04 METHANE AND CLIMATE CHANGE

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Methane is a powerful greenhouse gas. Its global warming potential is about 28 times greater than that of carbon dioxide.[1] It is the second most prevalent greenhouse gas (GHG) emitted through human activities, accounting for about 15 per cent global GHG emissions in 2012.[2]

Benefits of methane abatement

- Methane presents unique opportunities for mitigation through well-established, cost-effective technologies. In addition to mitigating climate change, methane abatement has energy, health and safety benefits.
- Methane-reduction technologies help reduce other hazardous air pollutants, thus yielding health benefits for the local population.
- Technologies that capture methane for use as a clean energy source can spur economic development and improve standards of living in local communities.
- The overall potential for methane mitigation without any additional investment (as benefits exceed costs) is 500 $MMTCO_2E$ (million metric tonnes of carbon dioxide equivalent).
- The mitigation potential is largest in the highest emitting countries, i.e. US and China.[3]

Table 1: Global warming potential of GHGs

Greenhouse gas	Global warming potential (100 years)
Carbon dioxide (CO_2)	1
Methane (CH_4)	28
Nitrous oxide (N_2O)	265
HCFC 22	1,760
HFC 134a	1,300
CFC 12	10,200
Sulphur hexafluoride (SF_6)	23,500

Source: The Greenhouse Gas Protocol, 2014, 'Global Warming Potentials'

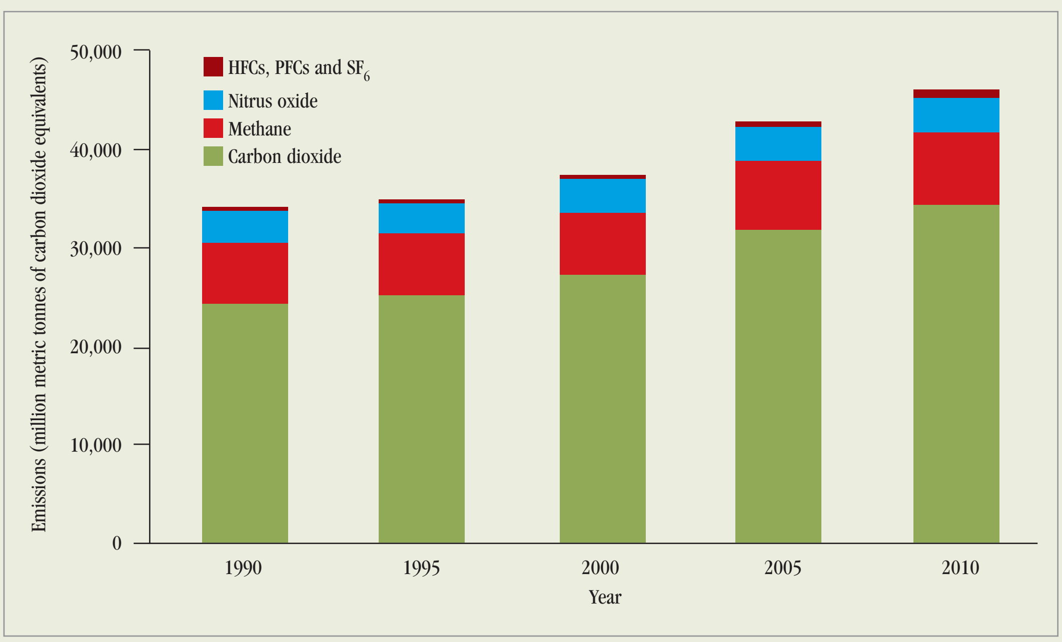
Sources of methane

There are both natural and anthropogenic sources of methane. About 28 per cent of the methane produced can be attributed to natural sources.[4]

Natural sources

- Methane emissions are released into the atmosphere by natural sources such as termites, wetlands and oceans.

