

## **Values of Time and Operating Costs**

### **TAG Unit 3.5.6**

April 2009

Department for Transport

Transport Analysis Guidance (TAG)

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# 1 Values of Time and Operating Costs

## 1.1 Introduction

- 1.1.1 This TAG Unit provides the latest values of time, occupancy figures, purpose splits, GDP growth rates and vehicle operating costs recommended by the Department for Transport (DfT) for use in economic appraisals of transport projects in England, as well as the rest of Great Britain with the relevant Overseeing Organisation's permission. This TAG Unit replaces the Transport Economics Note (TEN) dated March 2001.
- 1.1.2 The values presented in this Unit are suitable for use in COBA, TUBA and QUADRO computer programs, although this list is not exhaustive. Further advice relating to their application may be obtained from the DfT.
- 1.1.3 This Unit aims, as far as possible, to cover all modes of transport. However in certain parts of the Unit, notably vehicle occupancies and vehicle operating costs, a lack of available data means that all modes have not been covered.
- 1.1.4 Revision of the March 2001 TEN was necessary to allow implementation of the recommendations contained in the latest research for the DfT on valuation of non-working travel time savings (*Values of Travel Time Savings in the UK*, Institute for Transport Studies, University of Leeds, 2003). The research recommends three levels of appraisal with differing methodologies. This Unit implements the recommendations for 'level 1' appraisals; further guidance will be provided for level 2 and 3 appraisals in due course.

### Methods of Cost Benefit Analysis

- 1.1.5 Cost benefit analysis aims to take account of all the ways in which a project affects people, irrespective of whether those effects are registered in conventional financial accounts. The method of cost benefit analysis for appraisal is the calculus of 'willingness to pay' using a market price unit of account. A full discussion of the methodology is given in *Cost Benefit Analysis* (TAG Unit 3.5.4).

### Units of Account

- 1.1.6 The market price unit of account expresses prices in market prices. Market price refers to the price paid by consumers for goods and services in the market and therefore includes all indirect taxation (indirect taxation refers to taxation levied on a product and therefore includes excises, duties and VAT). Prices that do not include taxation (e.g. public transport fares) are still perceived by consumers in the market price unit of account.
- 1.1.7 The factor cost unit of account expresses prices in resource costs. Resource costs are costs that are net of indirect taxation. The prices paid by Government for goods and services are not subject to indirect taxation as any tax that is paid by Government bodies such as the Highways Agency is recovered by Government and thus may be ignored. Government expenditure is therefore in the factor cost unit of account. Business costs and benefits are also assumed to be in the factor cost unit of account as businesses are free of indirect taxation because they can claim it back. An exception to this is fuel duty, which businesses cannot claim back.
- 1.1.8 Costs can be converted to (or from) market prices by multiplying (or dividing) by the indirect tax correction factor,  $(1+t)$ , where  $t$  is 20.9% - the average rate of indirect taxation in the economy.
- 1.1.9 Perceived costs are those which are actually experienced by users. Perceived costs are different for work and non-work trips because businesses can claim

back VAT on purchases. Businesses cannot, however, claim back fuel duty and therefore this is included in their perceived cost. (N.B. certain classes of PSV can claim back fuel duty. This should be treated as a subsidy). Note that business users perceive costs in the factor cost unit of account, while consumers perceive costs in the market price unit of account.

## **1.2 Values of Time**

- 1.2.1 This section provides the latest values of time recommended by the DfT for use in most routine economic appraisals of transport projects. All items are expressed in average 2002 values and prices.
- 1.2.2 The Department accepts that different values of time may be needed in other circumstances, such as appraisal of strategic analysis, road user charging and toll roads. The Department will issue further guidance on appropriate values and methods to use for these appraisals. For most routine appraisals the guidance in this document is relevant.

### **Values of Working Time per Person**

- 1.2.3 Time spent travelling during the working day is a cost to the employer's business. It is assumed that savings in travel time convert non-productive time to productive use and that, in a free labour market, the value of an individual's working time to the economy is reflected in the wage rate paid. This benefit is assumed to be passed into the wider economy and to accrue in some proportion to the producer, the consumer and the employee, depending on market conditions.
- 1.2.4 Working time values, apply only to journeys made in the course of work. This excludes commuting journeys. The perceived value of working time is the value as perceived by the employer. Businesses perceive costs in the factor cost unit of account and therefore the perceived cost and the resource cost are the same for values of working time. The resource cost is calculated as being equal to the gross wage rate plus non-wage labour costs such as national insurance, pensions and other costs which vary with worker hours. The 24.1% mark-up for non-wage labour costs used in the March 2001 edition of TEN has been revised down to 21.2%, a figure derived using more recent data from the 2000 Labour Cost Survey.
- 1.2.5 Values for car drivers and passengers; rail, bus, underground and taxi passengers; walkers; cyclists; motorcyclists and average of all persons were derived from the 1999 – 2001 National Travel Survey (NTS), based on individual incomes. Values for the occupational groups (bus, OGV, taxi and LGV occupants) were obtained from the 2002 New Earnings Survey.
- 1.2.6 It may appear that the use of different values for each mode will introduce inconsistency in appraisal, since it suggests that those transferring between modes change their values of time in the process. This is not the case. The key to understanding this is to realise that the values of time used in appraisal are average values. For any group - bus passengers, car drivers and so on - there will be a distribution of values around the average value for the group. Thus, the value of time for any specific traveller within a group need not be the average value for the group as a whole. In addition, it is likely that there is a good deal of overlap between the distributions for different groups. This immediately resolves the apparent illogicality of the mode switcher: he retains his value of time, but takes up a different position in the distribution of values of time for his new mode, compared with that for his old mode. For example, a car driver with a value of time higher than the average for all car drivers could switch to rail, where his value of time might be lower than the average for all rail passengers.

