

The evaluation of the effect on fuel consumption of taxi roof signs Undertaken of behalf of West Berkshire and Wokingham Environmental Health and Licensing Service by Dr T Barlow, TRL, Crowthorne, 7 March 2013

1 Introduction

An analysis has been carried to evaluate the effect of signs fitted to the roofs of taxis to determine their effect on the vehicle's fuel consumption. For this work the PHEM emissions model (version 10.4.2) has been used. This input to this model is a vehicle specification file, containing vehicle details such an mass, power and frontal size etc. The model is run over one or more drive cycles – each cycle consisting of the second by second speed data. The PHEM model using vehicle dynamics to determine the load on the engine and the engine speed for each one second step, determines the emission and fuel consumption at each step then summates them over the cycle.

2 Input data

The PHEM model requires a number of inputs. This includes the vehicle specification and speed traces described in the section below.

Additional inputs include emission maps – for all of the analysis the maps for Euro 4 vehicles have been used (which cover, approximately, model years 2005 up to 2010). Other Euro classes may give slightly different absolute results, though relative changes are likely to be very similar.

2.1 Vehicle data

The evaluation was carried out on two car models popular in the taxi fleet:

- Ford Mondeo
- Fiat Doblo

The parameters used from these vehicles are shown in Table 1

Vehicle	Power (bhp)	Power (kW)	Width (mm)	Height (mm)	Kerb weight (kg)	A (m ²)
2.0 TDCi (115bhp) ZetecMondaeo (10/10 on) 5d	138	102.9	2092	1500	1557	2.824
Allied Vehicles - Fiat Doblo taxi	105	78.3	1832	2100	1410	3.462

Table 1. Vehicle specifications

Sources:

Mondeo: <u>http://www.parkers.co.uk/cars/reviews/facts-and-figures/</u> Doblo: <u>http://www.cabdirect.com/vehicles/freedom/</u>



The parameter "A" – the frontal cross sectional area – has been calculated as 0.9 of the product of height and width.

In both cases, the evaluation has been carried out with a load of 140kg, representing the weight of the driver and one passenger.

The sizes of the various taxis signs are shown in Table 2.

Sign	Length (mm)	Height (mm)	Area (m²)
Old sign	625	150	0.0938
New sign (large)	605	110	0.0666
New sign (small)	460	120	0.0552

Table 2.Taxi sign sizes

For each vehicle, 4 scenarios were run:

- 1. Without any sign
- 2. With the old sign
- 3. With the new large sign
- 4. With the new small sign

For the 4 scenarios, the input data remain constants for each vehicle apart from the cross section area as shown in Table 3. Although the sign for the Doblo is actually fitted to the bulkhead, an increase in area has been assumed to evaluated the worst case.

Table 3. Vehicle frontal areas for the different options

Vehicle	Base area (m²)	With old sign (m²)	With new sign (large) (m ²)	With new sign (small) (m ²)
2.0 TDCi (115bhp) ZetecMondaeo (10/10 on) 5d	2.824	2.918	2.891	2.879
Allied Vehicles - Fiat Doblo taxi	3.462	3.556	3.529	3.518

2.2 Drive cycles

As the aerodynamics effects would vary with the speed of the vehicle, a large number of different test cycles were used in the evaluated. These cycles were from real data logged from cars in normal use. A total of 122 cycles were used, including urban, congested urban, suburban, rural and motorway driving. The average speed varied from 2.9 km/h to 118.7 km.h.

3 Results

The resulting fuel consumption rates in I/100km are shown plotted against the average speed of the input cycle (km/h) in Figure 1 and Figure 2 for the Fiat Doblo and the Ford





Mondeo respectively. Each graph shows the four scenarios. A trend line has been fitted to each set of data, although they lie on top of one another.





Figure 2. Ford Mondeo results



To show the change in fuel consumption, the results were grouped into speed bands. The results are shown in Table 4and Table 5for the Fiat Doblo and the Ford Mondeo respectively. In both cases, the addition of a sign to the vehicle has a tiny effect in typical urban driving conditions (i.e. up to 40 km/h). For motorway driving (over 100 km/h) there is a small effect due to the signs.

	Average fuel consumption (1/100km)				Chang	e relative sign"	to "No
Speed range (km/h)	No sign	Old sign	New sign (large)	New sign (small)	Old sign	New sign (large)	New sign (small)
0 to 20	11.94	11.95	11.94	11.94	0.05%	0.03%	0.03%
20 to 40	7.12	7.14	7.14	7.14	0.27%	0.20%	0.18%
40 to 60	6.57	6.62	6.61	6.60	0.77%	0.59%	0.45%
60 to 80	6.21	6.26	6.25	6.24	0.86%	0.56%	0.50%
80 to 100	6.34	6.41	6.39	6.38	1.16%	0.83%	0.70%
100 to 120	7.16	7.25	7.22	7.21	1.22%	0.87%	0.73%

Table 4. Banded results for the Fiat Doblo

Table 5. Banded results for the FordMondeo

	Average fuel consumption (I/100km)				Chang	e relative sign"	to "No
Speed range (km/h)	No sign	Old sign	New sign (large)	New sign (small)	Old sign	New sign (large)	New sign (small)
0 to 20	14.85	14.86	14.86	14.86	0.06%	0.05%	0.02%
20 to 40	8.41	8.43	8.42	8.42	0.21%	0.16%	0.12%
40 to 60	7.34	7.38	7.37	7.36	0.53%	0.41%	0.32%
60 to 80	6.68	6.73	6.72	6.71	0.84%	0.63%	0.55%
80 to 100	6.53	6.62	6.60	6.59	1.28%	1.00%	0.86%
100 to 120	7.10	7.23	7.19	7.18	1.82%	1.24%	1.11%

4 Notes

In the analysis, only the cross section area of the vehicle has been modified. The additional of the sign may also change the drag coefficient (C_d) of the vehicle. This could be further evaluated through the use of coast-down tests on a test track.