EU Emissions Trading Scheme

Guidance to Operators for the Conversion of Natural Gas data to Standard Conditions[1]

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[1] (0^{o}C, 1.01325 bar, as defined within Commission Decision 2007/589/EC - Monitoring and Reporting Guidelines)

Contents

1 Introduction

This guidance is directed at operators who are using the National Inventory regional data to determine the NCV and EF for natural gas (tier 2a for NCV and EF). The aim of the guidance is to assist operators to comply with the MRG 2007 reporting requirements and outlines the approach applied in the development of the Regional Natural Gas Data correction sheet tool provided in the ETS7 Annual Emissions Report form. Operators may use the tool to automate correction of the data or may complete the corrections themselves.

Note: Although this guidance is aimed at natural gas corrections from typical metering conditions, the principles of the calculations set out in Appendix 1 may be applied to corrections for other gases or from other metering conditions.

The Commission Decision 2007/589/EC - Monitoring and Reporting Guidelines Appendix 1 Para 2.3.(i) states:-

"standard conditions' means temperature of 273,15 K (i.e. 0^o C) and pressure conditions of 101 325 Pa defining normal cubic meters (Nm3)."

The National Inventory NCV is determined by normalising the gas to metering conditions which are temperature of 288.15 K (15^oC) and pressure conditions of 101 325 Pa. Gas volumes reported by suppliers are also usually to these same metering conditions.

It is very important that the volume of gas and the NCV used to calculate the CO_2 emissions are determined at the same reference conditions to ensure the correct calculation of the CO_2 emissions.

2 Purpose

The purpose of this guidance is to assist operators who are using the National Inventories regional data to determine the NCV and EF of natural gas to report the volume and the NCV of natural gas at the reference conditions stated in the MRG guidance at the same time ensuring accurate reporting of the CO_2 emissions.

3 Background

Natural Gas, like any other gas is very compressible. So the mass of gas in a given volume will vary depending on the pressure and temperature of the gas. A cubic meter of gas at 1 bar pressure will contain less mass of gas than a cubic meter of gas at 2 bar pressure. When we determine the amount of CO_2 emissions from a cubic meter of natural gas, we need to know the actual mass of gas consumed.

There is a known relationship between the volume, pressure and temperature of gasses. If you decrease the volume of a gas (compress it), the pressure and the temperature will go up. If you know volume (V1), Temperature (T1) and Pressure (P1) of the gas before you compress it and the then measure the Pressure (P2) and Temperature (T2) of the gas after it is compressed, then the we can calculate the new compressed volume (V2). So if we know the volume, temperature and pressure of a gas at any one time, we can calculate what the volume of the gas would be if the temperature and pressure were changed to any other given values.

Most gas meters measure the volume of gas flowing through them. So if we measure the pressure and temperature at the same time, we can determine condition 1 (V1, P1 and T1) as above.

If we know the V1, T1 and P1 in the first condition at the meter, we can calculate the volume in an imaginary second condition (P2, V2 and T2). If we say that the temperature T2 is 288.15 K (15^oC) and the pressure P2 is 101 325 Pa then by using the V1, P1 and T1 data at the meter, we can calculate what the volume V2 would be at the second imaginary condition. This is the volume that is normally reported by the gas suppliers.

A simple example of this is attached as Appendix 3.

The amount of energy available in a gas is dependent on the mass of gas and is usually declared as J per kg (J/kg) However, if the gas is normalised to a known condition, as described above, then the mass of gas in a m^3 is known so the NCV can be declared as the energy in 1cubic meter of natural gas at 15^oC and 101 325 Pa. The NCV as MJ/m^3 is determined for each region and is listed in the National Inventory.

The NCV in the National Inventories is declared as MJ/m^3. There is a statement in the National Inventory for the regional data that states:-

"Data is based on reference conditions of 15^oC (combustion temperature) and 15^oC, 1.01325 bar (metering temperature and pressure)." This metering condition will be referred to as Sm^3 in this document for clarity.

The other condition that will be discussed is the MRG reference to standard conditions (101325 Pa, 0^0C). This MRG standard condition will be referred to as Nm^3 to be consistent with the MRG.

4 Conversion.

4.1 Conversion from Degrees Celsius(C) to Kelvin (K)

The temperatures in the following equations need to be in degrees Kelvin (K). To convert a temperature from degrees C to degrees K we just need to add 273.15 to the degrees C value.

4.2 Conversion from Bar to Pascal

The pressures used in the following equations will be in Pascal's for consistency. To convert Bar (bar) to Pascal (Pa) we need to multiply the bar value by 100,000. If the pressure is in millibars (mbar), then we need to multiply the mbar value by 100.