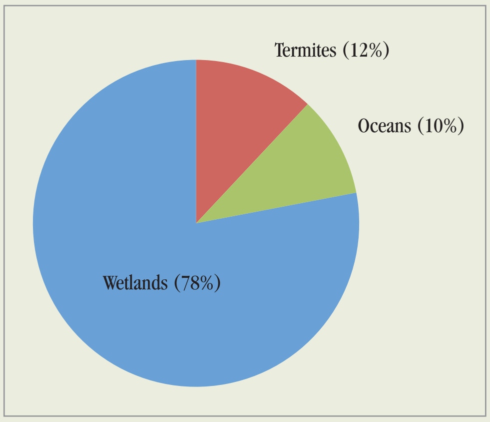
Figure 1: The share of different gases in global GHG emissions



Source: WRI, 2015, 'CAIT Emissions Projections'

* About 78 per cent of the total methane emissions from natural sources can be attributed to wetlands. The rest is split between termites and oceans.
* Methane production from all these three sources can be attributed to methane-producing bacteria that thrive in oxygen-less (anaerobic) environments.
* The methane produced from natural sources is offset by natural methane sinks, including tropospheric destruction of methane by hydroxyl (OH) radicals and oxidation by soil bacteria. These sinks reduce methane emissions by 500–600 $MMTCO_2E$ annually.[5]

Figure 2: Methane emissions from natural sources



Source: Bousquet, et.al. 'Contribution of anthropogenic and natural sources to atmospheric methane variability.' Nature 443, no. 7110 (2006): 439–43

Anthropogenic sources

* Anthropogenic methane emissions totalled 7,153 $MMTCO_2E$ in 2012.[6]
* Fossil fuels, rice cultivation, landfills, wastewater and animal husbandry account for the large majority of global anthropogenic methane emissions. They also offer the most opportunities for mitigation and productive use of methane.

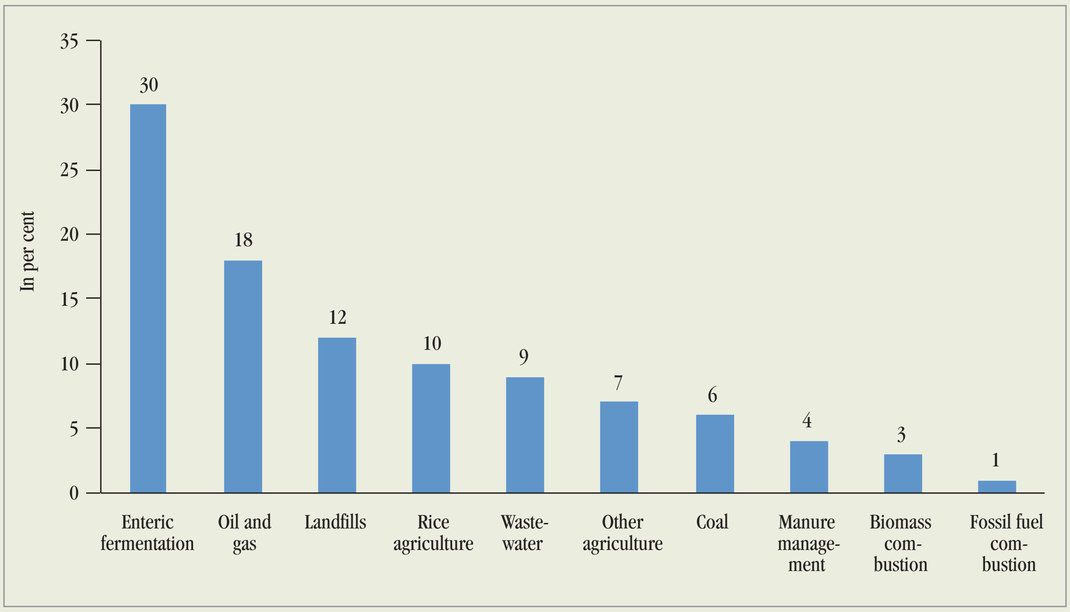
Methane emissions from fossil fuels

Oil and gas

Emissions during production, processing, transmission and distribution of oil and natural gas together accounted for 18 per cent of anthropogenic methane emissions.[7]

