The Greenhouse Gases Sub-Objective

TAG Unit 3.3.5

April 2011

Department for Transport

Transport Analysis Guidance (TAG)

Contents

1 The Greenhouse Gases Sub-Objective

1.1 Introduction

1.1.1 The Climate Change Act 2008 creates a new approach to managing and responding to climate change in the UK. At the heart of the Act is a legally binding target to reduce the UK's greenhouse gas emissions to at least 80 per cent below 1990 levels by 2050, to be achieved through action at home and abroad. To drive progress towards this target, the Act introduces five year "carbon budgets", which define the emissions pathway to the 2050 target by limiting the total greenhouse gas emissions allowed in each five year period, beginning in 2008.

1.1.2 The first three carbon budgets were announced in April 2009, covering the periods 2008–12, 2013–17 and 2018–22. They require emissions reductions of just over 22 per cent, 28 per cent and 34 per cent respectively below 1990 levels, and are in line with the recommendations of the Committee on Climate Change. Each sector must play its part in taking action to achieve these budgets.

1.1.3 It is therefore important that the impacts of proposed transport interventions on greenhouse gas emissions - whether they are increased or decreased - are incorporated within the cost benefit analysis in a consistent and transparent way. This TAG Unit explains how this can be done.

1.2 Calculating the greenhouse gas impact of the transport intervention

1.2.1 The first stage of the process is to assess the impact of the proposed intervention on greenhouse gas emissions, taken here to predominantly be carbon (equivalent) emissions. This is done by calculating relevant emissions under a 'without scheme' scenario and a 'with scheme' scenario[1] and calculating the difference.

1.2.2 In principle, this assessment should consider all greenhouse gas emissions, including those resulting from the production of materials used in any infrastructure for example cement, steel etc. (otherwise known as embedded carbon),as well as those resulting from changes to the use of transport fuels. However, there are proportionality issues and practical difficulties in reliably and consistently estimating non-carbon greenhouse gas emissions and embedded carbon emissions. Therefore, at this stage, no assessment of these emissions is required[2]. However, given the potential significance of these emissions in some cases, accounting for these emissions will be considered further for future editions of this TAG Unit. In the interim, such impacts could be qualitatively noted where possible. Carbon (equivalent) emissions from changes to transport fuels only are required to be considered in the detailed appraisal at this stage.

1.2.3 Although we focus on carbon (equivalent) emissions, it is recognised that relevant emissions may be expressed in terms of carbon equivalent (Ce) or carbon dioxide (CO_2e) For the purposes of these calculations, it has been assumed that all carbon present in transport fuel will be released via the emission of carbon dioxide, whereas in reality, some of the carbon will be released as particles or hydrocarbons. For emissions expressed in tonnes of carbon (Ce), they can be converted into CO_2e by

[1] The 'with scheme' term is being used in place of what was referred to as the 'do-something' scenario. The 'without scheme' term is being used in place of what was referred to as the 'do-minimum' scenario.
[2] Some carbon intensive sectors, such as cement, are included in the EU ETS; therefore, where materials are sourced from these sectors their carbon emissions would already be 'internalised' so are therefore implicitly accounted for.

multiplying by the factor $^{44}/_{12}$ [3]. Care must be taken to ensure the units under consideration are clear and consistent within the appraisal calculations and reporting.

1.2.4 The emissions calculation should be done for each year of the appraisal period. Where information for any of the years is not available, emissions should be estimated for a number of modelled years and interpolation and extrapolation techniques used to extend estimates of the change in carbon (Ce) emissions across the whole appraisal period. **Cost Benefit Analysis (TAG Unit 3.5.4)** describes the factors that should be considered when interpolating between modelled years and extrapolating beyond the last modelled year. It is important that the assumptions used to extrapolate and interpolate modelled estimates of the change in emissions across the whole appraisal period are consistent with those used for other economic benefits (e.g. changes in vehicle operating costs).

1.2.5 The monetary value of changes to relevant carbon (Ce) emissions should also be calculated. The methodology for carrying out this process is presented below.

1.2.6 Where a scheme impacts upon emissions from more than one transport mode, the net change in carbon (Ce) emissions for impacts on each mode should be estimated. That is, the difference between the sum of emissions from each mode in the 'with scheme' scenario and the sum of emissions from each mode in the 'without scheme' scenario should be estimated for each year. The appropriate monetary values can then be applied to these differences to derive the money value of the net impact of the scheme on emissions from each mode.