- 1.2.7 The use of working time values for modal groups may be criticised because the values remain fixed even though the distribution of users between modes might be affected by some options. In circumstances where large changes in mode are expected, the values by mode for the do-something might be significantly different from the values for the do-minimum. An alternative approach avoiding this problem might be to segment travellers into groups that would not be affected by options – income groups, for example. Each group could be assigned its own working value of time. The value of working time for each mode would then be an output of the modelling process, rather than an input to the appraisal process. However, this assumes that the modelling process will be relatively highly disaggregated. That might be feasible for spatially aggregate models, but could pose serious problems for spatially detailed models – this is discussed in more depth in *Modelling* (TAG Unit 3.1). Where this approach is considered, analysts should carry out tests to demonstrate that the segmentation adopted will adequately reflect the variation in modal values.
- 1.2.8 In certain circumstances it may be appropriate to make the simple assumption of a common working value of time for all travellers, in which case the average of all workers value given in Table 1 should be used. Where this approach is adopted, sensitivity tests should be carried out, using values disaggregated by modal group.
- 1.2.9 In the appraisal process, changes in travel time on employer's business are valued the same whatever stage of the journey is involved, i.e. there is no weighting applied to take account of the reluctance of passengers to walk to/from or wait for transport services. This is because the time spent or saved is assumed to be lost or gained in productive working time - the travel activity taking up the time is therefore deemed irrelevant. In cases of staged journeys, the value of working time for the main mode should be used, where the main mode refers to the mode for the longest journey by distance.
- 1.2.10 The Department recognises that use of mode specific values may increase the possibility of not taking into account people who switch between modes. To reduce this risk, values in Table 1 should not be used where the number of people switching modes is high compared to the number of existing users. In these special circumstances, please contact ITEA Division, DfT for further advice.

<b>Table 1: Values of Working Time per person (£ per hour, 2002 prices and values)</b>			
<b>Vehicle Occupant</b>	<b>Resource Cost</b>	<b>Perceived Cost</b>	<b>Market Price</b>
Car driver	21.86	21.86	26.43
Car passenger	15.66	15.66	18.94
LGV (driver or passenger)	8.42	8.42	10.18
OGV (driver or passenger)	8.42	8.42	10.18
PSV driver	8.42	8.42	10.18
PSV passenger	16.72	16.72	20.22
Taxi driver	8.08	8.08	9.77
Taxi/Minicab passenger	36.97	36.97	44.69
Rail passenger	30.57	30.57	36.96
Underground passenger	29.74	29.74	35.95
Walker	24.51	24.51	29.64
Cyclist	14.06	14.06	17.00
Motorcyclist	19.78	19.78	23.91
Average of all working persons	22.11	22.11	26.73

#### **Values of Non-Working Time per Person**

- 1.2.11 The majority of journeys do not take place during working hours, but in the traveller's own time. However, people implicitly put a value on their own time, in that they will trade a cheaper, slower journey against a faster, more expensive one. It is therefore appropriate to take account of this value in assessing the impact of different transport strategies or plans.
- 1.2.12 This 'willingness to pay' will vary considerably, depending on such factors as the income of the individual traveller, the value of the journey purpose and its urgency, and the comfort and attractiveness of the journey itself. Different values may therefore correctly be attributed to:
- time spent on the same activity by different people, whose incomes and journey characteristics may vary; and
  - time spent by the same individual on different journeys or parts of journeys.
- 1.2.13 One important specific application of this second type of variability is that time spent walking to/from and waiting for public transport services is commonly valued much more highly than time spent actually travelling. There is consistent evidence that people will pay more to save walking and waiting time than they will for an equivalent saving in ride time. This approach should normally be adopted for multi-modal transport appraisal.
- 1.2.14 Time savings to travellers in their own time typically make up a large proportion of the benefits of transport investment. If values of time for appraisal are based on an individual's willingness to pay (behavioural values) which are related to income, then strategies and plans will be biased towards those measures which most benefit travellers with higher incomes (which may favour some modes over others). Investment will then be concentrated into high-income areas, and the

- interests of those on lower incomes, who may already suffer from relatively lower mobility and accessibility, will be given less weight. For this reason, multi-modal transport appraisal should normally adopt the values for non-working time which is common across all modes and journey purposes.
- 1.2.15 The values for non-working time apply to all non-work journey purposes, including travel to and from work, by all modes. It is based on research conducted by the Institute for Transport Studies (ITS) for the Department for Transport, reported in 2003, and published as *Values of Travel Time Saving in the UK*. The value given in the ITS report was in end 1997 prices. These values were converted to 2002 values and prices by uprating in proportion to changes in values of time growth and changes in prices (using the Retail Price Index).
- 1.2.16 'Commuting' is travelling to and from the normal place of work. 'Other' is travel for other non-work purposes, for example leisure trips. There is no differentiation of 'commuting' and 'other' values of time by mode<sup>1</sup>.
- 1.2.17 The recommended values for all non-working trips are shown in Table 2. The values given in this table are averages which include retired persons in the calculations.
- 1.2.18 Individual consumers perceive costs in the market price unit of account and therefore the perceived cost and the market price are the same for 'commuting' and 'other' purposes.
- 1.2.19 The values for non-working time ('commuting' and 'other') spent waiting for public transport is two and a half times the 'commuting' and 'other' values.
- 1.2.20 Where walking and cycling is used as a means of inter-changing between modes of transport, the non-working values ('commuting' and 'other') of walking and cycling is twice the 'commuting' and 'other' values.

