GREEN CAR GUIDE

FEASIBILITY OF RATING THE ENVIRONMENTAL PERFORMANCE OF VEHICLES IN AUSTRALIA

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for

NSW Sustainable Energy Development Authority (SEDA)

October 2000.

Contents

Disclaimer

The views contained in this report represent those of the author. They do not necessarily represent the views or policy of the New South Wales Government or any organisation.

Introduction

This reports sets out the results of an investigation into the feasibility of rating the environmental performance of vehicles in Australia. It presents options for the implementation of a rating system and consumer guide to the fuel-efficiency and environmental friendliness of new motor vehicles. The primary aim of such a system is to reduce the environmental impact of motor vehicles.

The project was undertaken by Vehicle Design and Research Pty Limited for the NSW Sustainable Energy Development Authority (SEDA). It involved the development of a method of rating the environmental performance of motor vehicles (passenger cars, four-wheel-drives, light commercial vehicles and people movers). Parameters to be considered included fuel efficiency, air pollution emissions, ozone depletion, greenhouse gas emissions, fuel cycle emissions (for example, electric vehicles rated by emissions from electricity production) and impacts arising over the full life cycle of the vehicle, including resources use, recycling and disposal.

Options for implementing the rating system and presenting the results to consumers were also considered.

No testing of vehicles or techniques was undertaken during the project - the focus was primarily on existing data and viable technology.

The main output of the project is a Draft Protocol that sets out a possible methodology and is intended as a discussion document.

Background

Despite tighter pollution control laws (Australian Design Rules) and improved technology there are still substantial differences in the environmental performance of models of motor vehicles. Some vehicles emit substantially less pollutants than those which just meet the pollution control laws. There is also a wide variation in the fuel consumption of motor vehicles.

One method of encouraging the uptake and production of cleaner, more fuel efficient vehicles is to influence consumer buying decisions. This can be achieved by providing consumers with a guide to the fuel-efficiency and environmental friendliness of new vehicles. Overseas examples of this approach are the California Air Resources Board's "Buyers guide to cleaner cars" and the "Green guide to cars and trucks" published by the American Council for an Energy-Efficient Economy .

SEDA is a New South Wales Government agency with a primary mission of reducing greenhouse gas emissions through encouraging sustainable energy technologies. It has introduced programs for energy-smart buildings, industries and equipment, including electrical appliances.

Motor vehicles remain a significant source of greenhouse gases and SEDA is seeking to introduce a Green Rating system to help consumers choose appropriate vehicles.

A review of existing Green Car rating programs is provided in Appendix A.

Other types of consumer guides are available for Australian vehicle purchasers. For example, the Australian New Car Assessment Program (ANCAP) conducts crash tests of new motor vehicles and publishes a crashworthiness rating for consumers.

Consultations

SEDA formed a steering committee comprising representatives from the following organisations: SEDA, Roads and Traffic Authority, Premiers Dept, Environmental Protection Agency, NRMA, Australian Consumers Assoc. and Total Environment Centre.

Several draft documents were circulated by email to the Steering Committee. At the second meeting of the Steering Committee it was decided that members with emissions testing experience would meet to discuss technical issues. The results of that meeting are set out in Appendix B. In addition, a telephone conversation concerning fleet vehicles was held with a senior manager within the Dept of Public Works and Services (DPWS).

Discussions were also held with a representative from Parsons Australia. Parsons operate an independent emissions testing facility at Auburn.

No public announcement of the initiative was made by the NSW Government during the duration of the fact-finding phase of the project. No consultation was therefore undertaken with any organisations not represented on the Steering Committee (other than DPWS and Parsons) during preparation of the draft protocol. Subsequently meetings were held with Federal government and motor industry representatives (see Appendix F).

Environmental impacts of motor vehicles

This section briefly covers environmental issues. Estimates of the contribution from vehicles are from various references and should be regarded as ballpark figures.

The environmental impacts of motor vehicles can be broadly classified into short and long term effects.

Short/medium term and local

Human health and amenity:

- Health impacts of exhaust emissions, including asthma, respiratory diseases, effect on IQ of lead in children, carcinogens, premature mortality.
- Other health impacts, including traffic accidents, loss of urban space for outdoor activities, reduced attractiveness of walking and bicycling, stress from traffic and noise.
- Amenity impacts including reduced accessibility, loss of urban space, congestion and loss of time, noise and vibration, unsightly and intrusive constructions.

Effects on environment

- Impacts on flora, fauna and ecosystems of exhaust emissions, oil, paint, lead, rubber, solvents etc.
- Impacts of road construction and road use, including barriers to species movement, roadkill and effects of recreational off-roading activities.
- Impacts of fuel and materials production including exploration, extraction, refining, manufacture and transport.

- Impacts of the disposal of vehicles including use of land and leakage of damaging substances into the environment.
- Consumption of non-renewal resources in the manufacture and operation of vehicles.

Long term and global

- Greenhouse gases - global climate change
- Stratospheric ozone depletion - increased damage from ultra-violet radiation (the protective ozone layer is at an altitude of around 25km and is unaffected by ground level ozone, which is a pollutant). New western vehicles no longer use ozone-destroying CFC refrigerants in air conditioners but older vehicles remain a concern.
- Particulates - regional cooling and attenuated sunlight (eg decreased crop production)

Sources of pollutants

In the case of conventional vehicles with internal combustion engines exhaust emissions are usually the main source of pollutants. Hydrocarbon emissions in particular also occur during refuelling. Other evaporative emissions are released from various locations on the vehicle, especially after the vehicle stops and the engine bay heats up.

Other sources associated with road vehicles are:

- emissions associated with the production and distribution of fuel and oils (from the oil well to the petrol bowser), including energy consumption,
- emissions associated with manufacture and distribution of the vehicle, including mining, refinement and processing of raw materials, energy-related emissions and pollution associated with manufacturing such as paints, catalytic converters and water treatment.
- emissions associated with alternative fuel vehicles, such as energy-related emissions associated with electric vehicles,
- emissions and other pollution associated with disposal of vehicles. This may be partially offset by recycling programs.

Figure D1 in Appendix D gives a more comprehensive outline of sources of emissions.

Other environmental concerns

Noise affects other road users and residences or businesses adjacent to transport routes. The German consumer organisation VCD includes noise in its overall score for Green Cars. The UK Department of Environment, Transport and the Regions reports, but does not rate, vehicle noise levels.

Mining, manufacturing and distribution industries can have direct adverse effects on the environment. as can road construction and other vehicle-related construction such as parking facilities. However, these issues are unlikely to be relevant to a system that assigns an environmental rating to individual vehicle models.

Issues and Principles

Any rating system will need to strike a balance between the various environmental impacts of motor vehicles. Decisions will need to be made about the parameters that should be included in the rating system and the relative importance of these parameters. Options have been developed and a data modelling exercise (see next section) was undertaken to ensure that the rating system was flexible and that the various issues could be included if and when appropriate.

The following *draft* principles have been identified:

Essential

- The method of presentation of results to consumers must be simple, understandable and accessible. Brochures and an Internet website would be suitable ways of presenting information.
- The methodology must be credible and not open to valid criticism from stakeholders.
- The system must be flexible but consistent. In the long term previous ratings should be able to be compared with the latest ratings (the scope should readily encompass additional factors such as life cycle analysis). However, recalibration of the rating scale might be appropriate if major improvements occur in the fleet. This was recently found to be necessary with appliance energy ratings.
- The rating system should "spread the field" for current vehicles, clearly showing the best and worst performers, within each vehicle category.
- The rating system should cover most popular models of light vehicle sold in Australia (cars, car derivatives, people movers, four-wheel drives and light commercials). Ratings should be available for engine families within model.
- The types of vehicles covered should be sufficiently broad that consumers do not mistakenly choose potentially high-polluting vehicles due to their absence from the lists. "Bookends" (extreme cases of good and bad) should be included.
- From the start the methodology should cater for conventional (petrol and diesel) vehicles but should be capable of incorporating other types of vehicles, such as electric cars.
- From the start the methodology should rate in-use emissions but it must have the capacity to incorporate life-cycle analysis (e.g. manufacturing, deterioration and disposal).