1.3 Methodology for Plans and Strategies - Calculation of Carbon (equivalent) Emissions

1.3.1 The amount of fuel consumed, and therefore the amount of carbon (Ce) emissions per vehicle kilometre varies considerably by vehicle type. Therefore, for both road and rail schemes, predictions of emissions will be more accurate the more disaggregated is the data on traffic flow by vehicle type. For example, for rail, data disaggregated by individual train types will lead to more accurate estimates of emissions. Similarly for roads, more disaggregated data on traffic flow by vehicle type (e.g. car, light goods vehicle, rigid HGV, articulated HGV and coaches/buses) will lead to more accurate estimates. Grossly aggregated data can lead to significant errors and expert opinion may be required in order to determine the validity of any conclusions drawn from numerical differences in calculated emissions.

1.3.2 The requirements for documenting and assessing results for both road and rail schemes and the assessment can by found in section 1.5.

Roads

1.3.3 As noted in para 1.2.2, at this stage, due to the limited availability of evidence, the Department's guidance on estimating changes in carbon (Ce) emissions on roads focuses primarily on changes in emissions associated with changes in fuel consumption. The COBA and TUBA appraisal programs now use estimated changes in fuel consumption to produce estimates of carbon (Ce) emissions and the present value of their monetary value as an automatic output. The section below describes the process used in these programs.

[3] This factor represents the adjustment for the mass of the attached oxygen atoms, i.e. the factor will reflect the ratio of the atomic weights of the constituent elements. The atomic weight of carbon is approximately 12 while the atomic weight of CO_2 is approximately 44.

1.3.4 Fuel consumption is estimated using the formula given in **Values of Time and Operating Costs (TAG unit 3.5.6)**. The amount of fuel consumed by different vehicle types - expressed in litres per kilometre travelled - is approximated as a function of average speed in kilometres per hour (km/h).

1.3.5 As suggested above, to calculate the level of carbon (Ce) emissions in each year in the 'with scheme' and 'without scheme' scenarios, the appraiser/model first needs to estimate fuel consumption for each year in the appraisal period for both scenarios, distinguishing between petrol and diesel fuel usage.

1.3.6 Once fuel consumption has been estimated, this can be converted into carbon (Ce) emissions by multiplying by the grammes of carbon (Ce) estimated to be released from burning one litre of petrol or diesel. This is calculated by multiplying carbon (Ce) content (grammes of carbon (Ce) per gramme of fuel) by the density of the fuel (grammes per litre). The figures for 2005/6/7 are broadly in line with DECC estimates published in 'Digest of UK energy statistics' (DUKES) (a slight difference in the petrol carbon content figures may be due to the blending of butane with petrol). Note that Table 1 is presented in terms of carbon (Ce units) - to convert to carbon dioxide, a factor of 44/12 should be used.

1.3.7 To convert fuel used into carbon (Ce) emissions, Table 1 below shows the estimated grammes of carbon (Ce) released from burning a litre of fuel. The emissions provided in the table are on a combustion basis, not a lifecycle basis. In other words, they do not currently include emissions from the production of biofuels. Biofuels are considered to produce zero emissions when combusted, as the carbon released in combustion is offset by the carbon absorbed as the biofuel feedstock was grown. Research is being commissioned to understand the full lifecycle emissions of biofuels used in the UK, so the figures below may be revised in the future in line with further research to include lifecycle emissions. However, they currently only cover the combustion stage of the biofuel lifecycle, where emissions are zero

1.3.8 For 2005, 2006 and 2007 the figures for conventional petrol and diesel fuel are assumed constant. From 2008 to 2020, the figures will change to reflect the introduction of biofuels.[4] The Renewable Transport Fuel Obligations order 2007 (RTFO) came into effect in April 2008 and requires fuel suppliers to ensure that by 2014, 5% of their total aggregate fuel sales for UK road transport is made up of renewable fuels. Therefore it is estimated that the introduction of biofuels over the period 2007 to 2013 (which involves blending biofuels with conventional fuel) will result in a reduction in the grammes of carbon (Ce) released per litre of fuel burnt. The level of Obligation has been set as follows: In 2008/09 biofuels were 2.5% of existing fuel, rising to 3.25% in 2009/10, 3.5% in 2010/11, 4% in 2011/12, 4.5% in 2012/13 and then 5% in 2013/14 and this is reflected in the figures in Table 1.