<b>Table 2: Values of Non- Working Time per person (£ per hour, 2002 prices and values)</b>			
<b>Purpose</b>	<b>Resource Cost</b>	<b>Perceived Cost</b>	<b>Market Price</b>
Commuting	4.17	5.04	5.04
Other	3.68	4.46	4.46

#### **Annual Rates of Growth in Values of Time**

- 1.2.21 The value of non-working time is assumed to increase with income, with an elasticity<sup>2</sup> of 0.8. Working values of time are assumed to grow in line with income, with an elasticity of 1. The measure of income used is GDP per head. Forecasts for GDP are produced by HM Treasury and forecasts for population growth produced by ONS. Forecast growth in the real value of time is shown in Table 3.

<sup>1</sup> Based on research conducted by the Institute for Transport Studies (ITS) for the Department for Transport, reported in 2003, and published as *Values of Travel Time Saving in the UK*.

<sup>2</sup> Elasticity is the relative response of one variable to changes in another variable. The phrase "relative response" is best interpreted as the percentage change. In this context, the inter-temporal income elasticity of the value of time, is the percentage change in the value of time (over time) measured against the percentage change in income (over time).

<b>Table 3: Forecast Growth in the Working and Non-Working Values of Time</b>				
<b>Range of Years</b>	<b>GDP Growth (%pa)</b>	<b>Population Growth (%pa)</b>	<b>Work VOT Growth (% pa)</b>	<b>Non-Work VOT Growth (% pa)</b>
2002 – 2003	2.25	0.27	1.98	1.58
2003 – 2004	2.50	0.27	2.22	1.78
2004 – 2005	3.50	0.28	3.21	2.57
2005 – 2006	3.25	0.28	2.96	2.37
2006 – 2007	2.75	0.28	2.46	1.97
2007 – 2011	2.50	0.29	2.20	1.76
2011 – 2021	2.25	0.31	1.94	1.55
2021 – 2031	1.75	0.20	1.55	1.24
2031 – 2051	2.00	0.01	1.99	1.59
2051 – 2061	1.75	-0.06	1.81	1.45
2061 onwards	2.00	0.00	2.00	1.60

- 1.2.22 In accordance with the Treasury's Green Book, VOT growth rates in Table 3 above for a given year should be modified according to whether the discount rate for that year is different from the rate for the current year as follows:

$$\text{VOTgrowth\_modified year} = \text{VOTgrowth\_original year} \times \frac{\text{discount rate\_mod year}}{\text{discount rate\_current year}}$$

### Vehicle Occupancies

- 1.2.23 Car occupancy figures are shown in Table 4. These figures were derived from the 1999 - 2001 National Travel Survey and show the sum of driver occupancy (always 1) and passenger occupancy. Occupancies in the top half of Table 4 are expressed in per vehicle kilometre and those in the bottom half are per trip.

<b>Table 4: Car Occupancies (2000)</b>							
<b>Journey Purpose</b>	<b>Weekday</b>					<b>Weekend Average</b>	<b>All Week Average</b>
	<b>7am – 10am</b>	<b>10am – 4pm</b>	<b>4pm – 7pm</b>	<b>7pm – 7am</b>	<b>Weekday Average</b>		
<b>Occupancy Per Vehicle Kilometre Travelled</b>							
Work	1.23	1.19	1.17	1.18	1.20	1.28	1.20
Commuting	1.16	1.15	1.13	1.13	1.14	1.14	1.14
Other	1.71	1.78	1.82	1.77	1.78	1.97	1.85
Average Car	1.37	1.59	1.45	1.47	1.48	1.88	1.58
<b>Occupancy Per Trip</b>							
Work	1.26	1.19	1.20	1.21	1.21	1.30	1.22
Commuting	1.16	1.14	1.14	1.13	1.15	1.13	1.14
Other	1.72	1.70	1.76	1.71	1.72	1.96	1.79
Average Car	1.46	1.59	1.53	1.54	1.54	1.88	1.63



1.2.24 Occupancies for all other vehicles are shown in Table 5. These figures also show the sum of driver and passenger occupancy. Occupancies for different times of the day are only available for cars. For LGVs, different occupancy figures are available for a weekday and the weekend. For all other vehicles, only all week average occupancy figures are available. These should be used for all time periods. Values for heavy and light rail are not included as it is assumed that, if a public transport project is being appraised, a project specific public transport model will be used which will give appropriate details of passenger occupancy. Average PSV occupancy figures are given, as these are required for highways scheme appraisal.

<b>Table 5: Vehicle Occupancies (2000)</b>			
<b>Vehicle Type and Journey Purpose</b>	<b>Occupancy per Vehicle Kilometre Travelled</b>		
	<b>Weekday Average</b>	<b>Weekend Average</b>	<b>All Week Average</b>
<b>LGV</b>			
Work (freight)	1.20	1.26	1.20
Non Work (commuting and other)	1.46	2.03	1.59
Average LGV	1.23	1.35	1.25
<b>OGV1</b> Work only	1.00	1.00	1.00
<b>OGV2</b> Work only	1.00	1.00	1.00
<b>PSV</b>			
Driver	1.00	1.00	1.00
Passenger	12.20	12.20	12.20

1.2.25 Table 6 shows the predicted decline in car passenger occupancies as an annual percentage until 2036, after which car passengers are assumed to remain constant. The occupancy of all other vehicle types should be assumed to remain unchanged over time.

<b>Table 6: Annual Percentage Change in Car Passenger Occupancy (% pa) up to 2036</b>							
<b>Journey Purpose</b>	<b>Weekday</b>					<b>Weekend</b>	<b>All Week</b>
	<b>7am – 10am</b>	<b>10am – 4pm</b>	<b>4pm – 7pm</b>	<b>7pm – 7am</b>	<b>Weekday Average</b>		
Work	-0.48	-0.4	-0.62	-0.5	-0.44	-0.48	-0.45
Non – Work (commuting and other)	-0.67	-0.65	-0.53	-0.47	-0.59	-0.52	-0.56

#### **Journey Purpose Splits**

1.2.26 Data from the National Travel Survey (1999 – 2001) has been used to produce journey purpose splits for work and non-work travel (commuting and other), based on distance travelled and trips made. These purpose splits are necessary in order to calculate values of time per vehicle for the average vehicle. Journey purpose splits are assumed to remain constant over time.

