Appendix 3 Uncertainty Analysis

An important consideration in the examination of alternative fuels is that most emissions data is highly variable. Thus it is difficult to know, when comparing different fuels, whether observed variations reflect a genuine difference between the two fuels or merely reflect the statistical variability. Beer et al. (2000) stress that this indicates that, wherever possible, comparison between alternative fuels needs to be done on a statistical basis.

Comparing fuels on a statistical basis means that one needs an estimate of both the mean value and the standard deviation of the variable that is being studied. Beer et al. (2000) characterised the uncertainty as the standard deviation divided by the mean value (expressed as a percent). Both these quantities were evaluated on the basis of the measured tailpipe emissions from trucks and buses that Beer et al. (2000) obtained from the US Department of Energy web site.

Tables A3.1 and A3.2 give the percentage uncertainties from Beer et al. (2000). These uncertainties have been reproduced in each chapter of this report, and the uncertainty for the emissions in g/MJ has also been estimated as the average of the two values.

The numerical values of the uncertainties given in Part 2 of the report have been used to determine the uncertainty limits displayed on the bar charts of Part 1 of the report. They also form the basis for the determination of whether fuels are significantly better or worse than the reference fuel, as given in Table 1 of the executive summary.

A3.1 Buses

The uncertainties are tabulated for buses in Table A3.1.

Table A3.1
Uncertainties (in percent) of tailpipe emissions for buses

Fuel	*N*	*f*	CO	THC	NOx	PM	CO_2
BD	11	2.7	37	15	38	61	7
BD20	8	2.3	55		36	50	6
CNG	90	4.6	22	136	72	108	12
Diesel	73	4.4	78	17	27	50	11
E93	6	1.9	66		26	45	7
E95	47	4.0	46	73	35	46	13
LNG	22	3.4	106	11	28	46	8

The smallest uncertainties are associated with CO_2 emissions. This is to be expected because CO_2 can be estimated from fuel usage, which is determined by the engine technology and the mechanical energy required to accomplish the test cycle. The other emissions are trace, unwanted side products. In general, the lowest uncertainties are associated with THC and NOx emissions, and the highest with CO and particulate emissions. The large uncertainties associated with air pollutant emissions from CNG are particularly noticeable. As this fuel is in widespread use in Australian bus fleets, it appears that further analysis is required to reduce the uncertainties associated with CNG emissions and hence enable a more accurate assessment of their air pollution potential.

A3.2 Heavy vehicles other than buses

The uncertainties are tabulated for heavy vehicles other than buses in Table A3.2.

Table A3.2
Uncertainties (in percent) of tailpipe emissions for heavy vehicles other than buses

Fuel	*N*	*f*	CO	THC	NOx	PM	CO_2
BD	8	2.3	106	71	23	81	15
BD35	12	2.8	49		35	54	39
CNG	7	2.2	11		29	17	2
Diesel	33	3.8	144	50	30	39	9
E95	6	1.9	36	17	8	45	15
LNG	18	3.2	18		47	48	6
LSD	8	2.3	80		9	84	11