[4] The irregularity of emissions reductions from 2007 to 2010 is due to two details in the RTFO. One is that the increase in percentage obligation is not constant from year to year. The second is due to the RTFO compliance mechanisms. Table 1 is presented in calendar, not financial years, as the EU Renewable Energy Directive which requires the use of biofuels in transport requires 10% of transport energy to be from renewable sources by December 2020. Transport appraisal operates on a calendar year basis, so Table 1 is suitable for use in transport appraisal.

Table 1: Carbon emissions per litre of fuel burnt

Year	Emissions from petrol/bioethanol blend (gCarbon/litre)	Emissions from diesel/biodiesel blend (gCarbon/litre)
2005/6/7	637.91	719.73
2008	632.18	694.91
2009	619.64	699.00
2010	620.18	699.82
2011	614.73	693.82
2012	610.36	688.64
2013	607.09	684.82
2014	606.27	684.0
2015	606.27	684.0
2016	606.27	684.0
2017	606.27	684.0
2018	606.27	684.0
2019	606.27	684.0
2020 and	606.27	684.0

1.3.9 The energy content of biofuels is lower than for conventional fuels so more volume of fuel will be needed to travel the same distance as the blend of biofuel increases. This effect is taken account of in the assumed vehicle fuel efficiency values given in **TAG Unit 3.5.6 Values of Time and Operating Costs.**

1.3.10 Having calculated the carbon (Ce) emission levels for each year, the change between the ‘with scheme’ and ‘without scheme’ scenarios for each year can be calculated.

1.3.11 The estimated level of carbon (Ce) emissions for each of the years in the appraisal period is used for the monetary valuation exercise, where a net present value (NPV) of the change in carbon (Ce) emissions over the appraisal period is derived. This process of deriving the NPV from carbon emissions will be described in the following section.

Rail

1.3.12 The data with regard to the emissions associated with the running of diesel and electric trains is at present limited. DfT is currently developing new emission factors by stock type but these will not be available before March 2011. In the interim, practitioners should use their own information about emission factors if they have any available that is robust, and make this evidence clear in the supporting written documentation. If no robust data is available, advice should be sought from the Department for Transport.

1.3.13 To assess the carbon (Ce) implications of rail, the appraiser needs to estimate the emissions for the 'with scheme' and 'without scheme' scenarios for each year and the

change in carbon (Ce) emissions over the appraisal period. The process of deriving the NPV of the change in carbon emissions will be described in the following section.

1.4 Valuing greenhouse gas emissions in transport scheme appraisals

1.4.1 The next stage is therefore to convert the volume of relevant emissions into a monetary value, and calculating a net present value (NPV) over the appraisal period. The Department for Energy and Climate Change (DECC) in June, 2010 published 'Valuation of Energy Usage and Green House Gas Emissions for Appraisal and Evaluation'. This provides guidance on a new methodology for carbon valuation in UK policy appraisal based on the estimated abatement costs per tonne of carbon dioxide equivalent to achieve the government's emissions targets.

1.4.2 As shown in Table 2, the value placed on carbon emissions depends on the sector in which they are emitted. The 'traded sector' values are used for all relevant emissions from those sectors that are included within the Emissions Trading System (ETS) (primarily emissions associated with electricity generation and energy-intensive industry, though aviation will be included after 2012). These carbon values are based on expected EU ETS allowance prices because such prices reflect the abatement costs in those sectors**.**

1.4.3 For emissions in the non-traded sectors (i.e. all other sectors that are not in the ETS), the appropriate carbon values for use in appraisal are those shown in Table 2 as 'non-traded' values. These are estimated by the target-consistent marginal abatement costs consistent with the Government's commitments on greenhouse gas emissions.

1.4.4 Carbon values are provided as far as 2100, as well as higher and lower estimated values for use in sensitivity analysis. The traded and non-traded carbon values differ initially but converge towards 2030, the date from which they are assumed to become equal and subsequently follow the same trajectory. The convergence of the traded and non-traded values is based on the assumption that there will be a functioning global carbon market by 2030. It should be noted that the carbon values presented in Table 2a and Table 2b have been converted into 2002 prices to be consistent with other values presented in this guidance. The DECC guidance was published using 2009 prices. In addition, the values have been presented per tonne of carbon (Ce) using the appropriate conversion factor in order to be consistent with TUBA and COBA emissions outputs (DECC guidance is presented in terms of CO2e)

Table 2a: Traded and Non Traded Values, £ per Tonne of Carbon for use in Appraisal (2010-2050) expressed in 2002 prices