1.2.27 The purpose splits based on distance travelled in work and non-work time are given in Table 7.

<b>Table 7: Proportion of Travel in Work and Non-Work Time</b>							
<b>Mode /Vehicle Type &amp; Journey Purpose</b>	<b>Weekday</b>					<b>Weekend Average</b>	<b>All Week Average</b>
	<b>7am – 10am</b>	<b>10am – 4pm</b>	<b>4pm – 7pm</b>	<b>7pm – 7am</b>	<b>Weekday Average</b>		
<b>Percentage of Distance Travelled by Vehicles</b>							
<b>Car</b>							
Work	18.1	19.9	13.0	12.3	16.4	3.2	13.1
Commuting	46.0	11.4	40.8	36.2	31.0	8.5	25.3
Other	35.9	68.7	46.2	51.5	52.5	88.3	61.6
<b>LGV</b>							
Work (freight)	88.0	88.0	88.0	88.0	88.0	88.0	88.0
Non – Work (Commuting and Other)	12.0	12.0	12.0	12.0	12.0	12.0	12.0
<b>OGV1</b>							
Work	100	100	100	100	100	100	100
<b>OGV2</b>							
Work	100	100	100	100	100	100	100
<b>Percentage of Distance Travelled by Occupants</b>							
<b>Car</b>							
Work	15.4	13.8	10.2	9.9	12.6	2.0	9.2
Commuting	38.3	8.1	32.2	29.1	23.9	5.1	18.0
Other	46.4	78.1	57.6	61.0	63.5	92.9	72.7
<b>PSV</b>							
Work	3.9	2.0	3.9	5.7	3.4	1.5	2.9
Commuting	30.0	11.1	36.6	38.1	25.5	6.4	20.5
Other	66.1	86.9	59.5	56.2	71.1	92.0	76.6
<b>Heavy Rail</b>							
Work	14.1	22.4	16.4	23.2	18.3	6.3	16.5
Commuting	51.9	10.2	55.9	53.1	43.7	4.3	37.8
Other	34.1	67.4	27.7	23.7	38.1	89.5	45.7
<b>Light Rail</b>							
Work	1.9	0.2	1.8	2.3	1.3	0.4	1.2
Commuting	82.4	8.5	75.7	28.9	50.1	23.3	45.8
Other	15.7	91.3	22.5	68.9	48.6	76.3	53.1

Note: The shaded areas in the table indicate a small sample, hence these figures should be treated with caution.

1.2.28 The purpose splits based on trips made in work and non-work time are given in Table 8.

<b>Table 8: Proportion of Trips Made in Work and Non-Work Time</b>							
<b>Mode /Vehicle Type and Journey Purpose</b>	<b>Weekday</b>					<b>Weekend Average</b>	<b>All Week Average</b>
	<b>7am – 10am</b>	<b>10am – 4pm</b>	<b>4pm – 7pm</b>	<b>7pm – 7am</b>	<b>Weekday Average</b>		
<b>Percentage of Vehicle Trips</b>							
<b>Car</b>							
Work	6.8	8.3	5.5	3.6	6.5	1.7	5.0
Commuting	40.6	11.6	32.3	26.4	25.4	9.1	20.3
Other	52.7	80.1	62.2	70.0	68.1	89.3	74.7
<b>LGV</b>							
Work(freight)	88.0	88.0	88.0	88.0	88.0	88.0	88.0
Non – Work (Commuting and Other)	12.0	12.0	12.0	12.0	12.0	12.0	12.0
<b>OGV1</b>							
Work	100	100	100	100	100	100	100
<b>OGV2</b>							
Work	100	100	100	100	100	100	100
<b>Percentage of Person Trips</b>							
<b>Car</b>							
Work	5.2	2.2	4.1	1.2	4.7	1.1	3.4
Commuting	33.3	15.6	25.8	10.9	20.0	6.4	15.2
Other	61.5	82.2	70.1	87.9	75.3	92.5	81.4
<b>PSV</b>							
Work	1.5	1.2	1.8	2.6	1.5	1.0	1.4
Commuting	41.7	10.6	43.0	47.4	26.9	12.4	24.3
Other	56.8	88.2	55.2	50.0	71.5	86.6	74.3
<b>Heavy Rail</b>							
Work	6.7	13.6	6.7	8.8	8.3	2.8	7.6
Commuting	71.7	14.9	68.0	60.4	58.2	11.1	52.2
Other	21.6	71.5	25.4	30.8	33.5	86.1	40.3
<b>Light Rail</b>							
Work	2.8	0.7	3.3	5.3	2.4	1.2	2.2
Commuting	83.0	10.8	70.7	23.7	48.2	21.7	43.8
Other	14.2	88.5	26.0	71.1	49.4	77.1	54.0

Note: The shaded areas in the table indicate a small sample, hence these figures should be treated with caution.

**Values of Time per Vehicle**

1.2.29 The market price values of time per vehicle are given in Table 9. These values were calculated by multiplication of the appropriate figures from Tables 1, 2, 4, 5 and 6. Average car, average LGV and average PSV values also use the journey purpose split data from Table 7 as weights. The values are based on distance travelled.