Desirable

- There should be timely updating of the brochure/web site. Ratings for newly released vehicle models should be available promptly.
- In addition to an overall rating there should be a separate indication of performance for pollution and global warming so that consumers can apply their own balance to these factors.
- Avoid costly and complicated emissions testing. Try to use existing test data but if testing is necessary keep it simple.

- The initial user interface should be simple (such as only presenting an overall rating) but the consumer should be able to access increasing levels of detail, if desired.
- Where they are not able to be included in the rating system, important environmental impacts/initiatives should be reported in a manner that consumers can access.

Data Modelling

Data modelling is an exercise to look at the items of information that may be relevant to a project and to determine the relationships between these items. The scope of a data model usually goes beyond the information that is obviously relevant to the project. In this way a course of action can be identified which will be flexible enough to encompass additional information, should it become available.

The results of data modelling for a Green Car rating are set out in Appendix D. This shows that, although it is tempting to take the simplest approach for the initial phase of the program and report only exhaust emissions from conventional vehicles, a more appropriate course is to take the next step in the data path. This is the approach taken by ACEEE (see Appendix A) and involves converting the exhaust emissions (grams per kilometre) to an "Environmental Damage Index" (EDX) measured in cents per kilometre. This requires a "damage cost" (mainly community health) to be assigned to each pollutant. Although this is a possible source of disagreement during implementation of the program, in the longer term it provides a mechanism for comparing a wide range of inputs, including energy-related emissions associated with electric vehicles and life-cycle-analysis values. These have been successfully (but not completely) covered by ACEEE.

From the data modelling exercise the following key data items were identified:

Essential

- Make and model information, including engine families and kerb mass
- Fuel consumption (litres per 100km) according to a standardised, repeatable test
- Exhaust emissions (say grams per km) according to a standardised, repeatable test
- Relative environmental importance of each pollutant/Greenhouse Gas such as an environmental damage index per gram at vehicle exhaust (ACEEE assign a damage cost but this is not necessary for a rating system, provided that an alternative weighing method is available). A proximity factor would apply to factory and power station emissions (the base case should be for exhaust emissions).
- Environmental damage index (per km) - combination of weighted values for each pollutant
- Overall rating for each vehicle

Desirable - for additional analysis

- Estimated typical lifetime kilometres travelled (assumed constant for all vehicles but could depend on vehicle type)
- Estimates of fuel-cycle emissions (e.g. grams per litre of fuel produced - at pump).

- Estimates/measurements of in-use fuel emissions (evaporative emissions)
- Estimates of emissions under arduous conditions (cold starts, hard acceleration)
- "Smog" rating for each vehicle
- "Global warming" rating for each vehicle
- Class ranking for each vehicle

Desirable - to enable life-cycle analysis

- Estimated emissions associated with producing the vehicle (primarily electrical energy consumed per kg of vehicle)
- The material content of the vehicle (unlikely to obtain actual content - an average content may need to be assumed).
- Estimated emissions associated with the material components of the vehicle
- Recycling and other Green initiatives of the vehicle manufacturer.

Options for obtaining data about vehicle performance

Appendixes A, B and D contain information about possible sources of data about vehicle environmental performance. The following provides a summary the situation.

a) Data provided by vehicle manufacturers

Currently test results obtained by manufacturers for the purpose of demonstrating compliance with the emissions ADRs are confidential. It is possible, but considered unlikely, that manufacturers would voluntarily supply this information. Initial discussions with the Federal Chamber of Automotive Industries (FCAI) confirmed this view (see Appendix F).

An alternative to manufacturers providing actual test results is to have them nominate a range result for each pollutant. For example the ranges could be based on 25%, 50% and 75% of the ADR limits. This approach would be similar to the Tiers prescribed by the Californian Air Resources Board (CARB) for low emission vehicles. ACEEE uses the CARB system for rating vehicles in the USA but such a tiered system is not currently available in Australia.

A further possibility is that manufacturers may certify that particular models sold in Australia comply with standards that are more stringent than the ADRs, such as CARB tiers.

b) Make provision of information a condition of vehicle procurement

An alternative method of obtaining ADR test results from manufacturers is to require the provision of the results under the vehicle procurement contract for the state government fleet. Again, manufacturers might be more cooperative if the results were reported as ranges. The procurement contract would need to provide for the information to be passed on to other parties and made public.

c) Conduct independent tests

Arrange for independent testing of sample vehicles in accordance with recognised test procedures. See Appendix B for more details. At this stage this approach appears to be the most viable option, using a short test such as IM240 (see Appendix B).

Further research is needed to resolve uncertainties about test procedures, including sampling issues and variability in testing. Tests for diesel vehicles also need to be established (the Motor Vehicle Environment Committee is currently developing a short cycle test for diesels).

Options for rating vehicles

Existing rating systems are described in Appendix A. The main options are:

a) Simply report the values obtained in the emissions tests (e.g. grams per km for each pollutant). This is the approach taken by the UK DETR. Its main advantage is that it avoids the need for value judgements (the environmental damage caused by each pollutant). A serious disadvantage is that consumers cannot be expected to understand and compare these values.

b) Process the results of emissions tests to obtain a "smog" score, a "global warming" score and an overall score. This is the approach taken by What Car magazine. This is a simple system that provides effective ratings for consumers. A disadvantage is that the What Car system does not currently deal with unconventional vehicles (such as electric vehicles) or with the results of life-cycle analysis.

c) Process the results of emissions tests to calculate an Environmental Damage Index (EDX) based on exhaust emissions and, if available, life-cycle emissions. Calculate a "Green Score" from the EDX. (Say Green Score = 100 if EDX = zero emissions) This is the approach taken by ACEEE. This system is more complex to set up but provides superior flexibility for encompassing unconventional vehicles and life-cycle analysis. This appears to be the best option. Note that EDX would be based on a relative ranking of pollutants, rather than the ACEEE system of estimated health costs. The Green Score step might not be necessary if a star rating is based on EDX. That is, the lower the EDX the more stars earned. This is the What Car approach.

Further work is required in the application of ACEEE methodology to Australia – in particular the relative weights given to each pollutant, and star ratings, will need to be reviewed once some good data for new Australian is available.

Options for presenting results to consumers

Appendix C contains a review of existing methods of presenting the results of vehicle assessments to consumers. The options below are set out in increasing levels of detail and complexity.

a) List all vehicles within a category of vehicle type, with the best Green Score (least environmental damage) at the top of the list. Show the Green Score for each vehicle.

b) Add to (a) a graphical display of the Green Score and a star rating for each vehicle. This is similar to the latest ANCAP brochure -see figure C12 in Appendix C. Could include an 'all vehicle average' to show how the group performs (see Figure C18).

c) Add to (a) a "Smog" rating and a "Global Warming". This is similar to What Car magazine - see Figure C4.

d) In a separate summary list, provide details about the results for each vehicle. The list could be sorted by vehicle type then make and model. This is similar to ACEEE (Figure C1), CARB (Figure C6), AGO (Figure C7) and DETR (Figure C9).

e) Provide a separate, detailed rating report for each vehicle. This is similar to What Car Magazine (Figure C3) and ANCAP (Subaru Liberty example in Appendix C).

An advantage with an Internet information system is that the various levels of detail can be accessed through hyperlinks. The "index" page can be made simple so that it is not overwhelming to consumers but they can "click" on links for additional information.

With paper brochures the latest ANCAP approach has merit. One page brochures are provided at motor registries, NRMA offices and some motor dealers (where the vehicle rated well). The brochure has telephone numbers to request detailed brochures for specific vehicles. These can be posted or faxed to the consumers. General ANCAP experience is that the detailed sheets are not very popular but they are appreciated by those who request them. The detailed ANCAP sheets, such as the Subaru Liberty example in Appendix C, are not printed in bulk - copies of the Word document files are distributed to ANCAP partners so the sheets can be printed from a PC on demand.

Bulky booklets with tables of information, as provided by ACEEE, AGO and DETR, may be overwhelming for consumers. Consumer research, such as focus groups, may help to identify suitable methods of presentation for an Australian Green Car Guide.