	Traded			Non traded		
Year	Low	Central	High	Low	Central	High
2010	22.09	42.56	53.87	78.26	156.52	234.78
2011	22.42	43.20	54.68	79.43	158.87	238.30
2012	22.76	43.85	55.50	80.63	161.25	241.88
2013	23.10	44.50	56.33	81.84	163.67	245.51
2014	23.44	45.17	57.18	83.06	166.13	249.19
2015	23.79	45.85	58.04	84.31	168.62	252.93
2016	24.15	46.54	58.91	85.57	171.15	256.72
2017	24.51	47.23	59.79	86.86	173.71	260.57
2018	24.88	47.94	60.69	88.16	176.32	264.48
2019	25.25	48.66	61.60	89.48	178.97	268.45
2020	25.63	49.39	62.52	90.82	181.65	272.47
2021	33.67	65.65	88.06	92.34	184.68	277.02
2022	41.70	81.90	113.59	93.85	187.70	281.56
2023	49.73	98.15	139.13	95.37	190.73	286.10
2024	57.77	114.40	164.67	96.88	193.76	290.64
2025	65.80	130.66	190.20	98.39	196.79	295.18
2026	73.83	146.91	215.74	99.91	199.81	299.72
2027	81.86	163.16	241.28	101.42	202.84	304.26
2028	89.90	179.42	266.81	102.93	205.87	308.80
2029	97.93	195.67	292.35	104.45	208.90	313.35
2030	105.96	211.92	317.89	105.96	211.92	317.89
2031	115.80	231.60	347.40	115.80	231.60	347.40
2032	125.64	251.28	376.92	125.64	251.28	376.92
2033	135.48	270.96	406.44	135.48	270.96	406.44
2034	145.32	290.64	435.96	145.32	290.64	435.96
2035	155.16	310.32	465.48	155.16	310.32	465.48
2036	165.00	330.00	494.99	165.00	330.00	494.99
2037	174.84	349.68	524.51	174.84	349.68	524.51
2038	184.68	369.35	554.03	184.68	369.35	554.03
2039	194.52	389.03	583.55	194.52	389.03	583.55
2040	204.36	408.71	613.07	204.36	408.71	613.07
2041	214.20	428.39	642.59	214.20	428.39	642.59
2042	224.03	448.07	672.10	224.03	448.07	672.10
2043	233.87	467.75	701.62	233.87	467.75	701.62
2044	243.71	487.43	731.14	243.71	487.43	731.14
2045	253.55	507.10	760.66	253.55	507.10	760.66
2046	263.39	526.78	790.18	263.39	526.78	790.18
2047	273.23	546.46	819.69	273.23	546.46	819.69
2048	283.07	566.14	849.21	283.07	566.14	849.21
2049	292.91	585.82	878.73	292.91	585.82	878.73
2050	302.75	605.50	908.25	302.75	605.50	908.25

The values in Tables 2a and 2b are based on those referred to in Annex C in the DECC/HMT guidance 'Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation', June 2010. They differ because they are expressed in 2002 prices. They are also expressed in £ per tonne of carbon rather than CO_2. These values will be updated annually to reflect updates published by DECC.

Table 2b: Traded and Non Traded Values, £ per Tonne of Carbon for use in Appraisal (2050-2100) expressed in 2002 prices

