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Methodology for Estimating Fuel Consumption by Road Transport in the Greenhouse Gas Inventory Programme: Changes Made from 2005 GHGI

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Introduction

In the Greenhouse Gas Inventory (GHGI) and National Atmospheric Emissions Inventory (NAEI) programmes for DEFRA (Department for Environment, Food and Rural Affairs), a time-series of fuel consumption by road transport is calculated using a bottom-up method by combining fuel consumption factors (in g fuel/km) for many different types of vehicles with traffic activity data provided by DfT (Department for Transport). The fuel consumption factors take account of size of vehicle, technology (usually introduced to control air pollutant emissions, but which can affect fuel efficiency) and the type of driving cycles characteristic of different road conditions, e.g. whether slow urban driving or high speed motorway conditions.

The bottom-up calculated fuel consumption derived for each year is compared against the values of petrol and diesel consumption reported in the Digest of UK Energy Statistics (DUKES). The figures differ for a variety of reasons, partly reflecting modelling uncertainty and partly reflecting the difference between actual fuel consumption on UK roads and the amount of fuel actually purchased in the UK (as indicated by the figures in DUKES) that will be influenced by cross-border fuel purchasing patterns, hereafter referred to as 'fuel tourism'. The contribution that the effects of model uncertainty and fuel tourism make to the difference between DUKES and calculated values of fuel consumption cannot currently be quantified.

In the GHGI/NAEI, the international guidelines for reporting CO_2 emissions state that emissions must be based on the amount of fuel purchased in each country. For example, in the IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, it states "*the IPCC is bound to the principle of political responsibility (allocation according to fuel sale)……. National totals [of CO_2 from road transport] must be on the basis of fuel sales*". To satisfy this requirement, the GHGI therefore applies a normalisation procedure to the calculated fuel consumption (and hence CO_2 emissions) to ensure they add up to the figures for petrol and diesel consumption reported in DUKES.

The fuel consumption factors for individual types of vehicles used in the ***mapping and Local Authority assessments*** are combined with traffic data ***without any further normalisation***. This is deliberate, to ensure that fuel consumed, for example, by lorries that purchased fuel overseas before entering the UK ***are*** included in the Local Authority figures. However, the decision to do this means that the link between the fuel consumption calculated for the whole of the UK, by summing up local fuel consumed by each vehicle type area-by-area, and the figures reported in DUKES is broken and, importantly, the figures produced each year will reflect methodological changes, such as changes in fuel consumption rates, as much as it reflects changes in real levels of activity between different years.

The total UK fuel consumption and CO_2 emission figures reported to Defra and DfT each year are not affected by any methodological changes (at least not at the top level, though there could be a re-distribution of the same total amount of fuel consumed between different vehicle types) because the total fuel consumption is forced to sum up to the figures in DUKES. Furthermore, a full time-series of UK fuel consumption/CO_2 emissions (from 1990 onwards) is generated each year for the GHGI/NAEI figures reported to Defra and DfT based on the same methodology, so in any given inventory version, data for different years can be compared against one another and reflect real differences in activity levels. This is not ***currently*** the

case for the mapping results, where figures for a previous year have not usually been updated to be consistent with the latest year's methodology.

Methodological changes made in the 2006 GHGI

It has to be understood at the outset that we are not dealing with an exact science here. The amount of fuel that a vehicle consumes in travelling a certain distance depends on many parameters. Most important is the driving cycle, how much stopping and starting a vehicle does, how aggressively the vehicle is driven, how much the vehicle is loaded (i.e. how heavy it is), how maintained it is, tyre inflation and use of air conditioning etc. It is impossible to know about all these parameters for every vehicle on the road and averages have to be used for what are in fact quite variable rates of fuel consumption for different groups of vehicle types.

The fuel consumption factors used in the GHGI/NAEI calculations are polynomial functions expressing the relationship between fuel consumption rate and average vehicle speed for each class of vehicle. These are based on measurements of fuel consumption and emission rates for samples of in-service vehicles taken off the road and tested under controlled laboratory conditions over a range of different operational drive cycles. The factors we use come largely from a database of 'real world' test data held by TRL, but we have had to fill in gaps using sound judgement, especially for more modern classes of vehicles and technologies that have yet to be tested. This is especially the case for large HGVs and buses where the test sample size is small; it is very expensive to carry out these tests and they require special facilities. Using average speed of a vehicle is itself a fairly crude, but so far the only kind of indicator to the way a vehicle operates. There could be many different cycles, all with the same average speed, that have different amounts of acceleration and deceleration built into them and for each of these, the fuel consumption rate will be very different.

