Conference Proceedings

Solar World Congress 2015
Daegu, Korea, 08 – 12 November 2015

Estimation of greenhouse gas emission factors for natural gas in Bangladesh

H M Enamul Haque and Himangshu Ranjan Ghosh

Institute of Energy, Dhaka University, Dhaka-1000, Bangladesh

Abstract

Anthropogenic greenhouse gas emissions from fossil fuel burnings are strongly affected by fuel properties, operation procedure, emission control etc. Production of indigenous natural gas is around 23 billion metric tons/year from 120 wells of 19 fields in Bangladesh. At the production sites mole percent of methane in the natural gas varies from 93.50 to 98.00. Gas chromatography study on a sample from a natural gas based electric power station at Ashuganj shows that the fuel have lower heating value of 34.9389MJ/m^3, 96.60 mole percent CH_4, 0.54 mole percent N_2, 0.10 mole percent CO_2 and the rest other hydrocarbons. The average transmission and distribution losses of natural gas over the country is 1.77% and the estimated emission factors for main greenhouse gases are 55.52 gCO_2/MJ, 0.35 gCH_4/MJ and 0.17 gN_2O/MJ. Considering global warming potentials of Intergovernmental Panel on Climate Change 2007 report the equivalent CO2 emission factor for natural gas in Bangladesh is 115.04 gCO_2e/MJ.

Keywords: *Fossil Fuel, Greenhouse gases(GHG), GHG emission factors*

1. Introduction

Energy is a basic requirement for the existence and development of human life. The major percentage of the commercial demand of energy is generally supplied from the fossil fuels (coal, oil and natural gas). The demand for energy is growing at an alarming rate year after year.

Every year Greenhouse gases add to the carbon already present in atmosphere .The power sector is major source of carbon dioxide (CO_2) emission and accounts for about 36 % of the total CO2 emission in the world, 45 % in Asia and 40 % in Bangladesh. The power sector CO_2 emission has been increased at an average annual rate of 8.5 % from 1990 to 2004 in Asia as a whole (Shrestha et al. 2009). Because carbon dioxide is a good absorber of heat radiation coming from the Earth's surface, increased carbon dioxide acts like a blanket over the surface, keeping it warmer than it would otherwise be. With the increased temperature the amount of water vapour in the atmosphere also increases, providing more blanketing and causing it to be even warmer (Houghton, 2009). Due to heat trapping our earth is warming. Earth's average temperature has risen by 1.4°F over the past century, and is projected to rise another 2 to 11.5°F over the next hundred years (USEP online, 2015). The amount of CO_2 emission depends on carbon content of fossil fuel.

CO_2 emissions can be estimated fairly accurately based on the total amount of fuels combusted and the averaged carbon content of the fuels. However, emission factors for methane and nitrous oxide depend on the combustion technology and operating conditions and vary significantly, both between individual combustion installations and over time. Due to this variability, use of averaged emission factors for these gases, that must account for a large variability in technological conditions, will introduce relatively large uncertainties.

2. Methodology

The The IPCC Guidelines (2006) for estimating emissions from fossil fuel combustion estimate carbon emissions in terms of the species which are emitted. During the combustion process, most carbon is immediately emitted as CO_2. However, some carbon is released as carbon monoxide (CO), methane (CH_4) or

© 2016. The Authors. Published by International Solar Energy Society
Selection and/or peer review under responsibility of Scientific Committee
doi:10.18086/swc.2015.07.18 Available at http://proceedings.ises.org

non-methane volatile organic compounds (NMVOCs). Most of the carbon emitted as these non-CO_2 species eventually oxidizes to CO_2 in the atmosphere. The Reference Approach of IPCC 2006 can be used as an independent check of the sectoral approach and to produce a first-order estimate of national greenhouse gas emissions.

The Greenhouse Gas Emissions from stationary combustion can be found from the following equation 1

$$\text{Emission}_{GHG,fuel} = \text{Fuel Consumption}_{fuel} \times \text{Emission Factor}_{GHG,fuel} \quad \text{(equ. 1)}$$

Where:

$\text{Emissions}_{GHG,fuel}$ = emissions of a given GHG by type of fuel (kg GHG)

$\text{Fuel Consumption}_{fuel}$ = amount of fuel combusted (TJ)

To calculate the total emissions by gas from the source category, the emissions as calculated in Equation 1 are summed over all fuels:

$$\text{Emission}_{GHG,fuel} = \sum_{fuels} \text{Emissions}_{GHG,\,fuel} \quad \text{(equ. 2)}$$

The estimation of GHG emission factor from a fossil fuel burning is determined stepwise by estimating the consumption of fuels by fuel/product type, converting the fuel data to a common energy unit (TJ), selecting the carbon emission factors for each fuel/product type to estimate the total carbon content of the fuels, estimating the amount of carbon stores in products for long time, accounting for carbon not oxidized during combustion, converting emissions of carbon to full molecular weight of CO_2 and finally dividing the total estimated CO_2 by the total consumed fossil fuel.

3. Fuel sample collection and testing

Bangladesh produces gas from several different fields, and much of it is merged at the Ashuganj gas metering station (AGMS) before distribution via major trunk lines, some power plant customers, such as those of Jalalabad GasTransmission & Distribution System Ltd., receive gas from upstream of AGMS. Meanwhile,some gas fields feed their supply directly into the gas transmission grid downstream of AGMS. For this reason, the chemical composition, calorific value or other properties available from AGMS,would be more or less precisely for all natural gas combusted in Bangladesh.