<b>Table 9: Market Price Values of Time per Vehicle in 2002 based on distance travelled (£ per hour, 2002 prices and values)</b>							
<b>Vehicle Type and Journey Purpose</b>	<b>Weekday</b>					<b>Weekend</b>	<b>All Week</b>
	<b>7am – 10am</b>	<b>10am – 4pm</b>	<b>4pm – 7pm</b>	<b>7pm – 7am</b>	<b>Average Weekday</b>		
<b>Car</b>							
Work	30.74	30.00	29.61	29.81	30.18	31.68	30.18
Commuting	5.84	5.79	5.69	5.69	5.74	5.74	5.74
Other	7.58	7.89	8.08	7.86	7.90	8.74	8.21
Average Car	10.97	12.05	9.90	9.77	10.88	9.22	10.46
<b>LGV</b>							
Work (freight)	12.22	12.22	12.22	12.22	12.22	12.83	12.22
Non – Work (Commuting and Other)	6.70	6.70	6.70	6.70	6.70	9.31	7.29
Average LGV	11.55	11.55	11.55	11.55	11.55	12.41	11.63
<b>OGV1</b>							
Working	10.18	10.18	10.18	10.18	10.18	10.18	10.18
<b>OGV2</b>							
Working	10.18	10.18	10.18	10.18	10.18	10.18	10.18
<b>PSV (Occupants)</b>							
Work	19.80	15.11	19.80	24.24	18.57	13.88	17.33
Commuting	18.45	6.83	22.50	23.43	15.68	3.94	12.61
Other	35.97	47.28	32.38	30.58	38.69	50.06	41.68
Total	74.21	69.22	74.68	78.25	72.93	67.87	71.62

1.2.30 From Table 9, using national average vehicle proportions for 2002, the market price value of an average vehicle is **£11.28** per hour, 2002 prices and values.

## 1.3 Vehicle Operating Costs

- 1.3.1 The use of the road system by private cars and lorries gives rise to operating costs for the user. These include the obvious costs of fuel, oil and tyres, and an element of vehicle maintenance. The models for car and goods vehicle operating costs also include allowances for the purchase of new vehicles, as discussed below.
- 1.3.2 The distance-related costs to private households and business of car purchase are included in the car non-fuel operating costs by inclusion of an allowance for mileage related depreciation. In addition, for business cars, an allowance is also made for the decline in vehicle capital value (other than that accounted for by mileage related depreciation).
- 1.3.3 The costs to freight carriers of goods vehicle purchases are taken into account under goods vehicle non-fuel operating costs. As with private cars, it is assumed that the decision to purchase goods vehicles is independent of the transport policy option pursued. However, changes in congestion on the road system will influence the productivity with which any given fleet of goods vehicles can be used, and this element is taken into account in computing goods vehicle operating costs.
- 1.3.4 This section provides the latest vehicle operating cost (VOC) values recommended by the Department for use in economic appraisals of transport projects. VOCs are separated into fuel VOCs and non-fuel VOCs and are discussed separately within this section. All parameters are expressed in average 2002 values and prices.

### Vehicle Operating Costs - Fuel

- 1.3.5 Fuel consumption is estimated using a function of the form:

$$L = a + b.v + c.v^2 + d.v^3$$

Where:

L = consumption, expressed in litres per kilometre;

v = average speed in kilometres per hour; and

a, b, c, d are parameters defined for each vehicle category.

- 1.3.6 The parameters needed to calculate the fuel consumption element of VOCs are given in Table 10<sup>3</sup>.

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<sup>3</sup> This has been derived from an equation given by AEA Technology's National Environmental Technology Centre (NETCEN) which estimates carbon emissions in grams per kilometre travelled, based on laboratory testing of different vehicle types over different journey cycles (including varying degrees of accelerating, decelerating, idling and stop-starts, as well as travelling at constant speeds). The equations are consistent with those that are used to compile the National Atmospheric Emissions Inventory (NAEI). The NETCEN relationship has been adapted to reflect fuel consumption in litres per kilometre travelled by making use of the fact that carbon emissions and fuel consumption are directly proportional.

<b>Table 10: Fuel VOC Formulae Parameter Values (litres per km, 2002)</b>				
<b>Parameters</b>				
<b>Vehicle Category</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>
Petrol Car	0.18804764	-0.00437947	0.00005068	-0.0000001691
Diesel Car	0.14086613	-0.00285222	0.00002867	-0.0000000693
Average Car	0.17813952	-0.00405874	0.00004606	-0.0000001481
Petrol LGV	0.25246149	-0.00486999	0.00004424	-0.0000000753
Diesel LGV	0.18637593	-0.00268049	0.00001172	0.0000000823
Average LGV	0.19628876	-0.00300892	0.00001659	0.0000000587
OGV1	0.76833752	-0.02257303	0.00031766	-0.0000013544
OGV2	1.02443156	-0.03021812	0.00044285	-0.0000020059
PSV	0.63466867	-0.01898970	0.00027431	-0.0000012161

<b>Table 10a: Fuel VOC Formulae Parameter Values (pence per km, 2002)</b>				
<b>Parameters</b>				
<b>Vehicle Category</b>	<b>a</b>	<b>b</b>	<b>c</b>	<b>d</b>
Petrol Car	3.13851511	-0.07309335	0.00084585	-0.000000282
Diesel Car	2.59193679	-0.05248085	0.00052753	-0.000000128
Average Car	3.03711854	-0.06919799	0.00078525	-0.000000253
Petrol LGV	4.21358227	-0.08128013	0.00073837	-0.000000126
Diesel LGV	3.42931711	-0.04932102	0.00021565	0.000000151
Average LGV	3.56136519	-0.05459225	0.00030115	0.000000106
OGV1	14.13741037	-0.41534375	0.00584494	-0.00002492
OGV2	18.84954070	-0.55601341	0.00814844	-0.00003691
PSV	11.67790353	-0.34941048	0.00504730	-0.00002238

