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Changes in VED – modelling

The aim of the modelling exercise is to help gain an understanding of whether increases in differential between VED bands would help the UK achieve its:
1) two targets relating to lower carbon cars[1]
2) commitment to a 20% reduction in carbon emissions by 2010.

Base Case
To help model the impact that changes in the differential between bands would have, two 'base cases' were developed. These used current new vehicle purchase data as a starting point and factored this data up to take into account annual expected efficiency improvements and anticipated changes in purchasing patterns. The new vehicle data was for both private and company cars and differentiated by CO_2 emissions (SMMT, 2004). An example of the data used is provided below in Table 1.

Table 1 Company car New Vehicles - Total Registrations 2004 by CO2 (g/km)

Sales Type	CO2 (g/km)	Total Registrations 2004
Company	80	2.00
Company	87	4
Company	104	572
Company	107	432
Company	109	1425
Company	110	1373

Source: Society of Motor Manufacturers and Traders (2004)

The assumptions used with regard to efficiency and purchasing patterns are based on historic trends and differentiate between company and private vehicles. Assumptions are detailed below in tables 2 and 3. Table 2 assumptions reflect that efficiency gains are easier in larger less fuel-efficient vehicles than smaller vehicles.

Table 2 Assumptions regarding efficiency improvements

Vehicles (emissions per kilometre)	Efficiency improvements per annum	
	Base 1 (more improvements)	Base 2 (less improvements)
Less than 150 grams	1.50%	0.50
Between 151 to 200 grams	2.00%	0.75
Between 201 to 250 grams	2.00%	0.75
Greater than 251 grams	2.50%	1.00

[1] These are the DfT's Powering Future Vehicles Strategy target that 10% of new vehicle sales will be cars that offer 100g carbon dioxide per vehicle kilometre or lower by 2012, and the EU wide voluntary agreement that by 2008 average carbon emissions for new vehicles will be 140 g carbon dioxide per vehicle kilometre.

Table 3 Assumptions regarding changes in purchasing patterns (increases in the number of vehicles per annum)

	Base Case 1 (more efficiency improvements)		Base Case 2 (less efficiency improvements)	
Current vehicle emissions (per kilometre)	Company	Private	Company	Private
Less than 150 grams	3.00%	5.00%	2.00%	3.50%
Between 151 to 200 grams	2.00%	1.00%	1.00%	1.00%
Between 201 to 250 grams	1.00%	1.00%	1.00%	1.00%
Greater than 251 grams	2.00%	4.00%	2.00%	3.50%

Summary results from the development of the base data spreadsheet model are shown in Table 3 and Table 4.

Table 3 reflects the trend for the purchase of smaller and larger vehicles particularly in the private car. It also reflects the overall increase in the purchase of new cars.

Table 4 - Company Car registrations by VED band for 2008 and 2012 under base case 1 and 2 (i.e. assuming efficiency improvements and changes in purchasing patterns)

VED band	CO_2 emission figure grams per kilometre	2004*	2008 Base Case 1	2008 Base Case 2	2012 Base Case 1	2012 Base Case 2
AAA	Up to 100	6	651	6.5	12814	1959
AA	101-120	39425	90898	52779	154737	72817
A	121-150	394506	737109	597760	1018172	679714
B	151-165	351470	240890	255159	238944	198214
C	166-185	261414	227940	271167	123915	178963
D	185 +	320382	204192	268927	132459	301492
Total		1367203	1501680	1445799	1681041	1547546
Average carbon emissions		168.93	156.24	164.10	144.91	159.36
Percentage of vehicles under 100g CO2/Km		0.0004	0.04	0.0004	0.35	0.04

* source data obtained from Society of Motor Manufacturers and Traders Ltd

Table 5 - Private Car registrations by VED band under base case 1 and 2
(i.e. assuming efficiency improvements and changes in purchasing patterns)

VED band	CO_2 emission figure grams per kilometre	2004*	2008 Base Case 1	2008 Base Case 2	2012 Base Case 1	2012 Base Case 2
AAA	Up to 100	475	1809	545	17997	1959
AA	101-120	41229	86883	57773	165187	72817
A	121-150	377472	667605	536214	902634	679714
B	151-165	255032	167096	203909	165965	198214
C	166-185	180681	157051	188832	109627	178963
D	185 +	345177	270465	318254	196679	301492
Total number of vehicles purchased		1200066	1350910	1305528	1558089	1433159
Average carbon emissions		174.24	160.2	168.82	147.52	163.54
Percentage of vehicles under 100g CO2/Km		0.040	0.13	0.04	1.16	0.14