* In the last five years, there has been a large increase in global natural gas production due to technological improvements in shale gas extraction, i.e. hydraulic fracturing, or fracking. This has led to an increase in methane emissions, especially from the United States, which accounts for most of the global shale gas extraction.[8]
* Shale gas production, however, has high environmental costs. Studies show that if methane leakages during extraction exceed 3 per cent, shale gas will be more detrimental to the environment than coal.[9]
* Designed operational venting and unintentional fugitive emissions along the natural gas industry's supply chain (pipeline infrastructure) represent product losses that can be avoided using

Figure 3: Contribution of various sources of anthropogenic methane production



Source: Global Methane Initiative, 2012 'Global Methane Emissions and Mitigation Opportunities'

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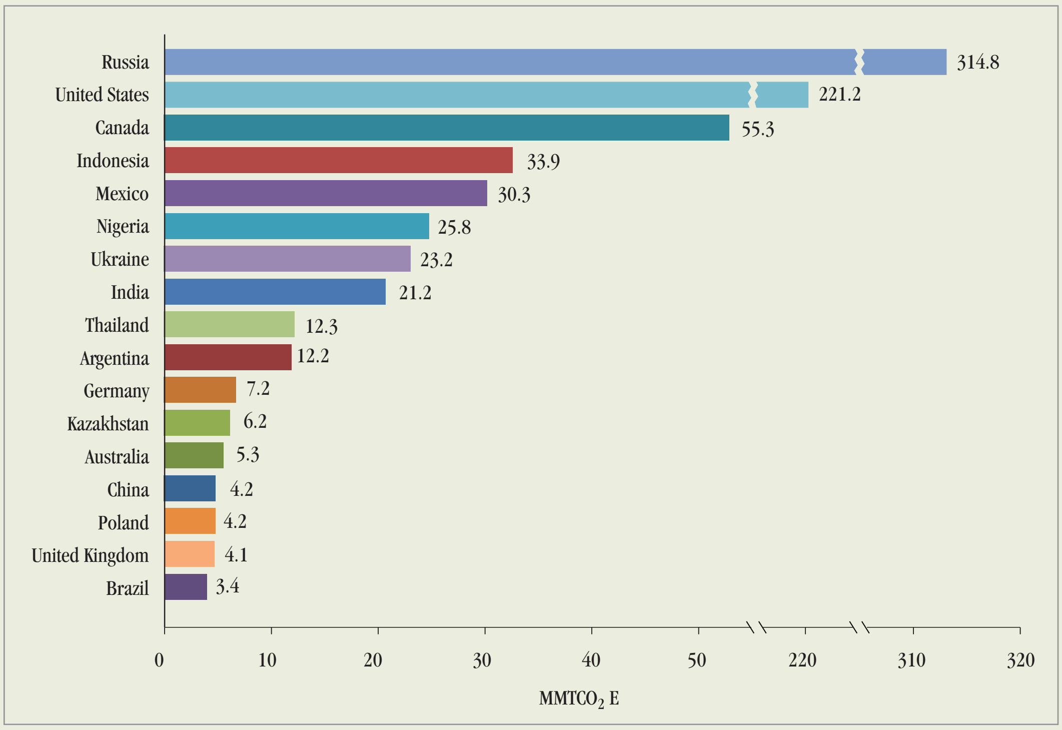
Figure 4: Countries with the highest methane emissions from the oil and gas sector in 2010



Source: Global Methane Initiative, 2012, 'Oil and Gas Systems Methane: Reducing Emissions, Advancing Recovery and Use'