Implementation issues

The initial system should not try to take on too much. It should, perhaps, start with ratings based on in-use factors (mostly exhaust emissions) and be limited to popular models of conventional vehicles. Other types of vehicles and additional rating factors can be added at a later stage, if appropriate.

If an independent testing program is established then the logistics of choosing and arranging tests of sample vehicles needs to be addressed.

If results are to be obtained from manufacturers then mechanisms for timely transfer of information need to be established.

Once the layout and structure of consumer information is established the logistics of distributing this information need to be addressed. The Internet has potential as a key source of information for stakeholders.

Conclusions and recommendations

There is a need for a system to provide consumers with information about the environmental performance of vehicles sold in Australia. The AGO Fuel Consumption Guide is useful but does not contain sufficient information about emissions. The few overseas guides that are available do not cover some popular Australian vehicles.

Existing systems have been reviewed and strengths and weaknesses of these systems have been noted. The features of a suitable system for Australia have been outlined in this report, together with a range of options for consideration.

The recommended option is based on a simplified version of the ACEEE approach and is described fully in the Draft Protocol (separate document). In brief, it involves deriving separate ratings for smog/health effects and Greenhouse effects, based on measured fuel consumption and exhaust emissions during short-cycle testing of sample new vehicles. These two ratings can then be combined to give an overall “Environmental Damage Index” and a star rating.

The following additional recommendations are made:

1. That a formal approach be made to the Federal Chamber of Automotive Industries and DoTRS about the provision of ADR emission test results and related issues.
2. That further discussions be held with the Australian Greenhouse Office and Motor Vehicle Emissions Committee to establish how the proposal enhances national strategies and opportunities for exchange of information.
3. That the NSW RTA and/or Parsons Australia be asked to conduct some research using their emissions test facilities to examine test variability, sampling issues, logistics and related technical issues. Comparisons of various test cycles should also be conducted (IM240, proposed CUE and Euro II).
4. That estimates of ratings be determined for typical vehicles in Australia and that differences between types of vehicles and types of fuel be evaluated. This will probably result in a review of the proposed star rating method.
5. That consumer research be conducted to determine appropriate methods of presenting results to consumers.
6. That management issues be investigated, including responsibilities for implementation and ongoing operation of the scheme, funding, selection and sourcing of sample vehicles, production of reports and web pages.

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APPENDIX A - REVIEW OF EXISTING RATING SYSTEMS

This appendix provides a review of existing systems for rating the environmental performance of road vehicles. Extracts from brochures and books are included in Appendix C.

American Council for an Energy-Efficient Economy (ACEEE)

ACEEE publishes an annual "Green Guide to Cars and Trucks". A "Green Score" is calculated for each model. This is covered in more detail below ("Methodology"). The booklet includes tables showing performance information for each make and model, within 14 vehicle classes. The tables list:

- the relevant emissions standard,
- city and country fuel economy,
- fuel cost per year,
- health cost per year (based on health effects from pollution),
- Greenhouse Gas (GHG) emissions in tons per year,
- environmental damage index (cents per mile, based on health costs and risks associated with global warming)
- Green Score - a number between 0 and 100, with 100 being the (unattainable) best score.
- A ranking within the class ("above average" etc)

These comprehensive tables may be a little overwhelming for consumers and the Guide includes a simplified table of top-rated models within each vehicle class. It also includes a section "Practical Picks" - best choices for various transportation needs.

Methodology

The ACEEE report "Rating the Environment Impacts of Motor Vehicles: The Green Guide to Cars and Trucks Methodology" by John DeCicco and Martin Thomas (1999 Edition) describes the methodology used in the Green Car Guide.

In essence a life-cycle assessment is attempted. Certified, tiered emissions standards are used for the in-use phase of the cycle but numerous assumptions are made about the manufacturing and disposal phases of the cycle.

The following table is taken from the report.

Table 1 from DeCicco and Thomas, 1999

Environmental Concern	Phase of Product Life Cycle				
	Materials Production	Product Manuf.	Product Distribution	Product Use	End of life
Air pollution	C	C	-	B	-
Energy Consumption	C	C	-	A	-
Greenhouse Gases	C	C	-	A	-
Others *	-	-	-	-	-

Notes

* "Others" includes land contamination, noise, water pollution, worker/community health, other ecosystem damage and other resource consumption.

A: Included explicitly, with good data quality and relatively high accuracy for discriminating among vehicles

B: Included explicitly, but with lower data quality and relatively high uncertainties.

C - Included only indirectly, with very aggregate or uncertain data

- Not included in Green Score calculation

Calculating the Score

(Note: this US methodology uses a strange mixture of imperial and metric units)

In effect, an Environmental Damage Index (EDX) is derived by calculating a "cents per mile" value for each of the valid cells in the above table. These are added together to produce the EDX. The EDX, which can range from 0 to infinity is then mapped to a 100 to 0 scale to produce a Green Score, with a Green Score of 100 corresponding to an EDX of zero (best possible).

For each cell in the table two values are required:

- The quantity of the emissions (eg grams per mile), averaged over the vehicle life
- An environmental damage cost (dollars per kilogram)

These values are multiplied together to produce a $ per mile value for each cell in the matrix.

Derivation of estimated values for emission quantities

Tailpipe Emissions

In the USA there are several levels of emission standards, with progressively more stringent limits for certain pollutants. For each model of vehicle the applicable emissions standard is known and therefore estimates can be made of in-use emissions. *This opportunity is probably not available in Australia (other than off-road vehicles optionally meeting the tougher car emission limits under ADR37).*

Tailpipe emissions are divided into four sources: on cycle, off cycle, degradation and malfunction. on cycle and degradation are assumed to be proportional to the applicable emissions standard. Off cycle and malfunction are assumed to be proportional to vehicle mass. Thus, for a given vehicle, the estimated tailpipe emissions are derived solely from the applicable emissions standard and the vehicle mass. *No measurement of emissions from specific models is used in the analysis*.

In essence, the reasons for not using model-specific test results are:

- emissions regulations are designed around pass/fail criteria and the actual test results are generally not available,
- only a small number of vehicles from each model are tested and the results are considered to be unreliable (the basis for this conclusion is not clear).

The effect of the various emissions standards can be gauged from the following table, which shows the emissions assumed for an average passenger vehicle.

Table 2 - Assumed emissions (grams per mile) for various standards

(Lifetime for Passenger Car of Average Mass)

Emissions Standard	CO	NMHC	NO_x	PM_{10}
Tier 1 (Federal)	9.5	0.6	1.04	0.02
TLEV	9.5	0.42	1.04	0.02
LEV	9.5	0.35	0.76	0.02
ULEV	7.2	0.3	0.76	0.008
Diesel	1.35	0.44	1.56	0.17
CNG ULEV	3.0	0.08	0.38	0.004

C0 Carbon monoxide

NMHC - Non-Methane Hydrocarbons

NO_x - Oxides of Nitrogen

PM_{10} - Particulates under 10 Microns

TLEV - Transitional Low Emissions Vehicle

LEV - Low Emissions Vehicle

ULEV - Ultra-Low Emissions Vehicle

CNG ULEV - Compressed Natural Gas Ultra-Low Emissions Vehicle

The authors also note that "Standard emissions tests tend to significantly underpredict in-use emissions" - average life-time emissions are two to four times higher than the nominal emissions standards levels. The estimated emissions used for calculating the EDX are therefore adjusted for this effect. The adjustments are included in the above table.

Fuel-consumption-dependent emissions

Fuel consumption (miles per gallon) values from city and highway driving cycles are available for each model. These are used (with adjustment factors) to estimate emissions per mile for the various pollutants. This applies where emissions are calculated in grams per gallon of fuel consumed. Values are estimated for in-use and "upstream" (fuel production and distribution) phases.

Vehicle mass-dependent emissions

Assumptions are made about the proportion of materials within a motor vehicle (proportion of steel, plastic, glass etc). The energy consumption (BTU per pound of material) and emissions associated with manufacture and energy production are estimated (grams per mile per kilogram/pound of material). No allowance is currently made for "green" manufacturing or recycling initiatives by manufacturers.