Changes in VED
Two scenarios were developed and utilised to help assess the impact that changes in VED might have. Key features of the scenarios are

Table 6 Key features of VED change scenarios

Scenario 1	Scenario 2
Introduction of a new top band E (220 +)	Introduction of a new top band E (220 +)
All car registrations are potentially impacted	Only cars in the bottom and top 10 grams of a band are impacted
Percentage change between impacted cars is detailed in Table 7	Percentage change between impacted cars is detailed in Table 12. Higher than scenario 1
Impact differs depending on size of vehicle	Impact differs depending on size of vehicle

Scenario 2 with its impact on the bottom and top 10 grams of each band can be considered a more 'pessimistic' scenario and Scenario 1 a more 'optimistic scenario'. The scenarios, and their impact on the two base cases are detailed below.

Scenario 1
Scenario 1 assumes that all vehicles within a band are potentially impacted by changes in VED. I.e. vehicles at the top end of band are as likely to move to the band below as vehicles at the bottom end of the band.

It assumes that significant change in the VED differential between bands would result in a substantial movement between bands. The assumption is based on Mori research (DfT, 2003), which suggests that if there were a £300 differential between each VED band 72% of people would swap bands. The research also suggests that people who currently own a larger vehicle would be less likely to swap. The research was used to inform the development of our assumptions (Table 7).

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Furthermore, band D would change from covering all vehicles greater than 186 grams of carbon dioxide per vehicle kilometre to covering vehicles in the range 186 – 220. A new top band E was introduced which would cover all vehicles greater than 221 grams of carbon dioxide per kilometre. Here we assume that vehicles in the range 220-240 would potentially move to band D.

Table 7 Percentage Change assumed in Scenario 1

From	To	Percentage change
AA	AAA	60%
A	AA	60%
B	A	50%
C	B	50%
D now (186-220)	C	40%
New band E (220 +)	D	40%

The new vehicles purchases, which are transferred to the lower bands, are distributed according to the number of vehicles in the different carbon categories. I.e. the higher the number of existing vehicles the more likely it is people would purchase it if they were moving to the lower band.

Table 8 - Scenario 1 – impact of changes in VED on Company cars

		2008 Base Case 1	2008 Base Case 2	2012 Base Case 1	2012 Base Case 2
AAA	Up to 100	55375	31674	102886	40107
AA	101-120	478563	379768	675568	467777
A	121-150	415165	366684	526741	428132
B	151-165	234415	263163	183912	257236
C	166-185	166399	204548	98607	180361
D	186 - 220	93873	117798	62350	102029
E	221 plus	57889	82164	30979	71921
Total number of cars		1501680	1445799	1681041	1547564
Average carbon emissions		144.28	152.18	132.48	147.20
Percentage of cars under 100 gram CO2 per km		3.69	2.19	6.12	2.59

Table 9 - Scenario 1 – impact of changes in VED on Private cars

		2008 Base Case 1	2008 Base Case 2	2012 Base Case 1	2012 Base Case 2
AAA	Up to 100	54122	35209	114063	45650
AA	101-120	435255	344838	610701	436955
A	121-150	350468	316440	444036	370993
B	151-165	162074	196371	141182	189822
C	166-185	137255	161437	101185	151646
D	186 - 220	109780	119297	85057	114305
E	221 plus	101956	131936	61865	123788
Total Number of cars		1350910	1305528	1558089	1433159
Average carbon emissions		148.08	157.11	135.66	151.51
Percentage of cars under 100 gram CO2 per km		4.01	2.70	7.32	3.19

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Table 10 - Scenario 1 – Company car - difference in average carbon emissions (comparison with base case)

	2008		2012	
	Base Case 1	Base Case 2	Base Case 1	Base Case 2
Base Case	156.24	164.10	144.91	159.36
Scenario 1 Average carbon emissions	144.28	152.18	132.48	147.20
Difference	11.96	11.92	12.43	12.16