	Traded			Non traded		
Year	Low	Central	High	Low	Central	High
2050	302.75	605.50	908.25	302.75	605.50	908.25
2051	310.32	626.91	943.50	310.32	626.91	943.50
2052	317.35	647.65	977.96	317.35	647.65	977.96
2053	324.22	668.50	1012.78	324.22	668.50	1012.78
2054	330.89	689.35	1047.81	330.89	689.35	1047.81
2055	337.03	709.54	1082.05	337.03	709.54	1082.05
2056	343.03	729.85	1116.66	343.03	729.85	1116.66
2057	348.48	749.41	1150.35	348.48	749.41	1150.35
2058	353.52	768.52	1183.51	353.52	768.52	1183.51
2059	358.22	787.30	1216.37	358.22	787.30	1216.37
2060	362.52	805.61	1248.69	362.52	805.61	1248.69
2061	364.96	820.14	1275.32	364.96	820.14	1275.32
2062	367.22	834.58	1301.95	367.22	834.58	1301.95
2063	368.69	847.57	1326.44	368.69	847.57	1326.44
2064	369.74	859.85	1349.96	369.74	859.85	1349.96
2065	370.03	870.65	1371.28	370.03	870.65	1371.28
2066	370.15	881.31	1392.47	370.15	881.31	1392.47
2067	369.44	890.21	1410.98	369.44	890.21	1410.98
2068	368.32	898.34	1428.37	368.32	898.34	1428.37
2069	366.62	905.24	1443.86	366.62	905.24	1443.86
2070	364.48	911.20	1457.91	364.48	911.20	1457.91
2071	362.26	917.11	1471.96	362.26	917.11	1471.96
2072	359.58	922.01	1484.43	359.58	922.01	1484.43
2073	356.57	926.17	1495.76	356.57	926.17	1495.76
2074	352.89	928.66	1504.43	352.89	928.66	1504.43
2075	349.23	931.28	1513.33	349.23	931.28	1513.33
2076	344.66	931.51	1518.36	344.66	931.51	1518.36
2077	340.12	931.84	1523.56	340.12	931.84	1523.56
2078	335.05	930.68	1526.32	335.05	930.68	1526.32
2079	329.78	928.96	1528.14	329.78	928.96	1528.14
2080	323.95	925.57	1527.19	323.95	925.57	1527.19
2081	319.16	925.10	1531.04	319.16	925.10	1531.04
2082	313.82	923.01	1532.19	313.82	923.01	1532.19
2083	308.27	920.21	1532.15	308.27	920.21	1532.15
2084	302.56	916.83	1531.11	302.56	916.83	1531.11
2085	297.01	913.86	1530.72	297.01	913.86	1530.72
2086	290.92	909.12	1527.32	290.92	909.12	1527.32
2087	284.65	903.65	1522.65	284.65	903.65	1522.65
2088	278.39	898.04	1517.69	278.39	898.04	1517.69
2089	271.93	891.58	1511.22	271.93	891.58	1511.22
2090	265.52	885.05	1504.59	265.52	885.05	1504.59
2091	259.46	879.54	1499.61	259.46	879.54	1499.61
2092	253.42	873.87	1494.32	253.42	873.87	1494.32
2093	247.03	866.79	1486.54	247.03	866.79	1486.54
2094	240.67	859.53	1478.40	240.67	859.53	1478.40
2095	234.29	851.98	1469.66	234.29	851.98	1469.66
2096	227.94	844.22	1460.50	227.94	844.22	1460.50
2097	221.75	836.79	1451.83	221.75	836.79	1451.83
2098	215.28	828.02	1440.75	215.28	828.02	1440.75
2099	209.12	820.07	1431.02	209.12	820.07	1431.02
2100	202.82	811.28	1419.75	202.82	811.28	1419.75

Using the DECC carbon values in transport appraisal

1.4.5 The discussion above outlines how changes to carbon emissions from transport fuel (excluding electricity) may be calculated. These emissions are within the non-traded sector and so should be valued using the non-traded values in Table 2. Where emissions impacts are in the non-traded sector, as with other 'external' costs and benefits, they are to be valued, then discounted into a present value and subtracted from or added to the net present value of benefits of the intervention.

1.4.6 Where there are changes to the use of transport fuel that is in the traded sector, for example electricity, the method must be adapted slightly. This is because the inclusion of a transport fuel in the traded sector (the EU Emissions Trading System) caps relevant emissions and creates a market for them. In this way, they are 'internalised' through the requirement for the relevant sectors to purchase allowances (EUAs) to cover relevant emissions[5].

1.4.7 If there are changes in the use of traded sector transport fuel (for example, in projects on the electrified rail network) such impacts should be accounted for in the appraisal, subject to proportionality considerations. The requirement for relevant sectors to hold allowances (EUAs) from the ETS to cover traded emissions will be reflected in the price of electricity; the projections of the purchase price of traded sector transport fuel such as electricity therefore include the future allowance purchase price. To be consistent with the accounting of traded sector emissions across Government, the following approach should be used (again using electricity for illustration)[6]:

i) estimate the electricity requirements in the 'with scheme' and 'without scheme' scenarios;

ii) use electricity prices which include the ETS allowance price (these can be found in the tables referred to in Annex C of "Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation", DECC, June, 2010);

iii) account for electricity costs in the 'with scheme' and 'without scheme' in line with standard guidance, which sets out where such transport fuel costs should feature in the appraisal. See section 2.3 in **The Estimation and Treatment of Scheme Costs**.

1.4.8 The Department for Transport should be contacted with any queries regarding this approach.

Use of TUBA and COBA

1.4.9 For road schemes being appraised using the COBA program and for road and multi-modal schemes using the TUBA program, the net present value of the change in carbon emissions from road-based fuel consumption that is in the non-traded sector will be presented as an automatic output of the program (in the Department's standard base year prices and values for the whole appraisal period). **Please note that if TUBA is being used to estimate the change in carbon emissions it is essential that all 8760 hours of the year are represented in the analysis**. For more details see **TUBA Manual (Mott MacDonald, 2006**).