This year we revised some of the fuel consumption factors used in the model based on new data and better understanding of the effects of technology. Some changes were made to those factors that had previously been estimated after discussions with engineers at DfT. Another important revision was made to the fuel consumption rates used for HGVs. More direct use was made of statistics published by DfT from an annual survey of hauliers on the average miles per gallon of lorries of different sizes. These data would be based on a larger and probably more representative sample of HGVs than the test data previously used and will reflect the types of conditions actually experienced on UK roads, including for example the typical load factor (a measure of how fully loaded a vehicle is by weight). The data published each year by DfT give a complete time-series of fuel efficiency of lorries and were used in conjunction with existing fuel consumption-speed relationships to estimate fuel consumption by different types of lorries on different types of roads.

From the above, it should be possible to appreciate why there are uncertainties in the estimation of fuel consumption by road vehicles in the UK when calculated using a detailed bottom-up method in conjunction with traffic data.

In previous years, it had always been the case that our calculated UK fuel consumption exceeded the figures quoted in DUKES. In the 2005 version of the inventory, the calculated consumption of diesel exceeded the DUKES figure for 2005 by 17% and for petrol by 12%. Using the new fuel consumption factors in this year's inventory has considerably closed the gap so that now the calculated total for diesel consumption in 2005 is ***3% less*** than the DUKES figure and the calculated total for petrol consumption is ***2% more*** than the DUKES figure; the comparisons between model and DUKES figures are similar for 2006 and in fact for many earlier years.

The changes made to the fuel consumption factors have also affected the distribution of fuel used by different vehicle types and Table 1 shows the breakdown in the ***pre-normalised***, calculated values of fuel consumption by vehicle type for 2005 based on last year's (2005) version of the inventory (2005 GHGI) and the figures for 2005 and 2006 from this year's version of the inventory (2006 GHGI). So comparing this year's figures for 2005 and last

year's gives an indication of the affect of methodological changes; comparing this year's figure for 2005 and the figure for 2006 gives an indication of 'actual' changes in fuel consumption between these years due to changes in traffic and fuel efficiencies of vehicles.

Table 1: Fuel consumption calculated in the 2005 and 2006 versions of the GHGI from traffic data and fuel consumption factors for individual types of vehicles. No normalisation applied to results to match with data in DUKES.

		2005 GHGI	2006 GHGI	
Mt fuel		**2005**	**2005**	**2006**
Cars	Petrol	19.97	18.07	17.70
	DERV	4.89	4.36	4.68
	All Cars	24.86	22.42	22.38
LGV	Petrol	0.50	0.45	0.45
	DERV	5.78	5.15	5.23
	All LGV	6.27	5.59	5.68
HGV	Artic	7.16	4.12	4.19
HGV	Rigid	3.54	3.93	3.97
ALL HGV		10.71	8.05	8.16
Buses		1.35	1.35	1.38
Motorcycles		0.16	0.16	0.15
All DERV		22.72	18.90	19.46
All Petrol		20.62	18.68	18.29
All Vehicles		**43.34**	**37.57**	**37.76**

Fuel tourism

The question might arise as to what this means about the magnitude of fuel tourism? Many people had jumped to the conclusion that because the GHGI calculated fuel consumption was higher then the figures in DUKES, therefore the difference was due to fuel tourism. It is true that the differences were in the right direction to support this conclusion and the fact that the estimation of diesel consumption was further away from the DUKES figure than was the estimation for petrol consumption lends support to this since one would imagine hauliers taking steps to purchase fuel on the continent to a greater extent than private motorists who are main consumers of petrol. However, model uncertainty must always have been a contributing factor. The fact that the calculated fuel consumption is now so much closer to the DUKES figures is encouraging, especially as the trend seems to be consistent over a long time series. One would certainly anticipate that the changes in the vehicle fuel consumption factors made this year would lead to better model agreement with DUKES fuel consumption data, but whether the closure of the gap now means that fuel tourism is actually a small effect or whether there is a cancellation of effects (fuel tourism being offset by a systematic model underprediction of fuel consumption due to model uncertainty) is not clear. We simply do not know.

Implications to estimates of fuel consumption at local authority level

The changes made to the fuel consumption factors used in this year's inventory will manifest themselves differently in different areas and local authority regions. The changes apparent in

each Local Authority would need to be interpreted in their own right. The fuel consumption factors were modified to varying degrees for different vehicle types – some were changed considerably, while others were hardly changed at all. Therefore the overall impacts of the changes in a given local authority region will depend on the mix of vehicles in the area. An area where there is a higher proportion of traffic on motorways or major trunk roads will, overall, be influenced by changes made to the fuel consumption factors for HGVs to a greater extent than in areas where there is less HGV activity where changes in the factors for cars will have a stronger influence.

Concluding remarks

The GHGI/NAEI programme is continuously looking to update and improve methodology and emission and fuel consumption factors as more information becomes available.