4.3 Conversion from Gas Volume at metering Conditions

As mentioned above, the MRG requires that gas volumes are reported at the declared standard conditions. They are 273.15K (0^0C) and 101325 Pa.

Gas volumes are usually reported by suppliers at metering conditions, 288.15^0K (15^0C) and 101325 Pa. The National Inventory regional natural gas data is also referenced to the same metering conditions so we need to convert them but we also need to ensure that the CO_2 is correctly reported.

We can use the relationship between volume, temperature and pressure as described previously. If we say the metering condition (Sm^3) is the first condition:-

V1 = volume at metering conditions (gas bill figure),
P1 = 101325 Pa
T1 = 288.15 K (15^0C)

We can then calculate the volume at a new second MRG standard condition (Nm^3):-

V2 = volume at MRG standard condition
P2 = 101325 Pa
T2 = 273.15 K (0^0C)

The calculation is attached as Annex 1 but basically, because the pressures are the same at each condition, they cancel each other out in the formula so V2 is in fact equal to:-

V2 = T2/T1 x V1

$V2 = 273.15^0 K / 288.15^0 K \times V1$.

Which works out at:-

$V2(Nm^3) = 0.9479 \times V1(Sm^3)$

There is one more factor that needs to be taken into account that will effect the conversion factor. That is how easy it is to compressed the gas (the compressibility) This will depend on the composition of the gas itself. The harder it is to compress the gas, the more energy is required so this will have an additional effect on the final pressure and temperature when conditions are changed. This can be calculated and in the case of natural gas it has a minor effect, 0.03%. So to be more accurate the conversion factor is 0.9476 and not 0.9479 as calculated above. The figure of 0.9476 is taken from BS EN ISO 13443:2005 “Natural Gas - Standard Reference Conditions”, Annex A (normative), Table A1.

So to modify the conversion description above accordingly:-

V2(Nm3) = V1(Sm3) x 0.9476

Put more simply:

MRG volume = Metered volume x 0.9476

4.4 Conversion of National Factor NCV to Standard Conditions

As described above, the National Factors NCV is in the units MJ per cubic meter at metering conditions (MJ/Sm^3). We have already determined that to change the metered cubic meters (Sm^3) to standard cubic meters (Nm^3) all we need to do is multiply the Sm^3 by 0.9476. So all we have to do to convert the NCV to MJ per standard cubic meter is multiply the Sm^3 by 0.9476 which is:

$MJ/Nm^3 = MJ / (Sm^3 \times 0.9476)$

which is the same as:

$MJ/Nm^3 = MJ/0.9476(Sm^3)$

So to convert the National Factor NCV to reference the MRG standard condition, we just need to divide the relevant NCV by 0.9476

4.5 Emissions Factor(EF)

The EF in the National Inventory is declared in terms of energy (tCO_2/TJ). If the volume and NCV are converted, then the activity data will be in terms of energy. There is no need to convert the EF as it is already in terms of energy.

5 Example Calculation

5.1 Normal Calculation

The normal calculation for gas volumes referenced metering conditions is as follows:-

Gas Volume = 1000Sm^3
NCV for Eastern Region = 35.4022 MJ/Sm^3
EF for Eastern Region = 56.6906 tCO_2/TJ
OF = 1

tCO2 = 1000Sm3 x 3.54022E-05TJ/Sm3 x 56.5906tCO_2/TJ x 1 = <u>2.003tCO_2</u>

5.2 Converted Calculation

To complete the converted calculation we first need to convert the volume at metering conditions to the volume at standard conditions:-

MRG Standard Cubic meters = 1000Sm^3 x 0.9476 = 947.6Nm^3

We then need to convert the National Inventory NCV:-

NCV (at MRG standard conditions) = 35.4022 MJ/Sm^3 / 0.9476 = 37.3599MJ/Nm^3

We can now do the calculation:

947.6Nm^3 x 3.73599E-5TJ/Nm^3 x 56.5906tCO_2/TJ x 1 = <u>2.003tCO_2</u>

It can be seen that in both calculations, the CO_2 is exactly the same. This will always be the case as we are multiplying part of the equation by a number (Sm^3 x 0.9476) and dividing another part of the equation by the exactly the same number (MJ/0.9476). The only difference between the normal calculation and the converted calculation is the different Gas Volume and NCV values.

N.B. the correction does not impact on the reported emissions, it is purely to ensure consistent reporting in line with the MRG.