A breakdown of the US energy industries is conducted to prepare estimates of emissions associated with energy consumption. For example, the CO_2 emissions associated with vehicle manufacture are estimated to be 0.056 grams per mile per kg of vehicle mass (assuming a 100 000 mile vehicle lifetime).

Similar calculations apply to the electrical energy consumed by electric vehicles. In theory, this enables electric vehicles to be directly compared with conventional vehicles. The difficulty lies in assigning weights to the various components of the matrix. For example, adding weight to Greenhouse emissions might severely disadvantage electric vehicles - the authors include a sensitivity analysis of these types of effects.

Estimating the Cost of Environmental Damage

Damage costs for pollutants are based on published *health cost* estimates. The geometric mean of the low and high health cost estimates are used. These are expressed in dollars per kilogram of pollutant.

Health effects due to emissions from refineries and electric power plants are assumed to be substantially less than those from tailpipes because these facilities are generally remote from the population at risk. Factory and refinery emission health costs are reduced by a factor of 5 and those of electrical utilities are reduced by a factor of 10.

"It is extremely difficult, if not impossible, to estimate meaningful damage costs for Greenhouse Gas emissions... In the light of these considerations, and our environmental point of view, we treat GHG emissions as equally important to traditional regulated pollutants...". The authors achieve this by assuming that the environmental cost of GHG emissions is equal to the health-related cost of regulated emissions for the average 1999 vehicle. This assumption results in an environmental cost of 1.7 cents per kg of CO_2. A "Global Warming Potential" factor is applied to other GHG to derive equivalent CO_2.emissions. For example, 1 kilogram of Methane is assumed to be equivalent to 22 kilograms of CO_2.

Results for the "average" vehicle.

The following table sets out the outcome of the analysis for an "average" 1999 vehicle (Emissions standard: Tier 1, Fuel consumption 24.6 MPG (during test), mass 1674kg).

Environmental Impact	Life Cycle Cost (cents per mile)
a) Emissions at the vehicle	0.79
b) Emissions from the fuel supply cycle	0.29
c) Emissions embodied in the vehicle (manufacturing etc)	0.25
d) GHG emissions from all sources	1.32*
Total environmental damage index (EDX)	2.64

* By definition, GHG costs are equated to the sum of a) to c) for this average vehicle.

The resulting Green Score for this average vehicle is 21.

Interestingly, this EDX corresponds to an environmental damage of 65 cents per gallon of gasoline, which is close to the typical fuel bowser price in the USA.

Comments about the ACEEE methodology

The main obstacle to using the ACEEE methodology in Australia is the lack of multi-tiered emissions regulations. The existence of more stringent Californian emissions standards enabled ACE[3] to avoid the need for testing individual models. On the other hand, the methodology does not differentiate the bulk of the vehicles that only meet the Federal (Tier 1) regulations. Some may just pass this test and others may be considerably "cleaner". The latter vehicles would not get recognition under the ACEEE system.

It is noted that the Green Guide to Cars and Trucks covers 1464 models of vehicle (although many of these are actually variants within the one model). One unstated reason for ACEEE not arranging emissions tests of individual models may have been the prohibitive costs of conducting thousands of emissions tests (particularly in view of the highly cost-effective methodology which uses published data about each model). The situation should be different in Australia due to the reduced number of vehicle models.

The various assumptions and factors used by ACEEE would need to be reviewed for applicability in Australia. Otherwise, provided that an alternative method of estimating lifetime tailpipe emissions was found, the methodology should prove useful for developing an Australian Green Guide.

Given the somewhat negative reaction of the Australian motor industry to consumer crash tests under the New Car Assessment Program, it could be expected that an environmental rating system based on pass/fail of regulation tests would be more acceptable to the industry than one based on tests of individual models. As indicated above, this opportunity does not currently exist in Australia but may be worth considering as an optional feature in Australian emissions regulations.

In regard to the scoring system, and consumer presentation, the Green Guide to Cars and Trucks is probably too overwhelming. A scoring scale of 0 to 100 appears to be too precise, particular given the uncertainty and numerous assumptions that produce the score. The additional percentile ratings (5 ranges) within vehicle class are likely to be more useful to consumers, although this may disguise the poor environmental performance of larger vehicles such as most four-wheel-drives.

What Car? Green Car Guide

What Car? is a British consumer magazine. The July 1999 issue of the magazine included a 36 page Green Car Guide which rated 85 cars and people movers. The magazine decided to arrange its own emissions tests. These were conducted by Rototest in Sweden. The magazine states that these tests are much more demanding than the regulation European emissions test. They claim that the European test is "unrepresentative of normal driving" and "acceleration is ludicrously gentle". They further suggest that some "unscrupulous car makers design a car to meet the requirements of the test procedure and no more" resulting in premature over-fuelling and excessive hydrocarbon emissions when the vehicle is under hard acceleration. These issues are open to debate.

The test measurements for each phase of the test are multiplied by a factor for each pollutant (HC by 1, NO_x by 0.125, CO by 0.00146 and CO_2 by 0.000714 - the reasons for these factors are not stated). The resulting values are summed to produce a Green Index figure for that phase. Results for each phase are multiplied by a further factor (0.25 for 35mph, 0.24 for 44mph, 0.17 for 56mph, 0.13 for 69mph, 0.13 for 81mph (!) and 0.15 for the acceleration phase). These are added together to give a total Green Index Rating. The vehicles ranged from the best score of 64 to the worst of 236. The score is also converted to a star (actually dot) rating, with five stars being the best.

The magazine includes separate ratings for "global warming" (based on CO_2 emissions) and "smog" (based on regulated pollutants).

Comments about the What Car? methodology

The rating system is based solely on test results. No attempt is made to include the environmental impacts of manufacture, fuel cycle or disposal.

It is not clear whether several representative vehicles for a model are tested or if the results rely on the random selection of a single vehicle for testing purposes. Presumably the motor industry would be concerned about the sample sizes and sampling methods.

The more rigorous test cycle may cause manufacturers to pay more attention to non-regulated operating conditions. However, the contribution of these phases to the total vehicle emissions problem is not clear.

VCD - Germany

The German consumer organisation VCD publishes a "Green Car List". Details about the system are sketchy but it is understood that the rating depends on information provided by manufacturers. Points are awarded in six categories:

1. Greenhouse gases: 80g/km is awarded 10 points, 210g/km receives zero points. (40% of total)
2. Noise: 65dB(A) is awarded 10 points, 75dB(A) receives zero points.(20% of total)
3. Carcinogenics - score depends on the emissions standard met (15% of total)
4. Other pollutants - " (10% of total)

5. Impact on nature - " (10% of total)
6. Top speed capability: 120km.h is awarded 10 points. 200km/h receives zero points (5% of total)

Note that noise contributes a substantial amount to the overall score (20%).

VCD assigns a separate score for each manufacturer based on a survey which covers numerous environmental performance measures.

UK Department of Environment, Transport and the Regions

The Department publishes "New Car Fuel Consumption and Emission Figures". The intention is "to inform buyers of new cars how they can reduce the impact of their new car on the environment. In it are listed the fuel consumptions, exhaust pollution levels and noise levels of most new petrol and diesel cars on sale in the UK...". The list includes engine capacity, urban fuel consumption, "extra-urban" fuel consumption, CO2 emissions (g/km), fuel cost (Pounds/6000 miles!), Noise level, CO, HC, NOX, Particulates (no values currently listed) and Euro Standard (II or III). Figure C9 in Appendix C shows an sample output.

Fuel consumption is based on test results provided by vehicle manufacturers and is carried out to EU Directive 93/116. All new vehicles in Europe must be labelled with the fuel consumption figures derived from these tests. Recently agreed driving cycles are used for the tests. The "urban cycle" involves a cold start then 820 seconds of driving with a maximum speed of 50km/h. The "extra-urban" cycle follows on from the urban cycle and involves 400 seconds of driving with a maximum speed of 120km/h.

