Institute for Transport Studies
FACULTY OF ENVIRONMENT

UNIVERSITY OF LEEDS

Appraisal of Sustainability in Transport

Final Report: Annex

Project Manager	:	Dr Greg Marsden (Institute for Transport Studies)
Project team	:	Mary Kimble (Institute for Transport Studies) John Nellthorp (Institute for Transport Studies) Charlotte Kelly (Institute for Transport Studies)
Title	:	Appraisal of Sustainability
Author(s)	:	Marsden, G., Kimble, M. and Nellthorp, J.
Reference Number	:	RG.TRAN.448750
Version	:	1
Date	:	15th January 2007
Distribution	:	Public
Availability	:	Public
File	:	C:Greg\research\projects\Rees Jeffreys\outputs\
Authorized By	:	
Signature	:	

Contents

A1 Environmental Indicators

A1.1 Pollutant Absorption Capacity

A1.1.1 Total CO_2 emissions

1. Model outputs of KM/mode and NAEI emission factors and fleet mix specifications (described in 3).
2. Using Excel to multiply KM by emission factors; 4 scenarios were created for cars. The default scenario is consistent with the assumptions in the DfT's WebTAG guidance on appraisal. Other scenarios (2 to 4) are explained below. Other modes have constant assumptions in technology for all tests as explained below.
3. Assumptions on emission factors: All petrol cars are mid size and diesel cars small size engine.

CARS: Data was obtained on the 2004 fleet profile of emissions of CO_2 from Vehicle Licensing Statistics 2005. For the 15M vehicles without a figure as they were registered before CO_2 was recorded, an average figure of 195g/km was assumed.

The average vehicle fleet emissions could then be estimated – 184 g/km

New car CO_2emissions was available from the SMMT and DfT for the period to 2005.

The National Road Traffic Forecast estimates on population, cars per household and size of household were used to make an estimate of vehicles per year.

New car purchases were assumed to be a similar % of the fleet as over the past 5 years – 9.73% of total fleet size for the year.

The number of vehicles retired was calculated as Number of vehicles from previous year + new cars – forecast fleet size

An assumption was made that the average CO_2 emissions of the current retiring vehicle fleet each year was equal to 195 g/km which is equal to the average for the existing fleet (note that fuel consumption data suggests that the total fleet average was relatively unchanged over the 1990s so this is fairly robust as an assumption.

Assumptions were made about new car CO_2 emissions as follows:

1. Continuation scenario: continuation of trends 1.3% reduction per year
2. Optimistic: Emission reductions accelerated to meet 2010 target of 140g/km and continuation of this trend 4.2 g/km per year to 2021

3. Mid range: 3g/km per year improvement

The fleet CO_2 was then calculated for each year by taking the average of the previous year * size of fleet in previous year + new car registrations*estimated new car emission rate – retiree total*retiree emission rate all divided by total new fleet size

It was assumed that the retiree emission rate remained at 195g/km for initial years. It was further assumed that from 2011 the retiree emission rate was 11g/km higher than the 8 years lagged new car emission rate. E.g. 2011 = 11+ new car emission rate 2003, 2012 = 11 + new car emission rate 2004

RAIL: CO_2 Taken from WebTAG - note 15900 as UK average with diesel and electric mix - Metropolitan area has a high local electric mix and diesel is more efficient so we may take this to be a conservative estimate

FREIGHT: CO_2 using fleet composition figures and average of CO_2 for each category (LGV, rigid and artic) for 2001, assumed a 5% improvement in efficiency assumed due to larger relative LGV fleet (note no clear trend in direction of CO_2 changes)

BUS: CO_2 from NAEI taking approx average of Euro 1 and pre Euro 1 with average speed of 25kph, improving to an average fleet emission represented by an estimate of Euro III efficiency

LRT: CO_2 2.28kg/km taken from Brand, 2005 Methodology report with a 15% improvement in CO_2 as a result of cleaner electricity generation assumed over 20 years

A1.1.2 Cumulative CO_2 emissions

1. Cumulative CO_2
2. Outcome of Total CO_2 calculations (See assumptions above)
3. For each of the model output years (2006, 2011, 2016, 2021) a total was given. Cumulative total was calculated= 2006*5 + 2011*5 + 2016*5 +2021.
4. Assumes that levels remain constant in each 5 year frame to model output.

A1.1.3 Total NO_x emissions

1. Total NOx emissions
2. NAEI emissions and fleet projection data, Brand, 2005 and SPM data
3. KM by mode were taken from the model outputs as well as average speed, then using the NAEI UK fleet projections and emissions factors data sets, to provide emissions rates and vehicle type breakdown, emission rates were calculated.
    a. Rail 72.0g/km and LRT 4.8g/km emission factors were taken from Brand, 2005 methodology report.
4. Assumes Metropolitan area fleet mix is precisely the same as UK. Inherent assumptions in NAEI fleet projection. All petrol cars are mid size and diesel cars small size engine.

A1.2 Resource Efficiency

A1.2.1 Total Non-renewable energy by all transport

1. Area-specific data forecasting fleet composition including life cycle energy use of materials used in construction and fuelling as well as infrastructure
2. Large amount of data collection and prediction required which proved beyond the feasibility of this research.

