ESTIMATING EMISSIONS FROM GAS USE AND LEAKAGE

Summary

Base Year: 2008
Atmospheric emissions from gas consumption and gas leakage for the 2008 base year were estimated from the 2007 Middle Layer Super Output Area (MLSOA) level Electricity and Gas Consumption datasets (i.e.,. Gas Consumption Data at Regional and Local Authority Level) produced by Department for Energy and Climate Change (DECC).

Projection Years: 2011 and 2015
The projection factors were derived from a statistical analysis of historical trends (gas consumption data at regional and local authority level from 2001 to 2008) in gas sales from the domestic and industrial-commercial sectors in the Greater London area (using 2008 as the base year).

2008 gas emission estimation methodology

The 2007 gas sales and numbers of customers by region and local authority workbooks were obtained from the Department for Energy and Climate Change (DECC) website: (http://www.berr.gov.uk/energy/statistics/regional/regional-local-gas/page36200.html). DBERR collects and compiles estimates of gas consumption at regional (NUTS1) and local authority levels (NUTS4) using base data at meter point level from the re-structured gas distribution network.

Within each workbook, several worksheets provided details of electricity and gas consumption down to MLSOA level for each LA in the UK. The 2007 datasheets showed electricity and gas consumption data (given in kWh for the entire year) for the Greater London area regarding total consumption, number of meters and average consumption levels for domestic and non-domestic users. Details about how the information on electricity and gas consumption has been collected and collated can be found in "DECC, Guidance Note for Regional Energy Data PUBLICATION URN 09D/608" at http://www.berr.gov.uk/files/file42994.pdf.

DECC's sub local authority gas consumption estimates at MLSOA level in the Greater London area for 2007 were used to estimate atmospheric emissions from gas consumption in the LAEI 2008. In order to produce local gas consumption statistics for 2008 at the 1-km^2 spatial resolution, the gas consumption statistics for each MLSOA was first cleansed, formated and then aggregated to the 1km^2 grid cells using GIS algorithms (i.e., spatial analysis by overlaying the MLSOAs' electricity consumption data with the 2,466 1-km^2 grid cells).Where a MLSOA covered more than one 1-km2 grid cell area, the gas consumption was divided between the relevant grid cells based on the proportion of the area covered by the MLSOA. There were also some circumstances where for confidentiality or other reasons, BERR combined MLSOA data, and each MLSOA was given an equal share of the gas data when

deriving statistics. Furthermore, due to data disclosure issues, gas consumption relating to larger commercial/industrial consumers could not be disaggregated below local authority level, and in some cases data relating to a particular area have been merged with data for nearby areas.

The summarised gas demand data were entered into an Excel spreadsheet containing emission factors for the various sectors (domestic, industrial & commercial and gas leakage). All data entered into the spreadsheet were double checked to ensure data accuracy. Atmospheric emissions are dependent on emission factors, the amounts of gas used and also the temperature and efficiency of combustion, but these latter influencing factors were not directly considered in the LAEI 2008 estimation methodology. The updated 2008 emissions factors (see Tables 1-3), obtained from the UK Emissions Factor Database and maintained by AEA, were used in estimating emissions from the gas demand data.

Below is the formula used for estimating annual atmospheric emissions of a pollutant from gas consumption data in a 1-km^2 grid cell.

$$AE_{p,j} = EF_{s,p} * GC_{s,j} * 10^{-3}$$

Where;

$AE_{p,j}$ = Annual Emission of pollutant p in grid cell j, tonne yr^{-1}

$EF_{s,p}$ = Sector s Emission Factor for pollutant p, kg kWh^{-1}

$GC_{s,j}$ = Sector s Gas Consumption in grid cell j, kWh yr^{-1}

10^{-3} = Conversion factor; kg to tonne

Grid cell j =1km x 1km grid cell

Sector s = Domestic or Industrial-commercial

Pollutant p = CO_2, Methane, NO_X, Hydrocarbons (HC) as NMVOC, CO, Black smoke, Benzene or PM_{10}

Emission factors

Table 1: Industrial-Commercial gas emission factors – 2008

Pollutant	Emission factors	
	Kt mth^{-1} fuel consumed	Kg kWh^{-1}
CO_2	5.41E+00	1.85E-01
Methane	5.27E-05	1.80E-06
SO_2		
NOx	5.60E-03	1.91E-04
NMVOC	2.34E-04	7.95E-06
CO	1.11E-03	3.79E-05
Black smoke	1.06E-05	3.60E-07
Benzene	2.13E-05	7.28E-07
1,3-Butadiene		
PM_{10}	8.06E-05	2.75E-06