It appears that the emission results listed in the tables are based on the measurement of exhaust emissions during the fuel consumption test. The booklet cautions that "...because of the nature of testing procedures the emission and noise figures listed in the tables should be treated with caution and specifically should not be used to rank a number of vehicles for which similar figures are quoted. The most reliable method for comparing vehicles is to use the Euro standard listed and to choose a vehicle meeting Euro III standards where possible." Apparently emission values are provided by manufacturers.

Noise testing is conducted according to EU Directive 92/97. This involves the vehicle driving into a test area and accelerating at full throttle from 50km/h.

Comments on DETR methodology

The DETR relies on the timely provision of test result information by manufacturers. This covers fuel consumption, emissions and noise.

The booklet lists the ten best vehicles in terms of CO2 emissions. One list covers petrol vehicles and the other covers diesel vehicles. No attempt is made to derive a score or otherwise rate the performance of each model. The lists simply quote the test results. The consumer must do the comparison work in order to find the best vehicle for a particular purpose. This could be overwhelming for most consumers.

More stringent Euro III emissions tests apply to new vehicles from January 2000. Some vehicles are already certified to these standards. In effect the European consumers have a tiered system similar to that used by ACEEE in the USA.

Emissions Testing in Australia (see also Appendix B)

New South Wales proposes to use the IM240 driving cycle for an in-service vehicle emissions testing program. This test is an abbreviated form of the ADR37 driving cycle. It has been estimated that it will cost no more than $30 per test. An analysis of nearly 600 Australian vehicles revealed reasonable correlation between ADR37 and IM240 test results and therefore this test may be suitable for the tailpipe emissions component of an Australian environmental rating system. If an alternative test, such as the Rototest driving cycle, is considered to be more appropriate then the RTA would need to confirm that its test facilities (currently at Botany and Penrith) are capable of performing the test. Otherwise an alternative testing facility would need to be considered (but may not be available).

It is understood that the RTA is currently undertaking voluntary testing of vehicles. It might be possible to arrange (and pay) for local car dealers to present new vehicles for testing so that a database of results for a range of Australian vehicles is available. Even if these test results were not subsequently used for an environmental rating they would prove useful for benchmarking and sampling analysis purposes.

Parsons Australia has carried out emissions testing of diesel vehicles at its Auburn facility. The company is able to test petrol vehicles to a variety of tests cycles.

APPENDIX B - REVIEW OF EMISSIONS TESTS

This appendix is based on a meeting between Bruce Dowdell. Leif Stephanson, Jack Haley and Michael Paine on 26 Nov 1999.

ADR 37/01

All petrol-fuelled cars, car derivatives, passenger vans, 4WDs, light buses and light trucks sold in Australia are required to comply with this ADR. Tests are prescribed for "fuel evaporative emissions" ("Diurnal breathing loss" test and "Hot Soak Loss" test) and "Exhaust emissions" test involving a dynamometer test. The "CVS-CH" driving schedule is specified in the ADR. This consists of

- a "cold start" then “hot transient” phase involving just under 23 minutes of variable speed driving
- a 10 minute pause
- a "hot start" phase involving a just under 9 minutes of further variable speed driving.

In addition pre-conditioning requirements can take up to 36 hours.

Limits are set for evaporative hydrocarbons, exhaust hydrocarbons, exhaust carbon monoxide and exhaust oxides of nitrogen. Cars and derivatives (MA vehicles) have stricter limits on HC and CO than the other light vehicles (75% in each case). Thus there is potential for tiered results for the other light vehicles.

Euro 2 requirements will replace this test from 2002.

ALTERNATIVE STANDARDS

The ADR allows other emissions standards to be used but does not specify particular standards:

(Extract from ADR37/01) 12.1 *In determining whether compliance has been established the ‘Administrator’ may accept approvals issued with respect to other emissions standards equal to or more stringent than this rule.*

It is understood that at present there are no alternative standards. Ultimately it is possible that manufacturers will not necessarily have ADR37 test results available - just approval to an overseas, more stringent standard.

Four-wheel-drives, buses and light trucks over 2.7 tonnes gross vehicle mass may comply with the less stringent ADR36 as an alternative to ADR37.

Operational issues

Due to the preparation time involved, the tests take one or two days per vehicle and cost around $1500, although bulk testing may reduce this. Only a few facilities are available in Australia for testing to ADR37. VIPAC in Victoria might be in a position to perform tests. Ford in Victoria and the Orbital Engine Company in Western Australia can also perform ADR37 testing. It is not known whether these facilities could be made available for the purpose of environmental ratings.

Environmental issues

What Car magazine claims that the acceleration components of the Euro test are not severe enough to show up deficiencies. The ADR37 test is based on a US test cycle and is more severe than the current Euro test so the What Car magazine criticisms are not applicable.

Fuel consumption during the test could be used for estimating GHG emissions or CO2 emissions could be measured directly (currently they are not necessarily recorded during manufacturer's ADR37 tests).

Sources of data

Currently test results obtained by manufacturers for the purpose of demonstrating compliance with the ADRs are confidential. It is possible, but considered unlikely, that manufacturers would voluntarily supply this information. Discussions would need to held with the Federal Chamber of Automotive Industries (FCAI) to resolve this issue. It is possible that the Federal Office of Road Safety (FORS) is negotiating with FCAI along similar lines.

An alternative to manufacturers providing actual test results is to have them nominate a range for each pollutant. For example the ranges could be based on 25%, 50% and 75% of the ADR limits. This approach would be similar to the Tiers prescribed by the Californian Air Resources Board (CARB) for low emission vehicles.

Another method of obtaining ADR test results from manufacturers is require the provision of the results under the vehicle procurement contract for the state government fleet. Initial discussions with the Department of Public Works and Services indicate that this may be a viable approach. It would be important that the contract provides for DPWS to disclose the emissions data to other parties (ie SEDA). Again, manufacturers might be more cooperative if the results were reported as ranges.

If manufacturer's data cannot be used then SEDA could arrange for independent testing of sample vehicles in accordance with ADR37 (see "operational issues"above). In view of the substantial costs and logistics involved the extra information provided by ADR37 testing may not be justified, compared with that from a simpler test such as IM240 (see below).

IM240

This is a variable speed driving cycle test that is essentially an abbreviated version of the exhaust emissions test of ADR37. It was developed by the US EPA primarily for inservice emissions testing. It does not normally include a "cold start" procedure and does not include an evaporative emissions test.

The NSW RTA recently commissioned two IM240 test stations as part of a proposed inservice emissions testing program in NSW. These stations could be available for testing samples of new vehicles on an ongoing basis.

The reference document for IM240 is “IM240 and Evaporative Test Guidance” issued by the US EPA. (document EPA-AA-RSPD-IM-98-1).

Operational issues

The tests take about 15 minutes each or four tests could be performed within 30 minutes. The cost would be approximately $30 for one test and $100 for four tests. In addition to the RTA's two test stations any facility that is capable of conducting the ADR37 exhaust emissions test should be capable of carrying out the IM240 test.

Environmental issues

The IM240 test does not measure evaporative emissions or "cold start" emissions. These may or may not be important for assessing environmental performance. One the one hand, US EPA engineers have advised that they do see substantial differences between vehicle models for these emissions. On the other hand, these emissions probably make a relatively small contribution to overall vehicle emissions.

In the case of cold start emissions, it may be advisable for the NSW RTA to carry out some research using its IM240 facilities. Cold start results could be compared with the normal hot start results. A test program could also check that there is little variation between vehicles of the same model, when new, and establish the desirable number of tests to conduct on each vehicle.

The magnitude of the evaporative emissions issue can be gauged from the ACEEE methodology. When expressed as grams per distance travelled, the evaporative HC emissions for the "Average 1999 Vehicle" were estimated to be almost the same as the HC exhaust emissions (0.7 grams per mile compared with 0.6 grams per mile). However, each of these HC sources was judged to represent just 1.5% of the total health related impacts of the vehicle (0.024 and 0.02 cents per mile compared with 1.32cents per mile overall). Therefore the consequence of not measuring evaporative emissions for each vehicle model are considered to be negligible - at most an exceptionally good vehicle would be penalised by 1.5% in its overall rating. Of course, manufacturers of these vehicles could be given the option of providing the results of ADR37 evaporative emissions test and these could be used in the calculation of rating rather than the generic value.