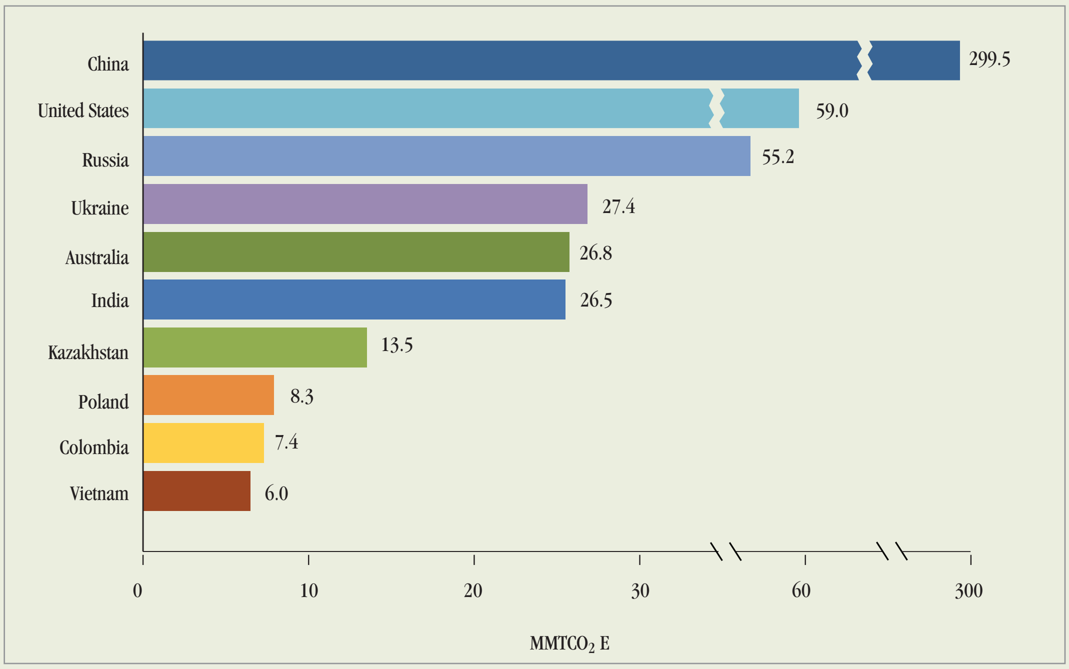
readily available, cost-effective practices and technologies.

- Methane emission reduction projects conserve natural gas, often recover their costs in less than one year and bring about lasting productivity and environmental performance improvements.
- More than 35 per cent of methane emissions from the oil and gas sector can be reduced with expenditures of up to \$15/$MTCO_2$ E (metric tonnes of carbon dioxide equivalent).[10]

Coal

- Methane is emitted during coal mining in active and abandoned (underground and surface) mines, coal

Figure 5: Countries with the highest methane emissions from the coal sector in 2010



Source: Global Methane Initiative, 2012, 'Coal Mine Methane: Reducing Emissions, Advancing Recovery and Use Opportunities'

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processing, storage and transportation.

- Global methane emissions from coal were estimated to be 6 per cent of total global methane emissions.[11]
- The implementation of cost-effective methane abatement initiatives in the coal industry can yield substantial economic (by way of capture and use of coal mine methane) and environmental benefits, such as improved mine safety, greater mine productivity, increased revenues and reduced GHG emissions.
- More than 65 per cent of methane emissions from coal can be reduced with expenditures of up to \$15/MT CO_2 E.[12]

Methane emissions from animal husbandry

The main sources of methane emissions are enteric fermentation and manure management.

Enteric fermentation

- Methane is produced as part of normal digestive processes in animals. During digestion, microbes resident in an animal's digestive system ferment food consumed by the animal. This microbial fermentation process, referred to as enteric fermentation, produces methane as a byproduct, which can be exhaled or eructated by the animal.
- Ruminant animals (e.g., cattle, buffalo, sheep, goats and camels) are the major emitters of methane because of their unique digestive system.
- In general, lower feed quality and/or higher feed intake leads to higher methane emissions.
- Enteric fermentation contributes 30 per cent of global methane emissions. These emissions can be controlled with dietary supplements and changes in feed intake, e.g. increasing intake of oil seeds has been found to reduce methane emissions from enteric fermentation.[13]

