BNXS01: Carbon Dioxide Emission Factors for UK Energy Use

Version 4.1

This Briefing Note and referenced information is a public consultation document and will be used to inform Government decisions. The information and analysis form part of the Evidence Base created by Defra's Market Transformation Programme (MTP).

1 Summary

This Briefing Note gives carbon dioxide (CO_2) emission factors for electricity, gas and oil to be used in constructing scenarios for the MTP Sustainable Products Policy Briefs and related work, and sets out the rationale behind them. Other emission factors and the circumstances where their use is appropriate are also identified.

In autumn 2008, MTP moved from using the emission figures stated in the Appendix to those used by Defra in other calculations, as shown in Table 1. This was to give greater consistency between the emission figures and ease comparison.

However, the figures used in the Appendix were used in the published MTP Sustainable Products Policy Briefs, so they are presented as part of their supporting documentation.

2 Defra Guidance on Emissions Data

For direct fuel use (gas, oil, etc), a single CO_2 emissions factor is used, as shown in Table 1.

For UK grid electricity use, the factor used depends on the context of the calculation:

- When reporting emissions on energy use (including projected energy use), MTP uses the emission factors presented in Defra's Environmental Reporting Guidelines for Company Reporting on Greenhouse Gas Emissions[1].
- When appraising emissions-saving policy (ie the avoided emissions due to electricity use being avoided), MTP, consistent with Defra usage, uses a different, marginal factor.

These are both shown in Table 1.

Table 1 Emissions factors used by MTP

Energy source	$kgCO_2/kWh$
Gas	0.185
Oil (domestic only – fuel oil)	0.268
Electricity (use)	0.537*
Electricity (savings - ie marginal)	0.430

3 Other Sources of Emissions Data

For EU emissions trading, separate emissions factors are recommended that relate to net calorific values for fuels [2a].

The World Business Council for Sustainable Development has an ongoing project to produce international methodologies for corporate and project greenhouse gas accounting. The greenhouse gas accounting tools can be accessed at www.ghgprotocol.org.

* latest 5 year rolling average value

Appendix – Emission factors used previously by MTP

NB as this is presented for historical reasons this text has not been substantially edited or updated since May 2008.

1 Introduction

For the MTP Policy Briefs to provide a credible and consistent assessment of the impact of policy actions it is important that the emission factors used to construct the scenarios provide a comprehensive coverage of their carbon impacts. There are currently several sets of CO_2 emission factors that are used by Government (and others) to calculate the CO_2 emitted as a result of using, or saving, a unit of energy[1],[2],[2a][3],[4],[5],[6].

For fossil fuels, differences between published emission factors are generally small whilst the carbon emission factor for electricity will vary considerably depending on the efficiency and fuel mix assumed to be used in its generation. Furthermore, it is recognised that the widespread convention of using the annual system average carbon intensity of grid electricity does not necessarily reflect the effect of a change in the level of demand for electricity. The most appropriate value for estimating policy carbon savings resulting in a reduction in electricity demand is the subject of ongoing debate within Government[7],[8].

2 Carbon Dioxide Emission Factors

Table A1 sets out emission factors for use in constructing scenarios for MTP work. These have been chosen to present a robust assessment of the actual emissions associated with different forms of delivered energy commonly used in the UK. The emission factors are suitable for use with gross[A] delivered energy data, i.e. the quantity that appears on energy bills. The factors quoted in this briefing note are for CO_2: to convert from CO_2 to carbon, CO_2 figures should be multiplied by 12/44, this being the ratio of the molecular weights of CO_2 and carbon (carbon: 12, oxygen: 16, CO_2: 44).

Table A1: Emission conversion factors previously used in constructing scenarios for MTP work