Other types of emissions tests

The Swedish Rototest is used by What Car magazine. It is claimed that the test is much more demanding than the current Euro emissions test but it is not known how it compares with ADR37 or IM240. Rototest Sweden was approached but did not disclose details of the test driving cycle. The concensus at the meeting was that the Rototest is unlikely to provide data which is more useful than that available from ADR37 or IM240.

Some US states have adopted constant speed dynamometers for inservice tests. These are cheaper and simpler to use than IM240 facilities but have limitations in the information they provide. In view of the reasonable correlation between IM240 and ADR37 test results and the availability of IM240 test facilities in Sydney there appears little point in pursuing other types of tests.

Parsons Australia

Parsons Australia is an independent emissions testing organisation based at Auburn. In mid-February 2000 I visited the premises to discuss emissions testing with Mr Steve Brown from the company. The company had just completed a major project bench-testing diesel vehicles for the Federal Government. They have the facilities to test both diesel and petrol vehicles to a variety of driving cycles. Significantly they are able to measure particulates (1 micron or less and 10 microns or less) and toxic emissions. This can be done for petrol as well as diesel vehicles. A national "Composite Urban Emission" drive cycle was developed for the recent tests. A variety of short tests were also conducted and they will be looking for correlation between the long and short tests.

It would be possible to test petrol vehicles according to the same driving cycle but Mr Brown cautioned that, being based on diesel vehicle operations in Australia, the acceleration modes may not be demanding enough for petrol vehicles. We discussed the possibility of using CUE for diesels and IM240 or similar for petrol vehicles and applying an adjustment factor for the diesel tests - this needs further research but looks feasible.

Another issue that would need to be resolved is the specification of fuel for tests. He suggested it would be better to use petrol that was representative of that available at bowsers in NSW.

We also discussed sampling and repeatability. If several (say 3) short tests are conducted on the same vehicle then the average of these could be used for the evaluation provided that the three sets of results were within a nominated range of each other. Apparently this method is used for compliance auditing of emissions regulations in the Netherlands. It is similar to procedures specified in some stationary noise tests.

If manufacturers have concerns about the results then they could be given the option of funding further tests of randomly selected vehicles.

It may be necessary for Parsons to demonstrate they have recognised quality control systems in place (eg NATA or ISO 9000/1) before they undertake testing for the purpose of rating the environmental performance of vehicles.

Durability

ADR37/01 requires vehicles to meet the prescribed limits after 5 years or 80,000 km. However, this requirement is deemed to have been met if a “new” vehicle meets limits that are about 9% lower than the long term limits.

ACEEE applies a degradation factor to its calculations. Since the same factor applies to all vehicles the effect of this step is to give greater weight to the exhaust emissions, compared with fuel-related and embodied emissions.

This issue of durability was discussed by the Steering Committee and it was decided that not adjustments would be made for in-service degradation. In the longer term, once a benchmark for new vehicles is established, it may be possible to sample older vehicles and monitor degradation. However, this information would not be suitable for rating new vehicles.

Fuel Consumption

The "city cycle" fuel consumption used in the AGO Fuel Consumption Guide is derived from the ADR37 test cycle and the "Highway Cycle" fuel consumption is derived from a separate test prescribed in AS2877. The highway cycle test runs for 13 minutes and commences 20 seconds after the completion of the ADR37 test. The overall test procedure is therefore quite time consuming. Manufacturers provide this information to AGO but there can be substantial delays.

The AGO data might not be timely enough for the purposes of a Green Car Guide. If IM240/CUE testing is used for the emissions ratings then it may be advisable to use the fuel consumption calculated from the test for the purpose of a published fuel consumption. It would need to be made clear that this was not the same as the "city cycle" or "highway cycle" fuel consumption published by AGO. Fuel consumption can be calculated from the CO2 measured in the test - it would be appropriate to use this measurement directly for calculating Greenhouse emissions of a vehicle. In addition, methane can be measured during an IM240/CUE test. This is not a regulated pollutant (in effect, it is measured so that it can be deducted from the HC result) but is a Greenhouse gas.

DETR (1999) describes the driving cycle used to measure fuel consumption in accordance with EU Directive 93/166. Apparently DETR also uses the measurements of emissions during this test in its list of vehicle performance. However, DETR cautions that these measurements should not be used to rank vehicles. It is suspected that this statement was the result of concerns from vehicle manufacturers about the use of the emission measurements for unintended purposes.

Non-petrol vehicles and other emissions

The ACEEE methodology provides for the rating of non-petrol vehicles, including electric vehicles. It is important that the modelling and design of an Australian Green Car rating system caters for these cases, and for other emissions issues such as emissions during manufacture and fuel cycle emissions. However, the recommended approach for the initial system is to restrict it to popular petrol-fuelled vehicles and to base the rating solely on exhaust emissions. This is the approach taken by What Car magazine.

See also the discussion about diesels under "Parsons Australia".

Selection of vehicles

The Australian New Car Assessment Program (ANCAP) selects the most popular variant of a model for crash testing, based on VFACTS statistics. What Car magazine also appears to only select one variant but in this case the selection criteria are not evident.

ACEEE apparently calculate a Green Index for all variants (note that ACEEE methodology does not involve any testing - only processing of published values). This has resulted in over 1400 variants being included in the ACEEE Guide. Similarly, AGO includes a wide range of variants within each model for its Fuel Consumption Guide.

It is considered important that a distinction is made between various engine families within a model range (particularly, say, a V6 compared with a 4 cylinder variant). However, separate results for each transmission type and body style are probably unnecessary. It may be advisable for the RTA to carry out an evaluation of the effects of these parameters so that selection criteria can be developed.

Number of seating positions is published in the AGO guide and may be useful for a Green Car Guide.

APPENDIX C - REVIEW OF METHODS OF PRESENTING RESULTS

This appendix covers the options for presenting the results of a Green Car Rating System to consumers.

Existing ratings systems

American Council for an Energy-Efficient Economy (ACEEE)

ACEEE publishes an annual "Green Guide to Cars and Trucks". A "Green Score" is calculated for each model. The booklet includes tables (figure A1) showing performance information for each make and model, within 14 vehicle classes. The tables list:

- the relevant emissions standard,
- city and country fuel economy,
- fuel cost per year,
- health cost per year (based on health effects from pollution),
- Greenhouse Gas (GHG) emissions in tons per year,
- environmental damage index (cents per mile, based on health costs and risks associated with global warming)
- Green Score - a number between 0 and 100, with 100 being the (unattainable) best score.
- A ranking within the class ("above average" etc)

The booklet also includes a summary table for top-rated models in each class (figure C2), "practical picks" and lists of the ten best and ten worst vehicles for the year.

	Emission Standard	Fuel Economy City	Hwy	Fuel Cost/yr	Health Cost/yr	GHG tons/yr	EDX ¢/mi	Green Score	Class Ranking
SUBCOMPACT CARS (cont.)									
HONDA CIVIC									
1.6L 4, manual	LEV	32	37	$510	$140	8	1.76	**33**	▲
1.6L 4, manual	LEV	29	35	$540	$140	9	1.86	**31**	▲
1.6L 4, auto	LEV	28	35	$560	$140	9	1.88	**31**	▲
1.6L 4, manual	Tier 1	32	37	$510	$160	8	1.91	**30**	▲
1.6L 4, manual [P]	LEV	26	31	$700	$150	10	1.99	**29**	▲
1.6L 4, manual	Tier 1	29	35	$540	$160	9	2.01	**29**	○
1.6L 4, auto	Tier 1	28	35	$560	$170	9	2.04	**28**	○
1.6L 4, auto	Tier 1	28	35	$570	$170	9	2.06	**28**	○
1.6L 4, manual [P]	Tier 1	26	31	$700	$170	10	2.15	**27**	○