6 Gas Volumes Reported at MRG Standard conditions

It is possible that your gas volumes could be reported at the MRG standard conditions. In this case, it is only necessary to convert the National Inventory NCV. If the gas volume has been normalised by your supplier, then the compressibility will have been taken into account. As discussed above the conversion factor from 15^{0}C to 0^{0}C taking compressibility into account is 0.9476.
If the gas volume is reported at MRG standard conditions, then all that is required to convert the relevant National Inventory NCV to reference MRG standard conditions is to divide the relevant NCV by 0.9476.

6.1 Example Calculation

Gas Volume = 947.6Nm^3
NCV = 35.4 MJ/Sm^3
EF = 56.6 tCO_2/TJ
OF = 1

Convert NCV to standard conditions
$3.54E-05 TJ/Sm^3 / 0.9476 = 3.74E-05 TJ/Nm^3$

$tCO_2 = 947.6 Nm^3 \times 3.74E-05 TJ/Nm^3 \times 56.6\ tCO_2/TJ \times 1 = 2.0031 tCO_2$

7 ETS7 Reporting

It needs to be clear exactly how the gas volumes are reported by the gas supplier. If meters are being used, then it also needs to be clear how the meter readings are converted to a metering condition and what the metering temperature and pressure conditions are referenced to. The supplier should be contacted to clarify this issue if it is not already clear.

It is important that the ETS7 report calculations are correct and that the report meets the reporting requirements of the MRG.

In order to meet these requirements, the ETS7 must reflect the gas volume reported to MRG standard conditions and the calculation of the CO_2 emissions must be correct. As shown above, the calculation will be correct if the Gas Volume and National Inventory regional NCV are converted as required.

A flow chart is attached as Appendix 2 to assist with this process.

The calculation example for converting both gas volume and NCV in paragraph 5.2 should be reported in the ETS7 report as shown below.

Type of fuel:	As Required (A/R)		
Sources included	A/R		
Parameter	**Units**	**Data**	**Tier applied**
Activity data (mass/vol.)	Nm3	947.9	A/R
(NCV)*	TJ/Nm3	3.73480E-05	2a
Emission factor	tCO2/TJ	56.5906	2a
Oxidation factor	**no units**	1	1
Emissions	**tCO_2**	2.003	

If you have had to convert both the gas volume and NCV from metering conditions then you can double check for the correct CO_2 emissions by doing both a pre and post conversion calculation and ensure that the resulting CO_2 emissions are the same.

Appendix 1

Conversion Equations

The equations below may be applied to convert from Sm^3 to Nm^3 for any gas without taking account of compressibility. Conversion from differing metering conditions can be achieved by substituting the relevant conditions for T_1 and P_1.

Volume - Conversion from Sm^3 to Nm^3

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Re arrange the formula for V_2

$$V_2 = \frac{P_1 T_2 V_1}{P_2 T_1}$$

P_1 and P_2 are the same so they cancel each other out:

$$V_2 = \frac{T_2}{T_1} \times V_1$$

$$V_2 = \frac{273.15}{288.15} \times V_1$$

$V_2 = 0.9479 \times V_1$

P_1 = pressure at 101 325 Pa
T_1 = temperature at 288.15K (15^0C)
V_1= gas volume at metering conditions (Sm^3)

P_2 = pressure at 101 325 Pa
T_2 = temperature at 273.15k (0^0C)
V_2 = gas volume at standard conditions (Nm^3)