Source: AEA, NAEI Emission Factors Database 2007

Table 2: Domestic gas emission factors - 2008

Pollutant	Emission factors	
	Kt mth^{-1} fuel consumed	Kg kWh^{-1}
CO_2	5.41E-00	1.85E-01
Methane	5.27E-04	1.80E-05
SO_2		
NOx	7.30E-03	2.49E-04
NMVOC	2.34E-04	7.97E-06
CO	3.25E-03	1.11E-04
Black smoke	1.05E-05	3.58E-07
Benzene	2.10E-05	7.18E-07
1,3-Butadiene		
PM_{10}	5.27E-05	1.80E-06

Source: AEA, NAEI Emission Factors Database 2007

Table 3: Gas Leakage emission factors – 2008

Pollutant	Emission factors	
	Kt mth^{-1} fuel consumed	Kg kWh^{-1}
CO_2		
Methane	7.70E-01	2.63E-02
SO_2		
NOx		
NMVOC	1.50E-01	5.12E-03
CO		
Black smoke		
Benzene	1.67E-03	5.70E-05
1,3-Butadiene		
PM_{10}		

Source: AEA, NAEI Emission Factors Database 2007

All the 2008 emission factors (with the exception of black smoke[1] and Methane[2]) used in estimating and projecting gas demand, gas leakage and their associated emissions were obtained from AEA. These emission factors were also used for the 2008 UK estimates in the NAEI. The emission factors for SO_2 and 1,3-butadiene are currently not available; thus, the emissions of SO_2 and 1,3-butadiene form gas consumption are currently not available in the LAEI 2008. Most of the gas emission factors used in the LAEI 2008 are considered to be of high reliability as they are based on NAEI/AEA's data.

Emission estimation methodology: 2008 Gas leakage

Gas leakage covers emissions of methane, benzene and NMVOC from the Local Distribution Network in the LAEI study area. Gas leakage to air from a distribution network is dependent on a number of factors including:

[1] Emission factors are from the AEA Report, "UK emissions of air pollution 1970-1994".
[2] Source: UK Emission Factor Database, 2000

- Type and condition of the gas pipeline;
- Pressure in the network;
- Soil permeability;
- Number of service customers; and
- Accidental pipe ruptures by contractors and excavation work

In the Greater London area, the level of gas leakage from the Local Distribution Network (before the gas reaches customer meters) is around 0.65%. Therefore, to calculate the amount of gas leakage (in kWh) in 2008, we simply took each MLSOA that was within the LAEI study area and multiplied its corresponding gas demand (i.e., annual quantities in kWh) value by 0.0065 (i.e., 0.65% of annual quantities in kWh). However, care should be exercised in using and interpreting the amount of gas leakage (in kWh) estimated by this simplified methodology since the gas demand dataset contained gas demand (in KWh) after the gas has reached customers' meters (when most gas leakage from the distribution network would have already taken place at several points along the supply chain). Consequently, the amount of gas leakage estimated by using the aforementioned methodology will be different to the actual amount of gas leaked from the distribution network before the gas reached customers' meters. Furthermore, the inherent limitations in the accuracy of meters used at various points of the chain supply; differences in the methods used to calculate flow of gas in energy terms; differences in temperature and pressure between the various points at which gas is measured; differences in the timing of reading meters; and other losses from the distribution network means that the actual amount of gas leakage in the LAEI area is inevitably subject to large uncertainties.

It was assumed that all natural gas lost from the distribution network would enter the atmosphere. It was also assumed that some gas lost underground might be partially or completely adsorbed by the soil and consumed by bacterial action. However, there were no reliable estimates of the significance of such a process for the distribution network, so it was assumed negligible.

Projection Years: 2011 and 2015

Projections of atmospheric emissions from gas demand and gas leakage were based on an analysis of historical trends in gas sales (obtained from DECC's website – Gas Consumption Data at Regional and Local Authority Level, http://www.berr.gov.uk/energy/statistics/regional/regional-local-gas/page36200.html

The % per annum growth/decay rates in gas demand from the domestic and industrial-commercial sectors in the Greater London area (using 2007 as the base year) were calculated as follows (see Table 4):

For Domestic gas projections to 2011 = -1.8%
For Industrial-Commercial gas projections to 2011 = -2.0%

For Domestic gas projections to 2015 = -7.5%
For Industrial-Commercial gas projections to 2015 = -7.5%

Table 4: Trends in gas sales (GWh) in Greater London and projection factors

Years	Domestic consumers	Commercial and Industrial consumers
	Gas Sales (GWh)	
2001	55,279.14	33,836.01
2002	55,749.34	33,812.69
2003	56,073.73	34,385.62
2004	53,463.09	29,261.52
2005	52,635.33	27,213.85
2006	50,943.40	26,006.73
2007	**49,920.59**	**24,428.74**