[5] Note that this also applies to emissions from sources other than transport fuels that are within the traded system. The cost of any EUAs to cover traded emissions will be reflected in the price of, for example, concrete or steel and so the purchase price of traded sector goods should therefore include the future allowance purchase price. Since the purchase price is used in transport appraisal, the cost of the relevant EUAs will be included in the cost benefit analysis. Therefore, unlike in the non-traded sector, carbon emissions should not be separately valued and subtracted from the net present value of benefits of the intervention.

[6] In the appraisal of aviation schemes and policies, the ETS allowance price should be accounted for in the price of air travel

1.4.10 Only the difference in non-traded fuel consumption related carbon (Ce) emissions between the 'with scheme' and 'without scheme' scenario is valued for each year in the appraisal. The value per tonne of carbon (Ce) emission which varies for each year, is applied to the difference in each year. This is then discounted at standard HM Treasury rates (**see TAG Unit 3.5.4, Cost Benefit Analysis**) and summated to give the NPV of the change in fuel consumption related carbon (Ce) emissions over the appraisal period. A positive number would suggest there has been an overall reduction in carbon (Ce) emissions and conversely a negative number would suggest that there has been an overall increase in carbon (Ce) emissions.

1.4.11 The non-traded carbon values for the Department's standard base year and the annual growth rate are programmed as default into the COBA and TUBA software. The TUBA and COBA programs also output the NPV based on the upper and lower estimates of the carbon values.

1.4.12 Where COBA and TUBA are not used, the TAG Greenhouse Gases excel spreadsheet which will soon accompany this unit ("TAG Greenhouse Gases Spreadsheet.xls") can be used to generate the same outputs as COBA and TUBA.

1.4.13 Non-traded fuel consumption related carbon (Ce) emissions may also be estimated using the DMRB 11.3.1 spreadsheet. These are then entered into the TAG Greenhouse Gases excel spreadsheet in tonnes for the 'with scheme' and 'without scheme' scenarios for each year of the appraisal period. The opening year of the scheme and the current year of appraisal must also be entered into the spreadsheet.

1.4.14 Internally the spreadsheet then calculates the change between the 'with scheme' and 'without scheme' scenarios for each year. It then multiplies the change in carbon (Ce) emissions, by the value per tonne of carbon emission for the year in which it is emitted (using values consistent with those in Table 2). The value of the change in emissions in each year is then discounted at standard HM Treasury rates (**see TAG Unit 3.5.4, Cost Benefit Analysis**) to give a net present value in the Department's standard base year of carbon emissions for that particular year. This is then summated over the appraisal period, to give the NPV of the change in carbon emissions for the scheme in question.

1.4.15 In addition to the primary output of the central NPV value, and in order to inform sensitivity analysis, the upper and lower NPV estimates will also be output from the spreadsheet.

1.4.16 The modelling and appraisal of rail schemes does not generally make use of TUBA for quantifying the costs and benefits, although the methods for valuing the costs and benefits are identical. The model used in the appraisal to specify the effects on train operations of changes in the timetable and services to be operated, or capacity to be provided, will give estimates of changes in energy consumption for the types of train which are being considered as options for the scheme. Where this information is not available, advice should be sought from DfT. DfT can also advise on carbon (Ce) emissions per litre of diesel fuel used by trains, since at present this differs slightly from the emissions from road fuel shown in Table 1 above. DfT is currently developing new emission factors by stock type but these will not be available before March 2011. Figures for emissions per kilowatt of electricity consumed have been published in guidance by DECC (see the tables referred to in Annex C of "Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation", DECC, June, 2010). Paragraphs 1.4.5 – 1.4.8 explain the principles to be used in valuing emissions from diesel (in the non-traded sector) and electric (in the traded sector) trains.

1.5 Assessment and Reporting Requirements

1.5.1 The 'Greenhouse Gases Worksheet 1' that heads the TAG Greenhouse Gases excel spreadsheet which will soon accompany this unit ("TAG Greenhouse Gases Spreadsheet.xls",), summarises the analyses outlined above, and the information set out there should be provided for all appraisals.

1.5.2 For those not using TUBA and COBA, the quantitative information will be output automatically after inputting fuel consumption related carbon (Ce) emissions for each year of the appraisal period for the 'with scheme' and 'without scheme' scenarios. Promoters who are using TUBA and COBA programs should extract suitable information from program outputs in completing the worksheet.