- 1.3.7 In Table 10a the VOC parameters have been converted into pence per kilometre by multiplying by the 2002 resource cost of fuel reported in Table 11. OGV1, OGV2 and PSV are assumed to be diesel driven and therefore parameters for these vehicles have been multiplied by the resource cost of diesel. The parameters for average car and average LGV are calculated as the average of the parameters for petrol and diesel cars and LGVs weighted according to the proportions of total traffic (vehicle kms) that are petrol and diesel. In the absence of more specific evidence it has been assumed that the proportions of traffic that are diesel and petrol are broadly equivalent to the proportions of diesel and petrol vehicles in the fleet. For the proportions of diesel and petrol cars in the fleet, see Table 12. The proportion of LGV traffic that is diesel is assumed to be constant through time, at 85%.
- 1.3.8 The cost of fuel is shown in Table 11. These figures are annual average observed values provided by Department of Energy and Climate Change (DECC)<sup>4</sup>. Figures for average cars and average LGVs represent the weighted averages of the corresponding petrol and diesel figures where the weights used are the proportions of total car / LGV fuel consumption that are forecast to be petrol and diesel in each year. In Table 11, 'Petrol' is a weighted average between Ultra Low Sulphur Petrol (standard unleaded) and Super Unleaded. Super Unleaded is assumed to constitute 10% of the petrol market by 2030. 'Diesel' comprises both Ultra Low Sulphur and Sulphur Free varieties.
- 1.3.9 The resource cost of fuel VOCs is net of indirect taxation. The market price is gross of indirect taxation and is therefore the sum of the resource cost and fuel duty, plus VAT (that is, market price = [resource cost + fuel duty] x [1 + VAT]). In work time the perceived cost of fuel VOCs is the cost perceived by businesses. Businesses are generally viewed as perceiving costs in the factor cost unit of account as most business costs are free of indirect taxation because they can claim it back. However, businesses cannot reclaim fuel duty and therefore the perceived value of fuel VOCs in work time is equal to the resource cost plus fuel duty. In non-work time, the perceived cost of fuel VOCs is the cost as perceived by the individual consumer. Consumers perceive costs in the market prices unit of account and therefore the perceived value of fuel VOCs in non-working time is equal to the market price.
- 1.3.10 The values for fuel duty take account of all increases announced in the 2008 Pre-Budget Report (HMT, 2008) – 2p increase on 1/12/2008, 1.8p increase on 1/4/2009 and 0.5p increase above indexation on 1/4/2010. From 1/4/2011 fuel duty is assumed to increase in line with the Retail Price Index (RPI) until 2030. Fuel duty is assumed to remain constant in real terms after 2030. Also, the VAT rate on road fuel was decreased from 17.5% to 15% from 1<sup>st</sup> December 2008 for 13 months. Because transport modelling software usually works in full calendar years, the VAT reduction is restricted to the year 2009.
- 1.3.10a The values in Table 11 have been deflated to 2002 prices using HM Treasury's GDP deflator. The GDP deflator is a much broader price index than the CPI, RPI or RPIX (which only measure consumer prices) as it reflects the prices of **all** domestically produced goods and services in the economy. Hence, the GDP deflator also includes the prices of investment goods, government services and exports, and subtracts the price of UK imports. The wider coverage of the GDP deflator makes it more appropriate for deflating public expenditure series.

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<sup>4</sup> In earlier versions of this TAG Unit, this Table presented April observed values, taken from *Transport Statistics Great Britain* (DfT 2005). Annual averages are considered to be more appropriate than April values.

**Table 11 Fuel Costs, Fuel Duty and VAT Rates (in 2002 prices)**

Year	Resource Cost (pence per litre)				Duty (pence per litre)		VAT (%)	
	Petrol	Diesel	Av. Car	Av. LGV	Petrol	Diesel	Petrol	Diesel
2002(actual)	16.7	18.4	17.0	18.1	45.8	45.8	17.5	17.5
2003(actual)	18.2	19.6	18.5	19.4	44.8	44.8	17.5	17.5
2004(actual)	20.2	21.4	20.5	21.2	44.5	44.5	17.5	17.5
2005(actual)	25.0	28.0	25.7	27.5	43.6	43.6	17.5	17.5
2006(actual)	27.6	30.4	28.3	30.0	42.8	42.8	17.5	17.5
2007(actual)	27.7	29.5	28.2	29.2	42.8	42.8	17.5	17.5
2008	)				43.3	43.3	17.5	17.5
2009	)				44.7	44.7	15.0	15.0
2010	)				45.1	45.1	17.5	17.5
2011	)				45.6	45.6	)	
2012	)	See	Table	14	46.0	46.0	)	
2013-17	)				46.2	46.2	)	17.5
2018-21	)				46.1	46.1	)	
2022-26	)				46.0	46.0	)	
2027-30	)				45.9	45.9	)	

1.3.11 Table 12 provides forecasts of the proportions of diesel and petrol vehicles in the car fleet<sup>5</sup>. These forecasts are used in the COBA and TUBA software programs when subdividing the total number of cars into petrol or diesel.<sup>6</sup>

<sup>5</sup> The figures for the proportion of car fleet using petrol or diesel in the previous version of this unit have been revised to reflect the use of a more reliable source of evidence.

<sup>6</sup> Ideally we would use the proportions of total traffic (vehicle kms) that are petrol and diesel in COBA and TUBA. The car fleet split is used here in the absence of forecasts of the car traffic split.