FUEL	GAS	OIL	ELECTRICITY	
SECTOR	ALL SECTORS	DOMESTIC ONLY	ALL SECTORS	
			CONSUMPTION	SAVINGS
YEAR	$kgCO_2/kWh$	$kgCO_2/kWh$	$kgCO_2/kWh$	$kgCO_2/kWh$
1970	0.264	0.265	1.069	N/A
1971	0.204	0.265	1.037	N/A
1972	0.199	0.265	1.022	N/A
1973	0.195	0.265	1.012	N/A
1974	0.193	0.265	0.972	N/A
1975	0.192	0.265	0.976	N/A
1976	0.191	0.265	0.947	N/A
1977	0.191	0.265	0.947	N/A
1978	0.191	0.265	0.914	N/A
1979	0.191	0.265	0.947	N/A
1980	0.191	0.265	0.943	N/A
1981	0.191	0.265	0.932	N/A
1982	0.191	0.265	0.889	N/A
1983	0.191	0.265	0.868	N/A
1984	0.191	0.265	0.828	N/A
1985	0.191	0.265	0.832	N/A
1986	0.191	0.265	0.824	N/A
1987	0.191	0.265	0.814	N/A
1988	0.191	0.265	0.774	N/A
1989	0.191	0.265	0.752	N/A
1990	0.191	0.265	0.770	N/A
1991	0.191	0.265	0.716	N/A
1992	0.191	0.265	0.684	N/A
1993	0.191	0.265	0.608	N/A
1994	0.191	0.265	0.590	N/A
1995	0.191	0.265	0.550	N/A
1996	0.191	0.265	0.510	N/A
1997	0.191	0.265	0.515	N/A
1998	0.191	0.265	0.518	N/A
1999	0.191	0.265	0.481	N/A
2000	0.191	0.265	0.518	N/A
2001	0.191	0.265	0.540	N/A
2002	0.191	0.265	0.523	N/A
2003	0.191	0.265	0.547	N/A
2004	0.191	0.265	0.543	N/A
2005	0.191	0.265	0.548	N/A
2006	0.191	0.265	0.543	N/A
2007	0.191	0.265	0.537	N/A
2008	0.191	0.265	0.531	0.569
2009	0.191	0.265	0.525	0.557
2010	0.191	0.265	0.520	0.546
2011	0.191	0.265	0.510	0.533
2012	0.191	0.265	0.500	0.520
2013	0.191	0.265	0.491	0.511
2014	0.191	0.265	0.481	0.498
2015	0.191	0.265	0.471	0.486
2016	0.191	0.265	0.462	0.480
2017	0.191	0.265	0.452	0.471
2018	0.191	0.265	0.442	0.465
2019	0.191	0.265	0.433	0.456
2020	0.191	0.265	0.423	0.450

The fossil fuel and electricity consumption emission factors were developed as proposed replacements for the 2005 SAP emission factors[6], which are in turn based on source emission factors from the most recent National Atmospheric Emissions Inventory Annual Report[2] and energy consumption and gross calorific value data for 2003 from the 2006 Digest of UK Energy Statistics[9]. They include upstream emissions from extracting, processing and distributing energy to the final user, but do not include emissions associated with transportation of fuels. The electricity saving emission factor is based on the average of the marginal generation plant and expected new generation plant. In this version of the briefing note the electricity emission factors have been revised in the light of more recent BERR electricity generation mix projections [10].

3 Gas Emission Factors

The gas emission factor is for all gas delivered via the national transmission system in 2003. It is appropriate to use this value for all years as the carbon content and calorific value of gas are unlikely to change significantly. Although it is possible that upstream emissions for delivered gas may change, as these only make up a small proportion of the total carbon impact, changes here will have only a small impact on the overall emission factor.

4 Oil Emission Factors

The emission factor for oil use in the domestic sector is the average for the mix of petroleum products (excluding LPG) used in that sector in 2003[B]. Like gas, the same value is used for all years.

5 Electricity Emission Factors

For electricity supplied in the UK via the public distribution system two different emission factors are needed:

- an emission factor for electricity consumption (the system average value),
- an electricity saving emission factor (the marginal carbon intensity).

The consumption emission factor is suitable for monitoring and reporting on CO_2 emissions based on actual or predicted energy consumption (Carbon Accounting). The savings emission factor is appropriate for assessing the CO_2 reduction that a particular (policy) action will achieve.

5.1 Electricity Consumption Emission Factors

The emission factor for electricity consumption is the system average value for the grid for years to 1970, based on actual data, whilst the electricity consumption factors for future years are based on projected fuel mix. The electricity consumption emission factors used for 2006 and beyond are based on the most recent BERR energy projections (for the central price, central carbon savings estimate published in May 2007[10]) increased by 13% to take account of transmission and distribution losses[D]. The BERR energy projections and therefore the future electricity consumption emission factors are based on a number of other assumptions that may or may not turn out to be correct. The electricity related carbon conversion figures in

Table 1 are therefore subject to regular review as new evidence about future developments in electricity generation becomes available.

5.2 Electricity Saving Emission Factors

It is widely recognised that the system average emission factor is not necessarily appropriate for calculating the impact of reduced electricity demand because the power stations that will be typically switched off in the short term, or not built in the long term, in response to a reduction in electricity demand are likely to be very different from the typical mix of power stations operating today. To accommodate this we use a marginal emission factor to calculate carbon reductions from policy actions that result in electricity savings. There is still debate about what is the most appropriate value for this in future years, and in particular the relative importance of the long and short term impacts for various policies and programmes[7],[8] so for the purpose of developing the MTP Sustainable Product Policy Briefs, a value that is the average of the long and short term impacts has been adopted.