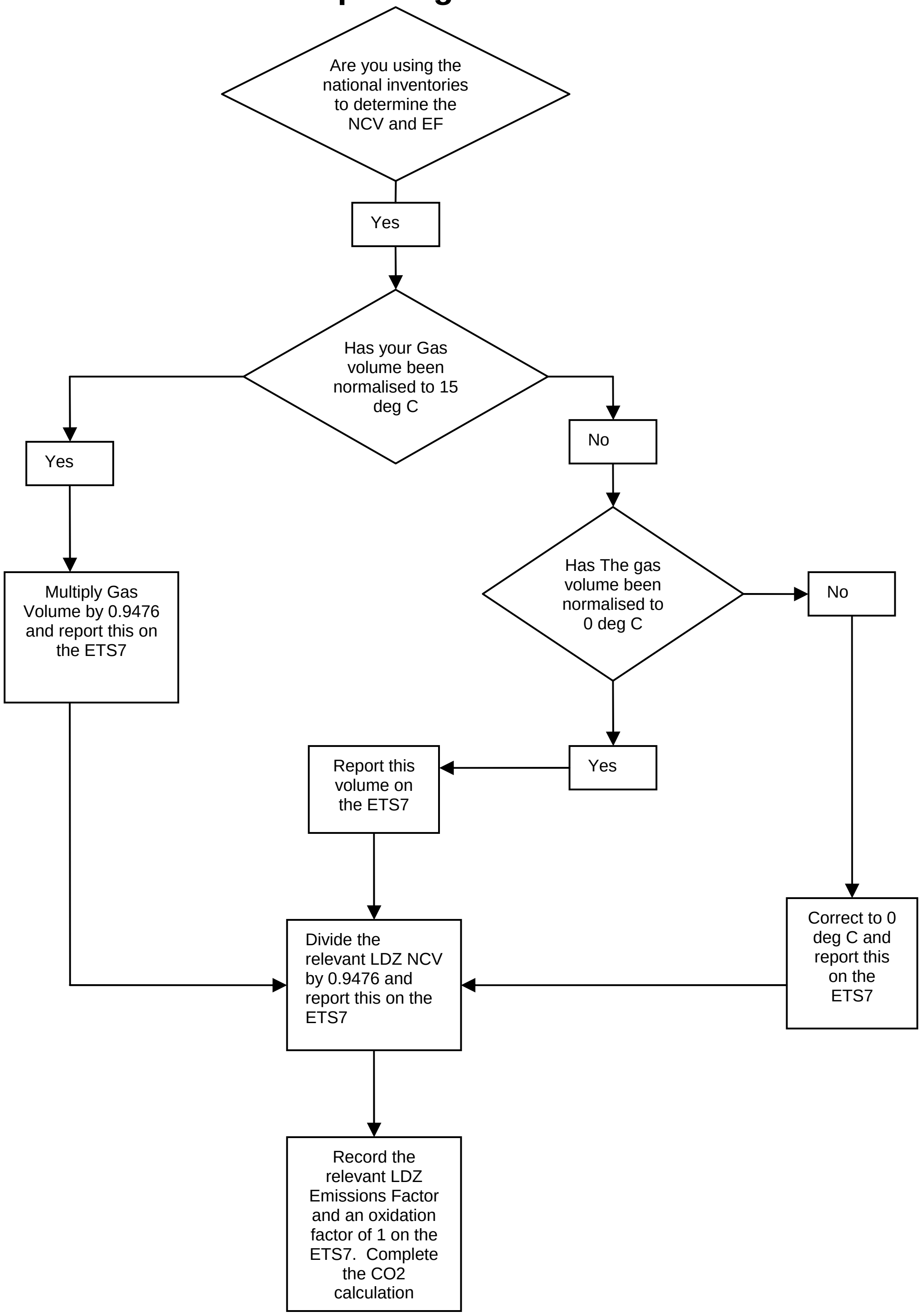
Net Calorific Value - Conversion of NCV at Sm^3 to NCV at Nm^3

$$\text{NCV} = \frac{MJ}{Sm^3} = \frac{MJ}{(Sm^3 \times 0.9479) Nm^3}$$

$$\text{NCV at Nm}^3 = \frac{MJ}{(0.9479) Nm^3}$$

Appendix 2

ETS7 Reporting Flow Chart



Appendix 3

Example of relationship between volume, temperature and pressures

Example of a gas being compressed with pressure and temperature increase

Pressure	1bar
Temp	10 deg C
Volume	1m3

Pressure	2bar
Temp	20 deg C
Volume	?

$$\frac{P1 \quad V1}{T1} = \frac{P2 \quad V2}{T2}$$

$$\frac{1bar \quad 1m3}{283.15K} = \frac{2bar \quad ?}{293.15K}$$

$$V2 = \frac{P1\ V1\ T2}{T1\ P2}$$

$$V2 = \frac{1 \times 1 \times 293.15}{283.15 \times 2}$$

$$V2 = \frac{293.15}{566.3}$$

$$V2 = 0.52 \quad m3$$

Example of a gas being cooled from metering conditions to MRG standard conditions maintaining the same pressure condition.

Pressure	101325Pa
Temp	15 deg C
Volume	1m3

Pressure	101325Pa
Temp	0 deg C
Volume	?

$$\frac{P1 \quad V1}{T1} = \frac{P2 \quad V2}{T2}$$

$$\frac{101325Pa \quad 1m3}{288.15K} = \frac{101325Pa \quad ?}{273.15K}$$

$$V2 = \frac{P1\ V1\ T2}{T1\ P2}$$

$$V2 = \frac{V1\ T2}{T1}$$

$$V2 = \frac{1 \times 273.15}{288.15}$$

$$V2 = \frac{273.15}{288.15}$$

$$V2 = 0.9479 \quad m3$$