<b>Table 12: Proportion of Car Fleet Using Petrol or Diesel (%)</b>		
<b>Year</b>	<b>Petrol</b>	<b>Diesel</b>
2002	79	21
2003	78	22
2004	77	23
2005	76	24
2006	75	25
2007	74	26
2008	72	28
2009	71	29
2010	69	31
	decreasing to	increasing to
2025	57	43
2026 onwards	57	43

#### **Rates of Change in Fuel VOCs**

- 1.3.12 There are two causes of changes in fuel VOC over time: improvements in vehicle efficiency; and changes in the cost of fuel. For cars, changes in fuel VOCs also reflect changes in the proportion of traffic using either petrol or diesel (see Table 12).
- 1.3.13 Vehicle efficiency assumptions are shown in Table 13. These figures show changes in fuel consumption and therefore negative figures indicate an improvement in vehicle efficiency. It should be noted that the figures for average car and average LGV represent the change in the fuel consumption of the petrol and diesel cars / LGVs weighted according to the proportion of car / LGV traffic driven by vehicles of each fuel type. The changes in average car fuel efficiency also reflect the increasing proportion of traffic that is diesel over time, and that diesel cars are expected to remain more fuel efficient than petrol cars.
- 1.3.14 The forecast changes in the cost of fuel are shown in Table 14. Changes in the resource cost of petrol and diesel are based on the Updated Energy Projections (UEP) published in November 2008 by the Department of Energy and Climate Change (DECC). The figures represent the **central oil price scenario**. The figures for average car and average LGV represent the change in resource cost per litre for the average car and LGV. The changes in each year for the average car reflect changes in the resource costs of petrol and diesel, the forecast increase in the proportion of traffic that are diesel cars, and that the resource cost of diesel is forecast to remain above the resource cost of petrol.

<b>Table 13: Assumed Vehicle Fuel Efficiency Improvements</b>									
<b>Vehicle Category</b>	<b>Change in Vehicle Efficiency</b>								
	<b>2002 - 2003 actual</b>	<b>2003 - 2004 actual</b>	<b>2004 -2005</b>	<b>2005 - 2010</b>		<b>2010 - 2015</b>		<b>2015 - 2020</b>	
	<b>(%)</b>	<b>(%)</b>	<b>(%)</b>	<b>(%)</b>	<b>(% pa)</b>	<b>(%)</b>	<b>(% pa)</b>	<b>(%)</b>	<b>(%pa)</b>
Petrol Car	-0.74	-0.75	-0.76	-4.18	-0.85	-5.96	-1.22	-7.18	-1.48
Diesel Car	-1.18	-1.19	-1.21	-5.95	-1.22	-5.84	-1.20	-6.03	-1.24
Average Car	-1.08	-1.10	-1.11	-6.49	-1.33	-7.62	-1.57	-8.21	-1.70
Petrol LGV	-1.22	-1.56	-1.78	-7.24	-1.49	0	0	0	0
Diesel LGV	0.97	-1.40	-1.78	-7.24	-1.49	0	0	0	0
Average LGV	0.64	-1.42	-1.78	-7.24	-1.49	0	0	0	0
OGV1	0.46	0	0	-6.0	-1.23	0	0	0	0
OGV2	-0.17	0	0	-6.0	-1.23	0	0	0	0
PSV	0	0	0	0	0	0	0	0	0

<b>Table 14: Forecast Growth in the Resource Cost of Fuel</b>				
<b>Range of Years</b>	<b>Petrol (% pa)</b>	<b>Diesel (% pa)</b>	<b>Average Car (% pa)</b>	<b>Average LGV (% pa)</b>
2007 – 2008	1.88	4.38	2.58	4.00
2008 – 2009	-7.37	-7.71	-7.47	-7.66
2009 – 2010	-2.64	-2.75	-2.67	-2.73
2010 – 2015	0.58	0.56	0.57	0.56
2015 – 2020	0.57	0.55	0.56	0.55
2020 – 2025	0.55	0.54	0.54	0.54
2025 – 2030	0.54	0.52	0.53	0.52
2030 +	0	0	0	0

1.3.15 The Department is aware that the accuracy of the cubic equation in representing the relationship between speed and fuel consumption (shown in paragraph 1.3.5 above), lessens at low speeds. The Department is engaged in research to further improve the robustness of this relationship at low speeds.

### Vehicle Operating Costs – Non-Fuel

- 1.3.16 The elements making up non-fuel vehicle operating costs include oil, tyres, maintenance, depreciation and vehicle capital saving (only for vehicles in working time). The non-fuel elements of VOC are combined in a formula of the form;

$$C = a1 + b1/V$$

where;

C = cost in pence per kilometre travelled,  
V = average link speed in kilometres per hour,  
a1 is a parameter for distance related costs defined for each vehicle category,  
and b1 is a parameter for vehicle capital saving defined for each vehicle category (this parameter is only relevant to working vehicles).

- 1.3.17 The parameters needed to calculate the non-fuel vehicle operating resource costs are given in Table 15. These parameters are in 2002 prices and exclude indirect taxation.

<b>Table 15: Non-Fuel Resource VOCs</b>		
<b>Vehicle Category</b>	<b>Parameter Values</b>	
	<b>a1 pence/km</b>	<b>b1 pence/hr</b>
<b>Car</b>		
Work	4.069	111.391
Non-Work Car (commuting and other)	3.151	-
Average Car	3.308	19.048
<b>LGV</b>		
Work	5.910	38.603
Non-Work (commuting and other)	5.910	-
Average LGV	5.910	33.970
<b>OGV1</b>	5.501	216.165
<b>OGV2</b>	10.702	416.672
<b>PSV</b>	24.959	569.094

- 1.3.18 Non-fuel VOC parameters for work and non-work cars (commuting and other) and private LGVs have been derived in accordance with previous methods outlined in *Review of Vehicle Operating Costs in COBA* (EEA Division, DoT 1990-91). Non-fuel parameters for all other vehicles have been updated from the *Transport Economics Note* (DfT 2001) by the ratio of average 1998 and 2002 Retail Price Indices.