On April 29, 2014,one sample of natural gas from Bakhrabad Gas Distribution Company Limited (BGDCL) at Ashuganj Power Station Company Limited (APSCL) has been analyzed at a gas cromotography system at Petroleum and MineralResources Engineering (PMRE) laboratory of the Bangladesh University of Engineering and Technology. The report showed that the sample had a Lower Heating Value (LHV) of 34.9389 MJ/m3Higher Heating Value (HHV) of 38.7536 MJ/m3(with a ideal gas density of 0.0442lb/ft3) as shown in Table 1.

Tab. 1: Chemical composition of Natural gas from BGDCL at APSCL

Gas	Composition	% Volume
Nitrogen	N_2	0.536
Carbon di-oxide	CO_2	0.090
Methane	CH_4	96.603
Ethane	C_2H_6	1.904
Propane	C_3H_8	0.378
i-Butane	C_4H_{10}	0.121
n-Butane	C_4H_{10}	0.085
i-Pentane	C_5H_{12}	0.053
n-Pentane	C_5H_{12}	0.037
Hexane	C_6H_{14}	0.095

Heptane	C_7H_{16}	0.072
Octane	C_8H_{18}	0.027
Nonane	C_9H_{20}	-
Decane	$C_{10}H_{22}$	-
Total		100.00

4. Estimation of GHG emission factor

Carbon dioxide (CO_2) emissions from natural gas combustion result from the release of carbon during combustion. The amount of carbon dioxide (CO_2) emissions are calculatedthrough the combustion Equation 3 of alkanes $C_nH_{(2n+2)}$.

$$C_nH_{(2n+2)} + \frac{3n+1}{2} (O_2 + 3.76\ N_2) \rightarrow n\ CO_2 + (n + 1)\ H_2O + \frac{3n+1}{2} 3.76\ N_2 \qquad \text{(equ. 3)}$$

During combustion process, most carbon is emitted as CO_2immediately. CO_2emission factors for fossil fuel combustion will depend upon the carbon content of the fuel that is inherently chemical property and does not depend upon the combustion process or conditions. In case of perfect and complete combustion, nitrogen can be neglected as there is no NOx creation and no carbon monoxide as well. The GHG is computed in Table 2.

Tab. 2: GHG emission during combustion

Gas	Composition	Amount (g in one mole)	C content (in g)	H content (in g)	N content (in g)	O content (in g)	g CO_2	g N_2O
Nitrogen	N_2	0.090	-	-	0.090	-	-	0.141
Carbon di-oxide	CO_2	0.015	0.004	-	-	0.011	0.015	
Methane	CH_4	16.218	12.164	4.055	-	-	44.600	
Ethane	C_2H_6	0.320	0.256	0.064	-	-	0.938	
Propane	C_3H_8	0.063	0.052	0.012	-	-	0.190	
i-Butane	C_4H_{10}	0.020	0.017	0.004	-	-	0.062	
n-Butane	C_4H_{10}	0.014	0.012	0.002	-	-	0.043	
i-Pentane	C_5H_{12}	0.009	0.007	0.001	-	-	0.027	
n-Pentane	C_5H_{12}	0.006	0.005	0.001	-	-	0.019	
Hexane	C_6H_{14}	0.016	0.013	0.003	-	-	0.049	
Heptane	C_7H_{16}	0.012	0.010	0.009	-	-	0.037	
Octane	C_8H_{18}	0.005	0.004	0.001	-	-	0.014	
Nonane	C_9H_{20}	-	-	-	-	-	-	
Decane	$C_{10}H_{22}$	-	-	-	-	-	-	
		16.79	12.544	4.151	0.090	0.011	45.995	0.141

For each greenhouse gas, a Global Warming Potential (GWP) has been calculated to reflect how long it remains in the atmosphere, on average, and how strongly it absorbs energy. Gases with a higher GWP absorb more energy, per pound, than gases with a lower GWP, and thus contribute more to warming Earth. The global warming potentials of Intergovernmental Panel on Climate Change (IPCC, 2007) are given in Table 3.

Tab. 3: Global Warming Potentials

GHG	GWP
Carbon dioxide	1

Methene	25
Nitrous oxide	298

The average transmission and distribution losses of natural gas over the country is 1.77% (Tital, 2013-2014). Estimated volume of 1 mole Natural Gas is 0.024 m^3 and Heating value of Natural Gas (as per test report) is 0.919 MJ. The estimated emission factors for main greenhouse gases are 55.52 gCO_2/MJ, 0.35 gCH_4/MJ and 0.17 gN_2O/MJ. Considering global warming potentials of IPCC 2007 report the equivalent CO2 emission factor for natural gas in Bangladesh is 115.04 gCO_2e/MJ.

5. Conclusion

Greenhouse gas emission factors for natual gas in Bangladesh are 55.52 gCO_2/MJ, 0.35 gCH_4/MJ, 0.17 gN_2O/MJ and equivalent CO_2 emission factor is 115.04 gCO_2e/MJ.

6. References

Agency, United Stated Environmental Protection, 2015. http://www.epa.gov/climatechange/ghg emissions/index.html

Annual Report, 2013-2014, Titas Gas Transmission and Distribution Company Limited, Dhaka, Bangladesh

Houghton, Sir John, 2009. Global Warming, The Complete Briefing Third Edition, Cambridge university press

IPCC Guidelines for National Greenhouse Gas Inventories, 2006. http://www.ipcc-nggip.iges.or.jp/ public/2006gl/

IPCC Fourth Assessment Report: Climate Change, 2007. www.ipcc.ch/publications

Shrestha, R M, Anandarajah G and Liyanage M H, 2009. Factors affecting CO2 emission from the power sector of selected countries in Asia and the Pacific. Energy Policy, Vol. 37. Page 2375-2384