Table 11 – Scenario 1 – Private car – difference in average carbon emissions (comparison with base case)

	2008		2012	
	Base Case 1	Base Case 2	Base Case 1	Base Case 2
Base Case	160.20	168.82	147.52	163.54
Scenario 1 Average carbon emissions	148.08	157.11	135.66	151.51
Difference	12.12	11.71	11.86	12.03

Scenario 2

Scenario 2 assumes that movements between bands would only be from the lowest 10 grams of a band to the highest 10 grams of the band below. The proportions of movement between these sections of the bands are detailed in Table 12. The percentage change is slightly higher than that used in Scenario to reflect that the application of the percentage change applies to a much smaller number of vehicles.

Table 12 – Scenario 2 changes in Vehicle purchasing patterns due to changes in VED

From	To	Percentage change
AA	AAA	70%
A	AA	70%
B	A	60%
C	B	50%
D now (186-220)	C	50%
New band E (220 +)	D	40%

As with Scenario 1 a new band D would change from covering all vehicles greater than 186 grams of carbon dioxide per vehicle kilometre to covering vehicles in the range 186 – 220. A new band E would be introduced which would cover all vehicles greater than 221 grams of carbon dioxide per kilometre

Table 13 - Scenario 2 – impact of changes in VED on company cars

		2008 Base Case 1	2008 Base Case 2	2012 Base Case 1	2012 Base Case 2
AAA	Up to 100	23584	6.49	51378	12396
AA	101-120	143208	92853	294988	115499
A	121-150	769986	660542	940051	783188
B	151-165	208969	225021	172586	230647
C	166-185	185716	234896	108936	205781
D	186 - 220	104692	142522	76537	119842
E	221 plus	65525	89960	36566	80211
Total number of cars		1501680	1445799	1681041	1547564
Average carbon emissions		153.99	162.16	142.67	157.30
Percentage of cars under 100 gram CO2 per km		1.57	0.0005	3.05	0.80

Table 14 – Scenario 2 - impact of changes in VED on private cars

		2008 Base Case 1	2008 Base Case 2	2012 Base Case 1	2012 Base Case 2
AAA	Up to 100	23343	545	60954	15472
AA	101-120	150237	89860	339664	121247
A	121-150	654757	597846	748347	704243
B	151-165	149738	159837	128915	160350
C	166-185	135932	163029	110174	160676
D	186 - 220	127739	153571	97440	136517
E	221 plus	109163	140840	72596	134653
Total Number of cars		1350910	1305528	1558089	1433159
Average carbon emissions		157.88	167.24	145.17	161.68
Percentage of cars under 100 gram CO2 per km		1.73	0.04	3.91	1.08

Table 15 - Scenario 2 – impact of changes in VED on company cars

	2008		2012	
	Base Case 1	Base Case 2	Base Case 1	Base Case 2
Base Case	156.24	164.10	144.91	159.36
Scenario 2 Average carbon emissions	153.99	162.16	142.67	157.30
Difference	2.25	1.94	2.24	2.06

Table 16 - Scenario 2 – impact of changes in VED on private cars

	2008		2012	
	Base Case 1	Base Case 2	Base Case 1	Base Case 2
Base Case	160.20	168.82	147.52	163.54
Scenario 2 Average carbon emissions	157.88	167.24	145.17	161.68
Difference	2.32	1.58	2.35	1.86

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Results

Table 17 Percentage of vehicles which are 100g of CO_2/km or lower in 2012

	Base Case 1	Average (weighted to take into account number of vehicles)	Base Case 2	Average (weighted to take into account number of vehicles)
No change in VED				
Company	0.35	0.73	0.044	0.09
Private	1.16		0.14	
Scenario 1				
Company	6.12	6.69	2.59	2.87
Private	7.32		3.19	
Scenario 2				
Company	3.06	3.47	0.80	0.93
Private	3.91		1.08	

Commitment to a 20% reduction in carbon emissions by 2010

We have modelled the impact of changes in VED under two different scenarios and base cases. A more 'optimistic' scenario (1) and more 'pessimistic' scenario (2) have been tested. The results suggest that average carbon reductions in the range of 2 grams/km/vehicle to 12 grams/km/vehicle may be possible. Below we have modelled the impact that this would have on overall carbon emission reductions, by examining the number of vehicle kilometres that would be impacted under two scenarios. Table 18 assumes that the percentage of vehicles impacted is related to the replacement of the vehicle stock by new vehicles. New vehicles take up 10% of vehicle stock. It is assumed that people drive the average number of kilometres. I.e. 10% of the vehicle stock is replaced each year and this correspondingly impacts on vehicle kilometres - 10% in 2008, 20% in 2009, and 30% in 2010. Table 19 takes into account that it is highly probable that new car owners (private and company) will drive more than the average number of kilometres.