- 1.3.19 The marginal resource costs of oil, tyres, mileage and maintenance related depreciation, are assumed to be fixed costs per kilometre and appear in the 'a1' term. The difference between the 'a1' term for work and non-work time non-fuel car operating costs reflects the difference in the composition of the vehicle fleet in work and non-work time. In work time, a large proportion of total mileage is by cars with large engine sizes and these cars have higher non-fuel VOCs. The 'b1' term in the non-fuel costs represents changes in the productivity of commercial vehicles and cars in working time, all goods vehicles and PSVs.
- 1.3.20 The time component of depreciation is excluded since it does not vary with distance or speed. For OGVs and PSVs depreciation is assumed to be totally time related; this is based on evidence from trade sources which suggest that factors such as obsolescence and condition are more important determinants of vehicle value than mileage *per se*. For cars and LGVs evidence from second hand prices indicates that part of their depreciation is related to mileage; and therefore this element is recorded as a marginal resource cost.
- 1.3.21 For demand modelling and the calculation of consumer surplus, costs must be expressed in perceived cost terms. The perceived cost of non-fuel VOCs differs for work and non-work time. In work time, the perceived cost is the cost perceived by businesses and is therefore equal to the resource cost. In non-work time, it is assumed that travellers do not perceive non-fuel VOCs, so the perceived cost is zero.
- 1.3.22 The assumption that those making non-work car trips do not perceive their non-fuel vehicle operating costs means that estimates of consumer surplus for non-work purposes, which are based on perceived costs, do not reflect changes in non-fuel vehicle operating costs.
- 1.3.23 However, changes in users' expenditure on non-fuel VOCs are included in the calculation of user benefits for non-work purposes - see TAG Unit 3.5.3, *Transport User Benefit Calculation* for details. These calculations use non-fuel VOCs expressed in market prices. Non-fuel VOCs in market prices for non-work purposes may be estimated from the formula given above, using the parameters given in Table 15 plus VAT (that is, market price = resource cost x (1+VAT)).

#### **Rates of Change in Non-Fuel VOCs**

- 1.3.24 Non-fuel VOCs are assumed to remain constant in real terms over the forecast period. This assumption is made because the main elements which make up non-fuel VOCs are subject to less volatility than fuel VOCs.

#### **Bus Operating Costs**

- 1.3.25 In a simple highway appraisal, buses are treated as part of the traffic flow, and the operating cost formulae described above are applied, using the appropriate parameter values for PSVs. In a multi-modal study, however, different options may result not only in faster or slower running times for existing bus services, but in the need for more or different levels and patterns of bus service provision. In these cases, the impact of options on the costs of bus service provision have to be considered in more detail.
- 1.3.26 The bus operating model requires assumptions to be input on various operational characteristics, such as sickness rates, working days per week, holiday allowances, employers' costs, engineering spares etc and also unit cost rates for each grade of staff, fuel and tyres etc. Vehicle fleet requirements and costs are considered as capital expenditure outside the model and are included in option costs. *The Overall Approach: The Steps in the Process* ([TAG Unit 2.1](#)) gives an overview of how costs are covered in the appraisal process. *The Estimation and Treatment of scheme costs* (TAG Unit 3.5.9) provides further detail on estimating and treating costs for use in the appraisal process.

- 1.3.27 Bus operating costs vary by region and by service type. Information on the operating cost of local bus services, by area, can be found in *Focus on Public Transport* and in *The Passenger Transport Industry in Great Britain Facts* (Confederation of Passenger Transport 1999-2000). Where no other information is available, these costs should be used as default indicators of the operating cost of bus services. However, more detailed information on bus costs should be sought where bus based measures are likely to play a significant part in a strategy. Study consultants may be able to provide more detailed cost estimates using bus operating cost models. The validity of such costs should be cross-checked with other data sources, including the range of values given in the national statistics. Where possible, the co-operation and views of local bus operators should be sought. The Confederation of Passenger Transport (CTP) may also be able to provide assistance in estimating the costs of bus operation.

### Rail Operating Costs

- 1.3.28 Information on rail operating cost assumptions can be obtained by discussion with the Department.

## 2 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:
The Appraisal Process	<i>The Overall Approach: The Steps in the Process</i>	TAG Unit 2.1
	<i>The Appraisal Process</i>	TAG Unit 2.5
Modelling	<i>Modelling</i>	TAG Unit 3.1
Estimating and Treating Scheme Costs	<i>The Estimation and Treatment of Scheme Costs</i>	TAG Unit 3.5.9

## 3 References

P.J Mackie, M. Wardman, A.S Fowkes, G. Whelan, J Nellthorp and J Bates, Institute for Transport Studies, University of Leeds (2003), *Values of Travel Time Savings in the UK*

Confederation of Passenger Transport (1999-2000), *Focus on Public Transport*

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ITEA Division, Department for Transport (2001), Transport Economics Note

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Department for Transport (2005), Transport Statistics Great Britain.

HM Treasury (2008) Pre-Budget Report November 2008.

## 4 Document provenance

1. This Transport Analysis Guidance (TAG) Unit is based on Appendix H of *Guidance on the Methodology for Multi-Modal Studies Volume 2* (DETR, 2000), the *Transport Economics Note* (DfT, 2001) and *Netcen's Carbon Emission and Fuel Consumption Parameters for the National Transport Model* (NETCEN, 2005).
2. February 2007:
  - (i) Parameters in Table 10 rounded.
  - (ii) Corrections to Table 15.
3. June 2008: In Draft Guidance
  - (i) Values in Tables 10a and 11 revised to include BERR actual annual average fuel prices.
  - (ii) Table 14 fuel price forecasts updated to include BERR central oil price forecast.
  - (iii) Table 15 and following text redrafted to clarify treatment in modelling and appraisal of non-fuel vehicle operating costs for non-work purposes.
4. December 2008: In Draft Guidance
  - (i) Table 4. Errors in Average Car values corrected.
  - (ii) Table 11 revised to reflect latest DECC fuel prices, Fuel Duty and VAT rate changes.
  - (iii) Table 14 fuel price forecasts updated to include DECC central oil price forecasts.
  - (iv) Table 15 headings clarified.
5. April 2009: This version of the Unit became definitive guidance.

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