The Six Greenhouse Gases

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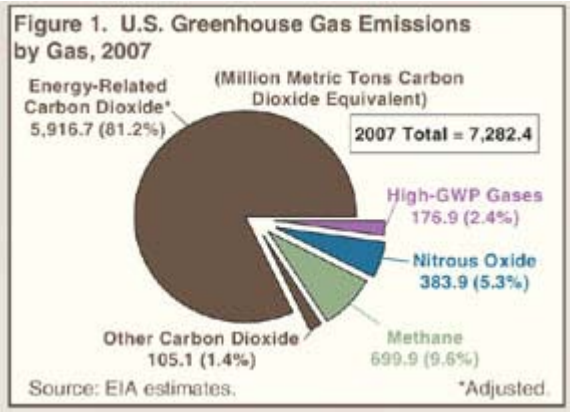
When we think about greenhouse gases, the first one that comes to mind is CO_2 (carbon dioxide). CO_2 is the major contributor to global warming and climate change but there are six greenhouse gases that are followed by the EPA[1] and included in the original Kyoto accord. These six gases are CO_2, CH_4 (methane), N_2O (nitrous oxide), and the three halocarbons, HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF6 (sulphur hexafluoride). While CO_2 is the major greenhouse gas, it is important to understand how the other 5 gases arise and how they contribute to the global warming situation. The global warming potential of all gases is measured in comparison to CO_2. Therefore CO_2 is considered to have a global warming potential of one. When we look at the other 5 gases, we will see that some have a global warming potential (gwp) much higher than CO_2. So while some of these gases may be small in amount, they can have an effect larger than similar amounts of CO_2. When the emissions of each of these six gases are reported, they are adjusted for their impact and given in CO_2 equivalents. The figure below[2] shows how each of these six gases contributed to the more than 7,000 million metric tons of CO_2 equivalents that the U.S produced in 2007



Carbon dioxide (CO2) is the major greenhouse gas and arises from the burning of various fossil fuels such as petroleum, natural gas and coal. These emissions are divided amongst the residential sector (21%), commercial sector (18%), industrial sector (27%) and transportation sector (34%). Efforts at efficiency in these sectors as well as the use of non fossil fuel energy sources such as solar and wind have the opportunity to significantly decrease the CO_2 from fossil fuel utilization.