Figure C1. ACEEE table of details for each vehicle

The Top-Rated Models by Vehicle Class

	Specifications*	Emission Standard	Fuel Economy City	Fuel Economy Hwy	Green Score	Class Ranking
TWO SEATERS						
AUTOMATICS						
California Certified						
GM EV-1	Electric[1]	ZEV	3.3	4.0	**57**	✔
MAZDA MX-5 MIATA	1.8L 4, auto	TLEV	23	28	**25**	▲
SUBCOMPACT CARS						
AUTOMATICS						
California Certified						
HONDA CIVIC GX	1.6L 4, auto [CNG][2]	ULEV	28	34	**46**	✔
CHEVROLET METRO†	1.3L 4, auto	LEV	30	34	**33**	▲
SUZUKI SWIFT†	1.3L 4, auto	LEV	30	34	**33**	▲
MITSUBISHI MIRAGE	1.5L 4, auto	LEV	28	36	**32**	▲
HONDA CIVIC	1.6L 4, auto	LEV*	28	35	**31**	▲
Federally Certified						
HONDA CIVIC HX	1.6L 4, CVT	Tier 1	34	38	**31**	▲
CHEVROLET METRO†	1.3L 4, auto	Tier 1	30	34	**30**	▲
SUZUKI SWIFT†	1.3L 4, auto	Tier 1	30	34	**30**	▲
TOYOTA TERCEL	1.5L 4, auto	Tier 1	30	37	**30**	▲

Figure C2. ACEEE Table of top-rated vehicles in each class.

Comment on the ACEEE presentation

The comprehensive tables cover 1464 models/variants and are considered to be a little overwhelming for consumers. However, the Guide includes a simplified table of top-rated models within each vehicle class and "Practical Picks" which help to overcome this criticism.

In regard to the scoring system, and consumer presentation, the Guide is probably too overwhelming. A scoring scale of 0 to 100 may be too precise, particularly given the uncertainty and numerous assumptions that produce the score. The additional percentile ratings (5 ranges) within vehicle class are likely to be more useful to consumers, although this may disguise the poor environmental performance of larger vehicles such as most four-wheel-drives.

What Car? Green Car Guide

What Car? is a British consumer magazine. The July 1999 issue of the magazine included a 36 page booklet "Green Car Guide" which rated 85 cars and people movers. The magazine arranged its own emissions tests. Test results are analysed to give a Green Index Rating where zero is the best value (zero emissions). The actual vehicles ranged from the best score of 64 to the worst of 236. The score is also converted to a star (actually dot) rating, with five stars being the best.

The booklet includes separate ratings for "global warming" (based on CO_2 emissions) and "smog" (based on regulated pollutants). The booklet is divided into vehicle classes. There is a separate report on each vehicle tested (figure C3) and a summary list for each vehicle class (figure C4). At the end of the report is a very wide graph showing the index value for every vehicle (figure C5).

Green index 66

Toyota Yaris

It didn't quite spoil VW's party, but the stylish new Toyota came mighty close – just two points behind the winning Lupo. Marginally better than the VW in its emissions of the smog pollutants (hydrocarbons, NOx and carbon monoxide), it might have toppled it but for 10 per cent higher carbon dioxide output. Nonetheless, it rates a five its urban and four for its global performance – the only Japanese car in the survey to achieve this.

NEW TAX RATE?

The Yaris is too new to have a Government CO_2 figure yet, but in our testing it generated almost as much as the Starlet. How ironic if the sliding-scale road tax should rate them equally

CO_2 Gov't n/a WC? 182

VERDICT

Toyota's well-received newcomer proves itself the equal of Europe's best in more than just looks and dynamics

RATING

Global warming ●●●●○
Smog ●●●●●
Overall ●●●●○

Figure C3. Individual vehicle result in What Car? booklet

RATINGS AT A GLANCE

CAR	GLOBAL WARMING INDEX	SMOG INDEX	GREEN INDEX	OVERALL RATING
VW Lupo 1.4 16V	50	14	64	●●●●●
Toyota Yaris	55	11	66	●●●●○
Vauxhall Corsa Eco 1.0	54	15	69	●●●●○
VW Polo 1.6i	52	18	70	●●●●○
Seat Arosa 1.4	53	24	77	●●●●○
VW Lupo 1.0 8V	59	21	80	●●●●○
Peugeot 206 1.4	57	32	89	●●●●○
Renault Clio 1.4 RTE	54	37	91	●●●●○
Honda Logo	52	46	98	●●●●○
Hyundai Atoz 1.0 GLS	55	47	102	●●●○○
Kia Pride 1.3	53	54	107	●●●○○
Daihatsu Sirion 1.0	45	77	122	●●●○○
Daewoo Matiz 0.8	50	83	133	●●●○○
Toyota Starlet 1.3	54	59	134	●●●○○

Figure C4. Summary for "Superminis"class from What Car? booklet.