A1.2.2 Energy Use per person trip

A1.2.3 Energy Use per tonne

1. Model outputs of KM/mode and energy use factors (described in 4)
2. Using Excel to multiply KM by energy use factor; 4 scenarios were created. The default scenario is consistent with the assumptions in the DfT's WebTAG guidance on appraisal. Other scenarios (2 to 4) are explained below. Other modes have constant assumptions in technology for all tests as explained below.
3. Assumptions on energy use factors

Assumed energy use conversion factor for continuation (Scenario 2) = 1.87061E-09
For optimistic (Scenario 3), greater inclusion of biofuels means energy use will be reduced so conversion factor reduced by 1*per year from 2003
For mid range (Scenario 4) a 0.5% change is assumed

Freight figure: assumed all vehicles with a payload of 8.5 tons and a total weight of 14 tons. Calculations derived from Volvo calculations giving typical fuel consumption values for a truck with above assumptions at 20-25 litres/100km empty and 25-30 liters/100km full load.
(fuel consumption= .25litres/km) X (diesel fuel rating = 38.6mj/litre) = 9.65mj/km

LRT figure: Energy use 40 mj/km taken from Vital Travel Statistics (Potter, 1997) with a minor allowance for technology improvements over the period 1997 to 2005 from 47 to 40 mj/km

Bus figure: energy use taken from Vital Travel Statistics (Potter, 1997) - factored according to same % improvement as CO2

Rail Figure: energy use 145mj/km taken from Vital Travel Statistics (Potter, 1997) - factored according to same % improvement as CO2

A1.3 Direct Impacts on Health

A1.3.1 Exceedences of Air Quality Objectives NO_x and/or PM_{10}

1. Outcome of the NO_x calculations combined with data from metropolitan area Air Quality Management plan projected reductions necessary for key nodal areas to meet targets.
2. Model outputs of NO_x were compared w/ reductions necessary to calculate number of exceedences for year. Several of the zones from the LUTI model corresponded well with Air Quality Management Zones. It was therefore possible to make a direct comparison of the number of zones within which the emission reductions were achieved.

A1.4 Local Quality of Life

A1.4.1 Number of residences exposed to aircraft noise above 57 LAeq,T

1. Current and forecasted data for development of land around area and possible airport expansions. Current data on noise exposure from airport sources w/ suitable forecast for improvements from technology/degradations from increased air traffic.
2. Large amount of data collection and prediction beyond the feasibility of this research. In particular, noise calculations require a detailed network model which the LUTI model does not have.

A1.4.2 Number of residences exposed to noise above 55dBA

1. Current baseline data and traffic levels.
2. Data not currently available.

A1.5 Environmental Capital

A1.5.1 Qualitative Environmental Capital score disaggregated by: Landscape, Townscape, Heritage of Historic resources, Biodiversity, and Water Quality.

1. Metropolitan area's SEA
2. Data only available for baseline test 'A'

A2 Economy Indicators

A2.1 Standard of Living

A2.1.1 Real GDP per Capita based on:

- ***In the short term* – proxied by net benefits measured in the transport sector using WebTAG methods**

1) Data was supplied by consultants including:

  - outputs from the Metropolitan area Strategic Planning Model (SPM), including details of the model assumptions and limitations (Kidd, 2006);
  - ballpark estimates of additional investment and operating costs (Ford, 2006).

2) Two tests were carried out:

  - both compared a scenario *with* Public transport investments against a baseline *without* public transport investment;
  - in the first test, the public transport scenario excluded road pricing (Scenario B), and in the second test, the public transport scenario included road pricing in the form of an 'area-based charge' (Scenario C).

Amortization of investment costs was undertaken as follows. The standard amortization formula was applied individually to each year's investment costs, over the period 2005-2016 during which investment would occur.

$$C_A = C\frac{r(1+r)^n}{(1+r)^n - 1}$$

where C is the investment to be amortized;
r is the interest rate;
n is the time period in years;
C_A is the annual amortized amount.

3)

- The interest rate chosen was the Bank of England repo (base) rate, currently 4.50%. This represents the minimum risk-free rate at which Government can borrow funds, although commercial borrowers would pay a higher rate. Amortization has something is common with discounting in conventional appraisal, however, note that in this case the total amortized amount will be larger than the initial amount, *C*, in the same way that the total repayments and interest on a mortgage are greater than the sum borrowed.

- The period *n* is set at 60 years, starting from the opening of the first main block of investment in 2011, matching the typical appraisal period for transport infrastructure assets. Some of the preliminary expenditures are, as a result, amortized over slightly longer than 60 years.

- Safety is omitted from the calculations – missing from the model outputs;
- the results are moderately sensitive to the interest rate used for amortization – for example, a 3.5% rate reduces the capital charge in 2021 to £88 million (B) or £96 million (C), so increasing the economy indicator to +£64 million and +£102 million respectively, and a rate of 7% is needed to turn the economy indicator negative (for B) or 9% for C;
- we have already noted that the investment costs and additional operating costs for B and C are 'ball park' figures provided by MVA and should therefore be treated with caution.