Manure management

- Methane is produced during the anaerobic decomposition of manure during collection, handling, storage and treatment.
- The quantity of methane emitted from manure management operations depends on the type of treatment or storage facility, the ambient climate and the composition of the manure.
- When manure is stored or treated in liquid systems such as lagoons, ponds and pits, anaerobic conditions can often develop and the decomposition process results in methane emissions.
- Ambient temperature and moisture content also affect methane formation, with higher ambient temperature and moisture conditions favouring methane production.
- The composition of manure is also directly related to animal types and diets. For example, milk production in dairy cattle is associated with higher feed intake, and therefore higher manure excretion rates than non-dairy cattle.[14]
- Manure management contributes 4 per cent of global methane emissions. These emissions can be controlled with the help of technologies that harness anaerobic digestion (such as biogas plants) to capture methane, which is then used as an additional source of energy.[15]

Methane emissions from landfills and wastewater

Methane is generated from the decomposition of solid biodegradable waste in landfills and from human/animal waste streams. Emissions from landfills and wastewater make up about 21 per cent of global methane emissions.

Landfills

- About 50 per cent of the gas emitted from landfills (landfill gas, LFG) during decomposition of organic matter is methane. The other half comprises CO_2 and other non-methanic organic compounds.
- Disposal rates in emerging economies like India, China and Brazil are increasing, leading to an increase in LFG.
- There is, however, a corresponding trend of improving waste-management practices in these countries, including design and construction of sanitary landfills.
- In addition to being sustainably designed, such landfills have mechanisms to make use of LFG to supplement energy demand in the area.
- Using LFG helps reduce odour and prevents methane from migrating into the atmosphere and contributing to smog and climate change.[16]

Wastewater

- Wastewater from domestic, commercial and industrial sources can also produce methane emissions during handling and treatment.
- Both aerobic and anaerobic wastewater treatment systems lead to the production of substantial amounts of methane emissions.
- Most wastewater treatment mechanisms in developing countries use anaerobic digestion,

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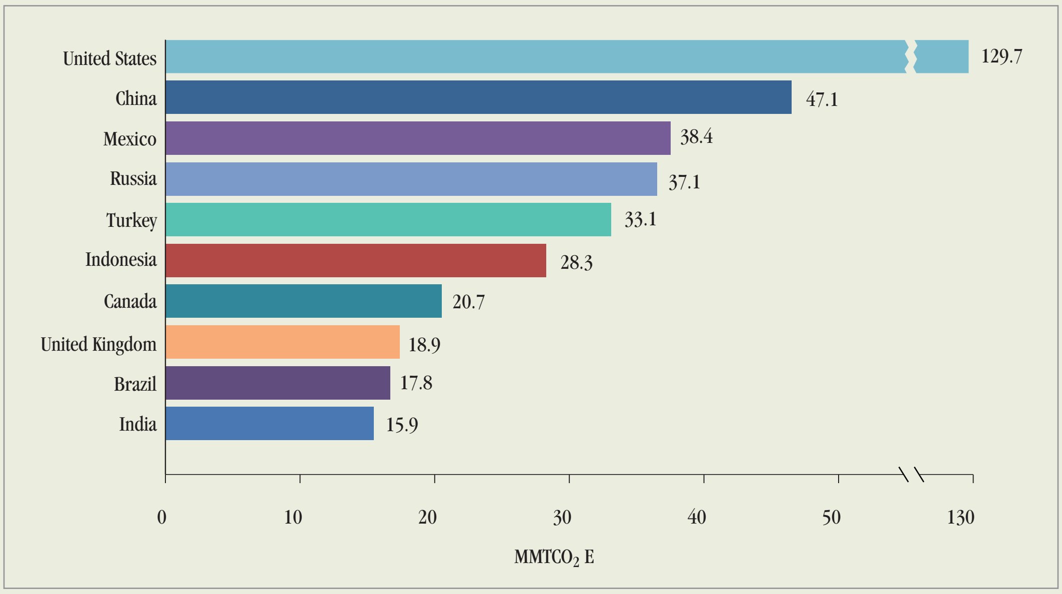
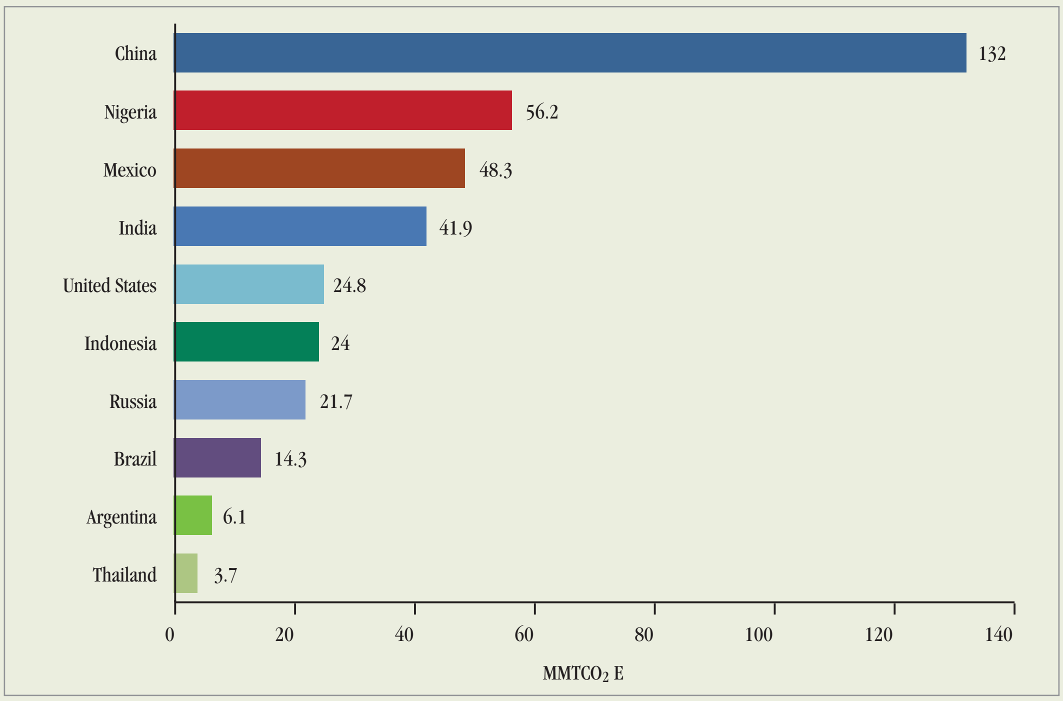
Figure 6: Countries with the highest methane emissions from landfills in 2010