Table 18 New car vehicle purchases – average emissions in 2008

	Base Case 1	Average (weighted to take into account number of vehicles)	Base Case 2	Average (weighted to take into account number of vehicles)
No change in VED				
Company	156.24	158.10	164.10	166.34
Private	160.20		168.82	
Scenario 1				
Company	144.28	146.04	152.18	154.51
Private	148.08		157.11	
Scenario 2				
Company	153.99	155.83	162.16	164.57
Private	157.88		167.24	

Table 19 Overall impact on carbon emissions

	2008	2010	2012	2015
Total vehicle kilometre (billion) [2]	418	431	443	461
Percentage of Vehicle kilometres impacted	10%	30%	50%	80%
Number of vehicle kilometre impacted (billion)	41.8	129.30	221.5	368.8
CO2 saving per vehicle kilometre and impact in terms of MtC*				
2 grams				
Saving in MtC	0.02	0.07	0.12	0.15
5 grams				
Saving in MtC	0.06	0.18	0.30	0.38
7 grams				
Saving in MtC	0.08	0.25	0.42	0.52
10 grams				
Saving in MtC	0.11	0.35	0.60	0.75
12 grams				
Saving in MtC	0.14	0.42	0.72	0.91

[2] Based on National Road Traffic Forecast central estimates

Table 20 Potential MtC savings under a number of gram reduction per vehicle kilometre

	2008	2010	2012	2015
Total Billion vehicle kilometre	418	431	443	461
Percentage of vehicle kilometre impacted	20%	60%	80%	100%
Number of vehicle kilometre impacted (billion)	83.6	258.6	354.4	461
CO_2 saving per vehicle kilometre and impact				
2 grams				
Saving in MtC	0.05	0.14	0.19	0.25
5 grams				
Saving in MtC	0.11	0.35	0.48	0.63
7 grams				
Saving in MtC	0.16	0.49	0.67	0.88
10 grams				
Saving in MtC	0.23	0.71	0.97	1.25
12 grams				
Saving in MtC	0.27	0.85	1.16	1.51

* Calculation of MtC – Example
Billion car vehicle kilometres x carbon dioxide (grams) saving per kilometre

41.8 x 2 = 83600000000 grams of carbon dioxide

Conversion into tonnes = 83600000000 / 1000000
= 83600 tonnes of carbon dioxide

Conversion into million tonnes = 83600/ 1000000
= 0.0836 million tonnes of carbon dioxide

Conversion into tonnes of carbon = 0.0836 x 12 / 44 (atomic mass of C (12) / (atomic mass of CO_2 (12 + 16 + 16)

= 0.0228

Limitations

The aim of the above analysis was to gain an understanding of the impact of changes in VED. The approach used is relatively simple but thought appropriate given the timescale available. We are aware that there are limitations to the approach some of which are detailed below:

- The sensitivity range for the base case could be widened.
- There has been no feasibility 'check' on movement between bands – e.g. in Scenario 2 base case 2 (2008) the model 'assumes' there are no vehicles in the range 90-100 grams there is therefore no movement between band AA and A.
- Scenario 2 assumes movement between lowest 10 grams and highest 10 grams of each band. Smaller ranging bands e.g. B are not treated differently.
- It is assumed that only vehicles in the range 220 to 240 (new band E) will move to the lower band D. This is the case in both Scenarios. It is plausible that vehicles that are much higher emitting could also move to the lower band.

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- Does not account for impact on second hand market
- Assumes that same impact on company and private vehicles

Reference

Department for Transport (2003) Assessing the Impact of Graduated Vehicle Excise Duty – Quantitative research