A3 Society Indicators

A3.1 Poverty

A3.1.1 Average cost of journey to key destinations

1. Model that allows a working cost function to be used w/ origin and destination to key locations. Accurate income data.
2. Accession software does not support cost function in part due to the complexity of ticketing arrangements between operators.

A3.2 Accessibility

A3.2.1 Weighted journey times by car and public transport to:

- **key centres of employment (over 500)**
- **primary, secondary and further education facilities**
- **GP**
- **Key food shops**

1. Location, road and PT data from Metropolitan area, imputed into Accession model as well as 2001 census data and boundaries from Casweb and UKborders.
2. Accession: Network accessibility Calculations run for each destination in separate tests for Car and PT.
3. All runs have a 1.5km maximum connection distance and the road node spacing was increased to be every 200m.

    - 2001 census data for the origin grid was clipped to the Metropolitan area (SPM 47 zone) boundary. PT networks clipped to this same boundary.

    - Origin Grid spacing was set at 1000m, no additional points added when combining with census data.

    - Time of Day used for PT runs for each destination is
        i. Education: Mon 7-9AM
        ii. Shops 12-2PM
        iii. Health: Mon 10-12 (typical morning appointment time range)
        iv. Work: Mon 7-9AM
    - In the car runs a speed of 10km/h on private restricted roads (formally 0) to try and eliminate any strange 'holes' in contour maps. The speed reductions that were made for cars for each of the runs are based on peak times:

Accession Speed Reductions (km/h)

	IZ base(70% of current speeds)	IZ 2021(9.2% reduction from base)	JF 2021(5.9% reduction from base)	JH 2021(3.3% reduction from base)
Motorway	78.841	68.479	72.198	75.124
A road	67.578	58.696	61.882	64.392
B road	45.052	39.130	41.254	42.928

Minor road/ Local road/Private unrestricted	33.789	29.348	30.941	32.196
Private Restricted	10	10	10	10

- PT investments were added in as new lines and routes using existing stops. Timetables were created based off existing times for similar modes/distances.
- Average journey times were taken from Access queries and represent as many destinations as possible from one origin before the threshold value of 60 minutes. These comparisons should be the same (within mode) as query linked origin and destination ID and then took all values from 2 runs <61.
- Threshold times show closest destination to origin times. (explaining why average journey time can be longer than the threshold)

A3.3 Safety

A3.3.1 Killed and Seriously Injured

Proxy measure for Safety: Estimate in accident rate given increase in flows to keep KSI and slight casualties constant.

1. Metropolitan current statistics and targets for KSI and Slight Casualties; Model outputs for flow.
2. The method is as follows:

Metropolitan Area has targets of KSI and slight casualty levels of 641 and 10798 respectively for 2010. The accident rate for 2010 can therefore be forecast as follows:

(i) KSI accident rate = KSI/Flow 2011 (from ZONE_IM..)
(ii) Slight accident rate = KSI/Flow 2011 (-"-)

For each scenario in 2021 we can also calculate the following

(a) KSI rate to keep KSI's constant = 2010KSI total/(2021 Flow)
(b) Slight rate to keep slights constant = 2010 slight total/(2021 Flow)
% change in accident rate to keep KSI constant = 100*((a)-(i))/(i)

This is essentially some measure related to the changes in flows produced by each scenario. It will provide an estimate of the comparative difficulty of reducing accidents between scenarios (rather than forecasting how many will actually happen).

3. See above.

A3.3.2 Recorded incidences of crime on public transport

1. Forecasted rate of crime for 2021 and forecasted reductions via new programmes and technology.
2. Data not currently available.

A3.4 Walkability

A3.4.1 Percentage of residents living within 1000m or 15-minute 'safe walk'[1] to key destinations.

1. Routings of official safe routes
2. Data not currently available.

[1] Determined by an official safe route. A safe cycle route to these destinations could also be included.

A3.5 Housing

A3.5.1 Real lowest 10%value of house prices within X minutes (based on average local journey times to employment) of: a) the town centre b) Key centres of employment.

1. Data on current and forecasted house prices
2. Difficulty of forecasting house prices.

References

Brand, Christian. (2005) Methodology Report, Integrated Travel Emissions Profiles. University of Oxford. Online http://www.tsu.ox.ac.uk/oxontravel/reports/ESRC_ITEP_rep2_i2.pdf

Ford A (2006), Information Note 1 'Estimate of Investment Costs of Scenarios', MVA.

Kidd P (2006), Information Note 1 'Rees Jeffreys Work', MVA.

Potter, Stephen. (1997) Vital Transport Statistics. Landor Publishing, London

NETCEN. (2003) Vehicle speed emissions factors. NAEI online http://www.naei.org.uk/other/vehicle_emissions_v8.xls

NETCEN. (2003) UK fleet composition projections. NAEI online http://www.naei.org.uk/other/uk_fleet_composition_projections_v2.xls

Mårtensson, Lars. (2003) Emissions from Volvo's trucks (standard diesel fuel) (Memo# 20640/03-017)

CASWEB online http://census.ac.uk/casweb/

UK Borders online http://edina.ac.uk/ukborders/