Source: Global Methane Initiative, 2012, 'Landfill Methane: Reducing Emissions, Advancing Recovery and Use Opportunities'

Figure 7: Countries with the highest methane emissions from wastewater in 2010



Source: Global Methane Initiative, 2012, 'Municipal Wastewater Methane: Reducing Emissions, Advancing Recovery and Use Opportunities'

which produce larger amounts of methane.

- Increasing consumption will lead to an increasing need for sustainable wastewater treatment and handling facilities.
- Methane produced from wastewater can be captured and used as a clean source of energy. There are both aerobic and anaerobic technologies available that capture methane produced during treatment and handling of wastewater.
- These technologies can help supplement local energy needs, reduce odour and decrease the migration of methane to the atmosphere.[17]

Methane emissions from rice cultivation

- The flooding of fields during rice cultivation creates ideal environments for the growth of anaerobic methane-producing bacteria. The methane

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produced is emitted into the atmosphere by diffusive transport through the rice plants during the growing season.

- Methane emissions from rice cultivation vary temporally (with time/season) with different soil type and texture, application of organic matter and use of mineral fertilizer.
- The major rice-producing countries are India, China, Thailand, Bangladesh and Vietnam.
- Total emissions from rice production are about 10 per cent of annual global methane emissions.
- These emissions can be reduced by switching from continuous flooding to different intermittent flooding practices (mid-season/alternating/dry), changing tilling practices and changing fertilization mechanisms (using different fertilizers).
- Studies show that switching to dry-land production (i.e. no flooding) provides the largest emissions reductions, though it results in major reductions in rice yield.
- Approximately 60 per cent of total annual emissions in 2030 can be reduced with expenditures of up to \$10/MTCO$_2$e.[18]

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