutants
2. Occupational exposure to methane may occur among people working where methane is extracted, produced, or used. Examples are people working in oil and gas production industries, refineries, landfills, coal mines, livestock facilities, and wastewater treatment facilities.

[12] Kim, S. Y., Kim, E., & Kim, W. J. (2020). Health effects of ozone on respiratory diseases. Tuberculosis and Respiratory Diseases, 83(Supple 1), S6.

3. Community exposure: Communities living near significant oil and gas operations, particularly those close to onshore fields, are at greater risk of methane exposure. These areas often have higher concentrations of methane, which can negatively impact residents' health over time.
4. Vulnerable populations, including children, the elderly, pregnant women, and people with pre-existing health conditions, are at heightened risk from methane exposure. Children, in particular, are more susceptible to pollutants like ozone, as their lungs are still developing, and they tend to spend more time outdoors when ozone levels are high, increasing their exposure to harmful pollutants.

3. Strategies for reducing methane emission (Methane mitigation)

Methane is known to contribute significantly to climate change. However, it also poses direct and indirect health impacts, including respiratory issues, cardiovascular diseases, and increased premature mortality from air pollution. Reducing methane emissions can mitigate these health risks and improve air quality. The following strategies can help significantly reduce methane emissions and their associated environmental and health impacts:

3.1 Reducing Methane Emissions in the Oil and Gas Sector:

- **Extended Recovery and Utilisation:** Promote the recovery and use of associated gas (mainly methane) instead of venting or flaring into the atmosphere.
- **Alternative Uses of Methane:** Encourage the use of methane for energy production or manufacturing ammonia used in fertilisers.
- **Improved Equipment and Maintenance:** Enhance the control of fugitive methane emissions through better equipment and regular inspection and maintenance programs, such as leak detection and repair systems.

3.2 Reducing Methane Emissions from Agriculture:

- **Livestock Dietary Adjustments:** Modify livestock diets to reduce methane production by altering the microbial community in their digestive systems.
- **Proper Manure Management:** Implement effective manure management practices, such as composting, to prevent methane emissions from decomposing organic matter.
- **Sustainable Rice Cultivation:** Adopt techniques like Alternate Wetting and Drying (AWD) to reduce flooding periods, limiting the anaerobic conditions that promote methane production in rice paddies.
- **Crop Residue Management:** Using crop residues for biogas production or as livestock feed prevents methane emissions from decomposing biomass in the field.

3.3 Reducing Methane Emissions from the Municipal Solid Waste Sector:

- **Waste Separation and Treatment:** Separate biodegradable municipal waste and treat it through recycling, composting, or anaerobic digestion to reduce methane emissions from landfills.
- **Landfill Gas Collection:** Implement systems to capture and utilise methane gas from landfills by combustion or converting it into usable energy.

- **Avoid Open Burning:** Discourage the practice of open garbage burning, which emits not only methane but also black carbon and other harmful pollutants.

3.4 Reducing Methane Emissions from Household Cooking and Domestic Heating:

- **Clean-Burning Cookstoves:** Introduce improved biomass cookstoves, such as fan-assisted models, which reduce methane and other harmful emissions.
- **Fuel Substitution:** Replace traditional biomass fuels (e.g., firewood and charcoal) with cleaner-burning fuels like liquefied petroleum gas (LPG), biogas, or ethanol to reduce methane and particulate emissions from cooking and heating.

7

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