1.5.3 As well as the standard outputs described below, the worksheet enables more detailed information to be documented on assumptions made, sensitivity analysis, and data sources. The worksheet should record the assessment method used, e.g. COBA/TUBA or DMRB (including the version number where appropriate), and whether rail emissions have been taken into account and, where they have, the basis of the calculations. Any uncertainties involved in the calculation of emissions should also be recorded. This should be presented by all scheme promoters and will provide a basis for the required input into the Appraisal Summary Table (AST).

1.5.4 The following describes the information that should be recorded and presented in the AST.

Overall Assessment Score:

1.5.5 The entry in the Overall Assessment column of the AST should give the net present value of the monetary value of the total change in the non-traded fuel consumption related carbon (Ce) emissions between the 'with scheme' and 'without scheme' scenarios over the whole appraisal period. A positive value will reflect a net benefit, i.e. there would be a reduction in the non-traded fuel consumption related carbon (Ce) emissions over the whole appraisal period in comparison to the 'without scheme' case.

Quantitative measures:

1.5.6 This part of the AST should present the total impact on non-traded carbon (Ce) emissions resulting from the difference in fuel consumption between the 'with scheme' and 'without scheme' scenarios for the whole appraisal period (which is the sum of the changes in each year) and also for the scheme opening year[7] . In this instance, a positive number will suggest an increase in non-traded fuel consumption related carbon (Ce) emissions (relative to the 'without scheme' case), i.e. the scheme has an adverse impact on the greenhouse gas sub-objective. Alternatively a negative number will suggest that the scheme tends to reduce fuel consumption related non-traded carbon (Ce) emissions from the 'without scheme' case and hence there is a relative improvement on the greenhouse gas objective.

1.5.7 Note that, as in past analyses, these results should be expressed in terms of tonnes of carbon equivalent (tCe).

Qualitative comment:

1.5.8 This part of the AST should be used to indicate any special features of the appraisal, along with an indication of the key drivers which are responsible for any change in conditions. Any uncertainties involved in the calculation of emissions should also be identified in the qualitative column.

1.5.9 In addition, given the legally binding carbon budgets to which the Government has committed under the Climate Change Act (2008), it is important that appraisals are consistent with cross Whitehall guidance and therefore produce emission figures **(expressed in $MtCO_2e$)** needed for carbon budget accounting and reporting requirements. Therefore the appraisal should also present:

[7] Amount of carbon emitted should be stated in metric tonnes whereby 1 tonne = 1000 kilograms = 1000000 grams.

i) The impact on carbon dioxide emissions relative to the 'without scheme' case in the scheme opening year, reported as a breakdown between the traded and non-traded emissions

ii) The impact on carbon dioxide emissions relative to the 'without scheme' case in each of the five-year carbon budget periods (2008-2012; 2013-2017 and 2018-2022), reported as a breakdown between the traded and non-traded emissions

1.5.10 For non-traded emissions, this information may be derived from the 'Greenhouse Gases Worksheet 1', noting that these results must be converted from tonnes of carbon equivalent (tCe) to millions of tonnes of carbon dioxide equivalent ($MtCO_2e$) using the conversion factor 44/12 to convert from tCe to tCO_2e.

1.5.11 It should be noted that because most transport energy sources – except electricity - generate carbon emissions in the non-traded sector, the carbon emissions impacts would therefore affect the UK's net carbon account, and hence the need for it to be reported. Where a scheme leads to a change in for example electricity use, then because this is in the traded sector it would not have an impact on the UK net carbon account. Such impacts should however also be reported because it illustrates the implications for the purchase of ETS allowances to cover those emissions. The different nature of these emissions means that they are not required to be summed and reported as a total

1.5.12 For those interventions that reduce emissions, **a cost-effectiveness indicator** may be required. This is the case if the reduction exceeds a given threshold**.** There are two separate thresholds to be considered:

i) If the stream of CO2e savings (intervention lifetime less than 20 years) exceeds 0.1MtCO2e average per year, or

ii) if the stream of CO2e savings (intervention lifetime more than 20 years) exceeds 2.0MtCO2e over the lifetime and exceed an average per year of 0.05 MtCO2e.

1.5.13 Cost effectiveness analysis provides an estimate of the net social cost per tonne of CO_2e reduction in the traded and/or in the non traded sectors. Where this is required, detailed guidance is provided in "Valuation of Energy Use and Greenhouse Gas Emissions for Appraisal and Evaluation", DECC, June 2010.