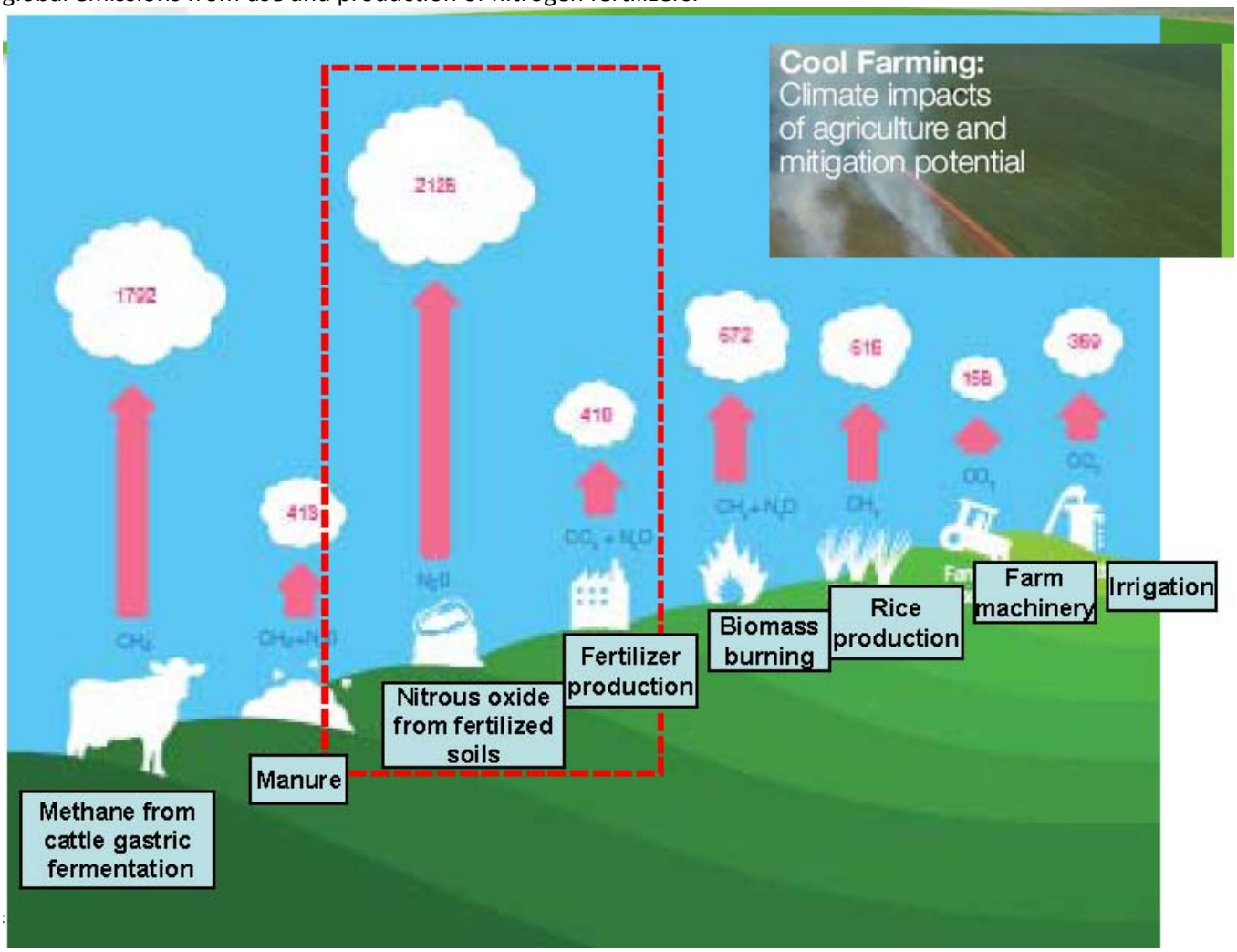
Methane (CH4) has a global warming potential 23 times that of CO_2. Methane arises from three major activities; energy production and transport, animal agriculture and human waste management. Energy activities include the methane that is released during the production of coal, natural gas and oil and account for over 40% of the methane emissions. The second largest contributor to methane is agriculture at 30%. Agricultural methane arises mostly from *in vivo* enteric fermentation (2/3) and management of animal wastes (1/3). The third major contributor to methane production in the U.S. is management of human wastes at 28%. The majority of the methane from human waste comes from landfills, but domestic and industrial waste water treatments also contribute. Looking at the sources of methane allows one to see that efforts at preventing methane release during natural gas production or capturing methane produced in agriculture and human waste management have a large potential, both to reduce total greenhouse gases, but also to provide usable energy.

Nitrous Oxide(N_2O) has a global warming potential 296 times that of CO_2, so it is important to look at the sources of this gas. The sources of human caused nitrous oxide include agriculture, energy use, industrial process and waste management. At 294 MMT CO_2 equivalents/yr, agriculture accounts for over 75% of U.S. nitrous oxide emissions. The

agricultural related N2O emissions oxide are divided between fertilizer usage (~ ¾) and animal waste management (~1/4). Examining the sources of N_2O demonstrates that efforts to more efficiently use nitrogen fertilizers as well as use alternate sources of nitrogen could have both positive effects on ghg emissions as well as limit some of the negative effects of nitrogen runoff into our water.

Halocarbons include three groups of gases, HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF6 (sulphur hexafluoride). They are often called the High GWP gases as their gwp potential can range from several thousand to 22,000 times that of CO_2. These gases can be found in various refrigerants and aerosols and can also be emitted during a variety of industrial processes including aluminum production, semiconductor manufacturing and electric power transmission. Efforts to limit their escape or to use alternatives with less gwp potential are underway and have the possibility to be in place in a fairly short period of time.

It can be edifying to look at one sector and see how the various greenhouse gases contribute to the emissions from that sector. A diagrammatic view of the various emissions from the estimated worldwide agriculture sector is below[3]. Agriculture is a good example because there are significant emissions from CO_2, CH_4 and N_2O. The red box highlights the global emissions from use and production of nitrogen fertilizers.



Sources: 1 http://www.epa.gov/climatechange/emissions/index.html
2 http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html
3 http://www.greenpeace.org/raw/content/international/press/reports/cool-farming-full-report.pdf