The long term marginal emission factor (new plant avoided) is based on the mix of new build plant from the BERR central fossil fuel price/central carbon savings estimates. This gives a mix of 50% combined cycle gas turbine, 18% coal fired plant, with the remainder coming from renewable sources and imports[E] which gives a value of 0.105 kgC/kWh once transmission losses are taken into account[F]. However, it is clear that short term impacts (plant not run) will also have a significant impact over this timescale. So the long term (plant avoided) emission factor is combined with the short term marginal emission factor which is based on electricity supply modelling work carried out for Defra (SEP) and the Carbon Trust.

The short term emission factors that are presented here are based on updates of this earlier work[7],[8] which have not yet been published[G] and represent the marginal change than would occur for a 2% decrease in demand. These short term marginal emission factors have been adjusted to reflect the difference in the projected generation system between the most recent and the earlier DTI energy projection which this analysis was based on, and also to take account of transmission loses[11]. To approximate for these changes an adjustment has been made to the short term marginal emission factor based on the ratio of system average emission factors given in the 2007 and 2000 BERR energy projections.

6 Using electricity carbon emission factors to construct MTP scenarios and policy briefs

For developing the MTP Sustainable Products Policy Briefs, the consumption (or accounting) emission factor is used to construct the Reference Case, whilst the savings emission factors is used to calculate the CO_2 savings from policy actions which are then subtracted from the Reference Case.

Example:
For a sector which is expected to consume 20 TWh of electricity in 2010 under the Reference Case then the CO_2 emissions will be:

20 TWh * 0.520 kgCO_2/kWh = 10.4 Million tonnes CO_2 pa

If identified policy actions were expected to results in electricity savings of 4 TWh in that sector in 2010 then emissions from the Policy Scenario will be:

= (20 TWh * 0.520 kg CO_2/kWh) - (4 TWh * 0.546kg CO_2/kWh)
= 8.216 Million tonnes CO_2 pa

Notes

[A] Gross energy data are inclusive of the energy used to evaporate the water produced during the combustions process and any already present in the delivered fuel.
[B] 94% burning oil (28 SEC), 6% gas oil (35 SEC) from the Digest of United Kingdom Energy Statistics [9].
[C] Average of published CL (central growth, low energy prices) and CH (central growth, high energy prices) scenarios.
[D] Based on the ratio of electricity generation:supply in 2005.
[E] It is recommended that this assumption be reviewed regularly, and particularly if any decision taken to build new nuclear power stations.
[F] This is based on the average efficiency of CCGT and coal plant in 2005 and assumes zero carbon emissions from renewable and other generation plant.
[G] These differ in that the earlier modelling work derived short term emission factors from a model constructed using half hourly data on the marginal plant used to generate electricity in 1997 and the published unconstrained merit order. Whereas the more recent work uses half hourly data on all plant generating electricity in 2000 and constructs the merit order from annual plant loads.
[H] British Electricity Trading and Transmission Arrangements

References

[1] Guidelines to Defra's Greenhouse Gas Conversion factors for Company Reporting, updated June 2008 from http://www.defra.gov.uk/environment/business/envrp/pdf/ghg-cf-guidelines2008.pdf
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[2a] Carbon Emission Factors and Calorific Values from the UK Greenhouse Gas Inventory (Netcen, 2006) to Support the EU ETS from http://www.defra.gov.uk/environment/climatechange/trading/eu/permits/index.htm
[3] The Government's Standard Assessment Procedure for Energy Rating of Dwellings 2005 EDITION from http://projects.bre.co.uk/sap2005

[4] The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, Revised Edition from http://www.ghgprotocol.org/
[5] Emission factors for SAP based on 2001 data, from http://projects.bre.co.uk
[6] Updated emissions factors for SAP, from http://projects.bre.co.uk
[7] BRE Client Report to Defra/The Carbon Trust, Evaluation of Carbon Savings from Reduced Electricity Demand, CR 211 730, 2003.
[8] E.R. Hitchin and C.H. Pout, The carbon intensity of electricity: How many kgC per kWe?, Building Serv.Eng. Res. Technol. 23,4 (2002), (Also presented at CIB/CIBSE International Conference:Climate Change and the Built Environment, UMIST, April 2002).
[9] Digest of United Kingdom Energy Statistics, DTI, National Statistics, 2006.
[10] Updated energy and carbon projections – The Energy White Paper, May 2007, http://www.berr.gov.uk/files/file39580.pdf
[11] Energy Projections for the UK, Energy Paper 68: Energy Use and Energy Emissions of Carbon Dioxide in the UK 2000-2020, DTI the Stationery Office, 2000, ISB 0 11 5154965

Related MTP information

None.

Changes from version 3

Different emission figures. Previous figures moved to Appendix

Consultation and further information

Stakeholders are encouraged to review this document and provide suggestions that may improve the quality of information provided, email **info@mtprog.com** quoting the document reference, or call the MTP enquiry line on +44 (0) 845 600 8951.

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