2 Application of TAG to Highway Schemes

This section provides advice on the links between TAG's treatment of the Greenhouse Gases sub-objective and the advice given in Volume 11 of the Design Manual for Roads and Bridges (DMRB), which deals with the environmental assessment of highway projects. An explanation of the correspondence between the advice set out in TAG and DMRB is given in Applying the Multi-Modal New Approach to Appraisal to Highway Schemes (TAG unit 2.6).

2.1 Methods and Worksheets

2.1.1 The method for assessment of Greenhouse Gases in TAG is broadly consistent with the regional impact assessment in DMRB 11.3.1 in terms of fuel consumption related carbon emission rates. However, the regional impact assessment is carried out for the opening year only whereas the TAG greenhouse gas assessment is for the whole of the appraisal period as well as the opening year. The TAG assessment goes further than the DMRB by estimating the net present monetary value of the total change in fuel consumption related carbon emissions between the 'with scheme' and 'without scheme' scenarios over the whole appraisal period.

2.2 Data Transformation from DMRB to TAG

2.2.1 Fuel consumption related carbon emissions for the 'with scheme' and 'without scheme' scenarios can be estimated using the DMRB 11.3.1 spreadsheet and then entered into the TAG Greenhouse Gases excel spreadsheet to obtain the value of the change in fuel consumption related carbon emissions if COBA or TUBA are not used. As only the opening year will have been assessed as part of the DMRB regional assessment, a forecast year will also have to be estimated and information for other years derived by interpolation and extrapolation as described above.

2.3 DMRB Stages and TAG

2.3.1 The greenhouse gas assessment is generally undertaken at DMRB Stage 3 together with a regional assessment for emissions of oxides of nitrogen, PM_{10}, carbon monoxide, and hydrocarbons. However, the greenhouse gas estimates should be undertaken for the AST at all stages of the assessment, including pre-TPI entry.

3 Further Information

The following documents provide information that follows on directly from the key topics covered in this Unit.

For information on:	See:	TAG Unit number:
Interpolation and Extrapolation	Cost Benefit Analysis	3.5.4
Estimating Changes in Fuel Consumption	Values of Time and Operating Costs	3.5.6
Correspondence between TAG and DMRB	Applying the Multi-Modal New Approach to Appraisal to Highway Schemes	2.6
Rail Emission Model	http://www.dft.gov.uk/pgr/rail/researchtech/research/railemissionmodel	
Climate Change and Transport	http://www.dft.gov.uk/pgr/sustainable/climatechange/	
Renewable Transport Fuel Obligation	http://www.dft.gov.uk/pgr/roads/environment/rtfo/	

4 References

Mott MacDonald. Transport User Benefit Appraisal User Manual

Department for Transport (2006), COBA User Manual, available at: http://www.dft.gov.uk/pgr/economics/software/coba11usermanual/

Highways Agency, Design Manual for Roads and Bridges (DMRB)

DECC, June 2010, Valuation of Energy Usage and Green House Gases (GREENHOUSE GAS EMISSION) Emissions for Appraisal and Evaluation, available at:

http://www.decc.gov.uk/assets/decc/statistics/analysis_group/122-valuationenergyuseggemissions.pdf

5 Document provenance

1. This Transport Analysis Guidance (TAG) Unit is based on Chapter 4, Section 5 (including worksheet 4.5) of Guidance on the Methodology for Multi-Modal Studies Volume 2 (DETR, 2002).

2. This guidance was updated in September 2006 to include advice on the calculation of monetary valuation for the change in carbon emissions.

3. The guidance was further revised in June 2008 to reflect new Defra advice on the Shadow Price valuation of carbon emissions. This became definitive guidance in April 2009.

4. January 2010: In Draft Guidance. Latest DECC values for estimated abatement costs of carbon equivalent and guidance for appraising fuel consumption related carbon added to this Unit.

5. January 2010: Updated In Draft Guidance. Includes DECC-based values for estimated abatement costs of carbon equivalent to 2100, and reference to DECC guidance published January 2010.

6. January 2011: Updated Guidance. Values in Table 2a for traded carbon between 2010 and 2029 updated in line with DECC values published in June, 2010.

Technical queries and comments on this Unit should be referred to:

Integrated Transport Economic Appraisal (ITEA) Division
Department for Transport
Zone 3/08 Great Minster House
76 Marsham Street
London
SW1P 4DR
itea@dft.gsi.gov.uk
Tel. 020 7944 6176
Fax. 020 7944 2198