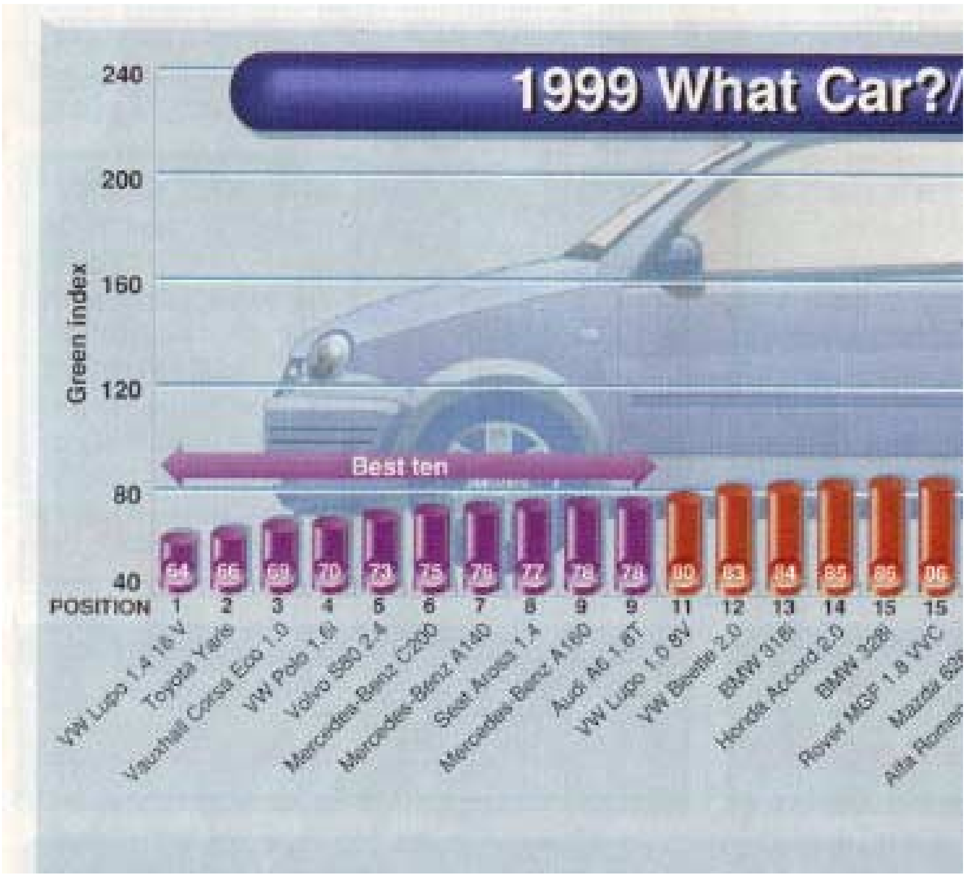


Figure C5. Part of summary graph from What Car? booklet

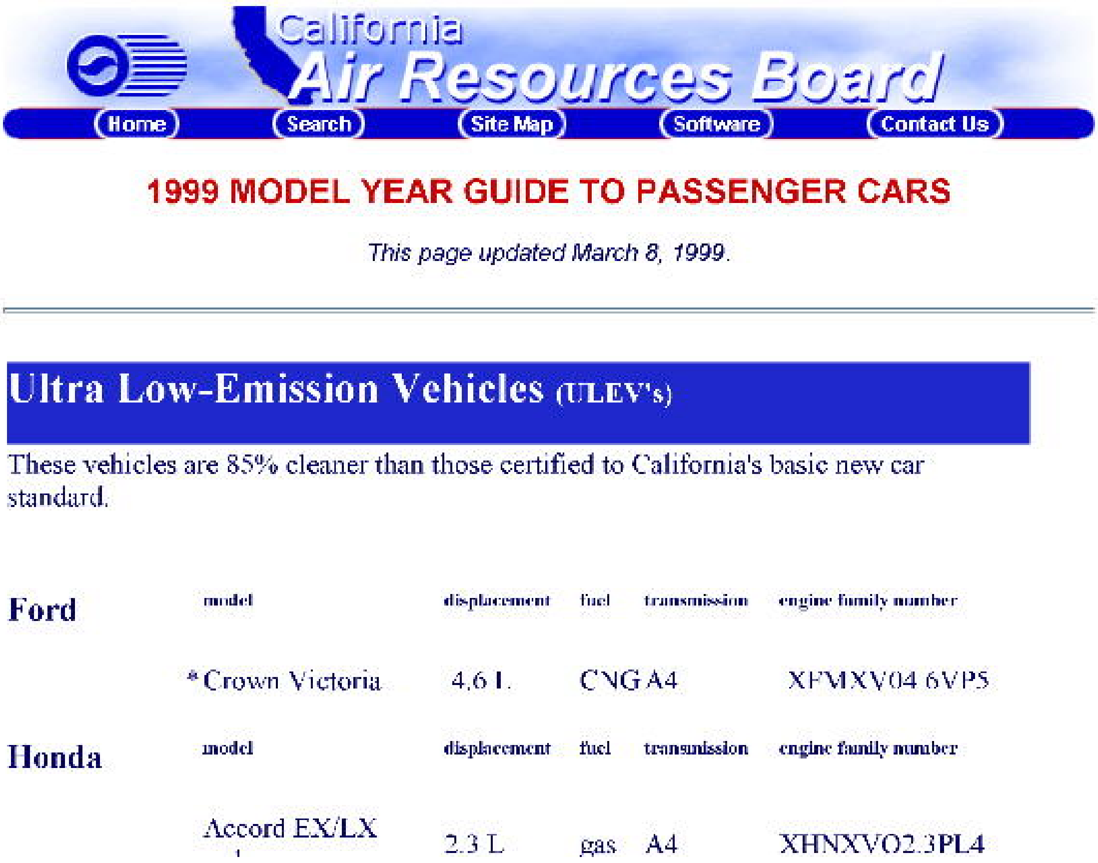
Comments on the What Car presentation

The method of presentation is considered to be effective but very demanding on document space. Consumers are given an overall rating (up to 5 stars/dots) and separate ratings for "Global warming" and "Smog". They can therefore apply their own weighting to the results.

The use of a Green Index that starts with the best performance at zero may be confusing. The difficulty is that the lower the Green Index the more stars the vehicle earns - an inverse relationship.

California Air Resources Board

CARB maintains a list of vehicles that comply with the more stringent emissions standards


California Air Resources Board

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1999 MODEL YEAR GUIDE TO PASSENGER CARS

This page updated March 8, 1999.

Ultra Low-Emission Vehicles (ULEV's)

These vehicles are 85% cleaner than those certified to California's basic new car standard.

	model	displacement	fuel	transmission	engine family number
Ford	*Crown Victoria	4.6 L	CNG	A4	XFMXV04 6VP5
Honda	Accord EX/LX	2.3 L	gas	A4	XHNXV02.3PL4

Figure C6. CARB List of ULEV vehicles

Australian Greenhouse Office - Fuel Consumption Guide

The Australian Greenhouse Office publishes a list of the fuel consumption for most models sold in Australia.

PASSENGER CARS (PETROL) Table 1

HONDA (continued)	L/100km City Cycle	L/100km Highway Cycle	Fuel System	Engine Displacement (litres)	No. of Cylinders/Rotors	No. of Gear Ratios	Seating Capacity	Axle Ratio
Odyssey Auto sedan 5dr	11	8	I	2.3	4	4	6/7	4.785
Prelude Si Auto coupe 2dr	10	7.4	I	2.2	4	4	4	4.466
Prelude Si Man coupe 2dr	10	7.8	I	2.2	4	5	4	4.266

Figure C7. Fuel Consumption Guide - Australian Greenhouse Office

UK Dept Environment, Transport and the Regions

An interactive Internet site allows users to select vehicle parameters and display a list of environment-related information.

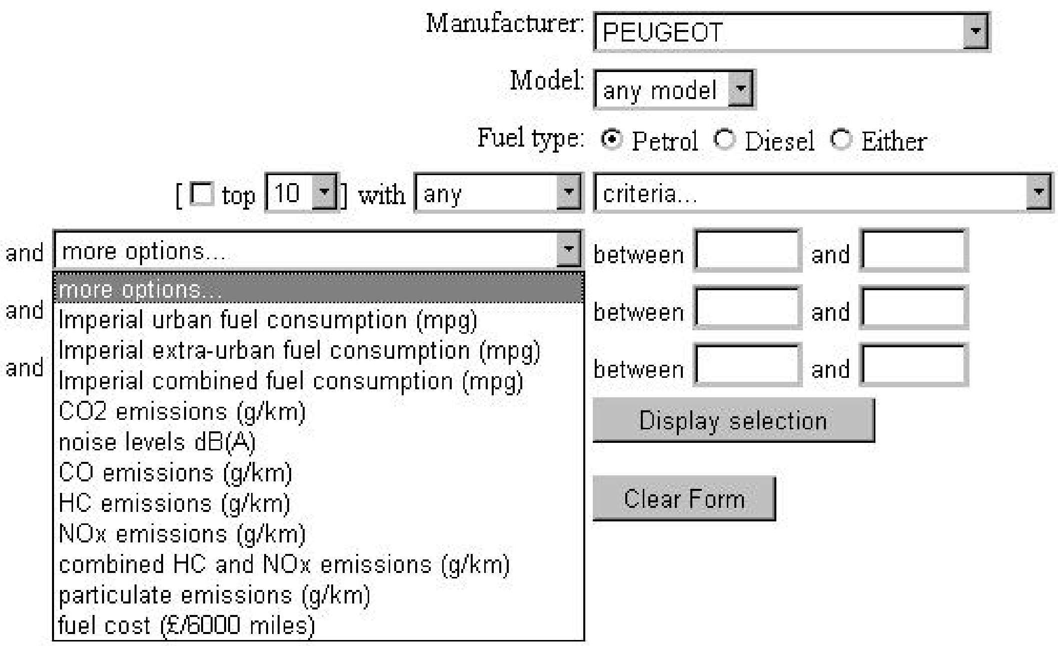


Figure C8. DETR Selection window

Search results
All petrol vehicles from PEUGEOT.

Manufacturer and Model	Engine Capacity	Trans-mission	Fuel Type	Imperial Urban	Imperial Extra-urban	Imperial Combined	CO2 (g/km)	Fuel Cost	Noise Level	CO	HC	NOx	HC + NOx	Particles	Euro Standard
	(cc)			(mpg)	(mpg)	(mpg)	(g/km)	(£/ 6000m)	dB(A)	(g/km)	(g/km)	(g/km)	(g/km)	(g/km)	
PEUGEOT															
106															
106 GTi 1.6	1587	M5	Petrol	24.7	44.7	34.9	194	547.0831	73.1	1.224			0.389		II
106 Quiksilver 1.4	1360	M5	Petrol	30.2	52.2	41.5	167	460.0771	72.7	1.422			0.254		II
106 Zest 3 1.4 Auto	1360	A3	Petrol	26.8	44	35.7	195	534.8235	66.9	0.947			0.451		II
106 Zest/Zest 2/Zest 3 1.1	1124	M5	Petrol	33.5	54.2	44	154	432.9524	72.8	0.582			0.166		II
206															
206 GLX/XS 1.6/Roland Garros 1.6	1587	M5	Petrol	30	50.4	40.2	171	473.7767	73.6	1.057			0.355		II

Figure C9. DETR Sample output

Crash test brochures

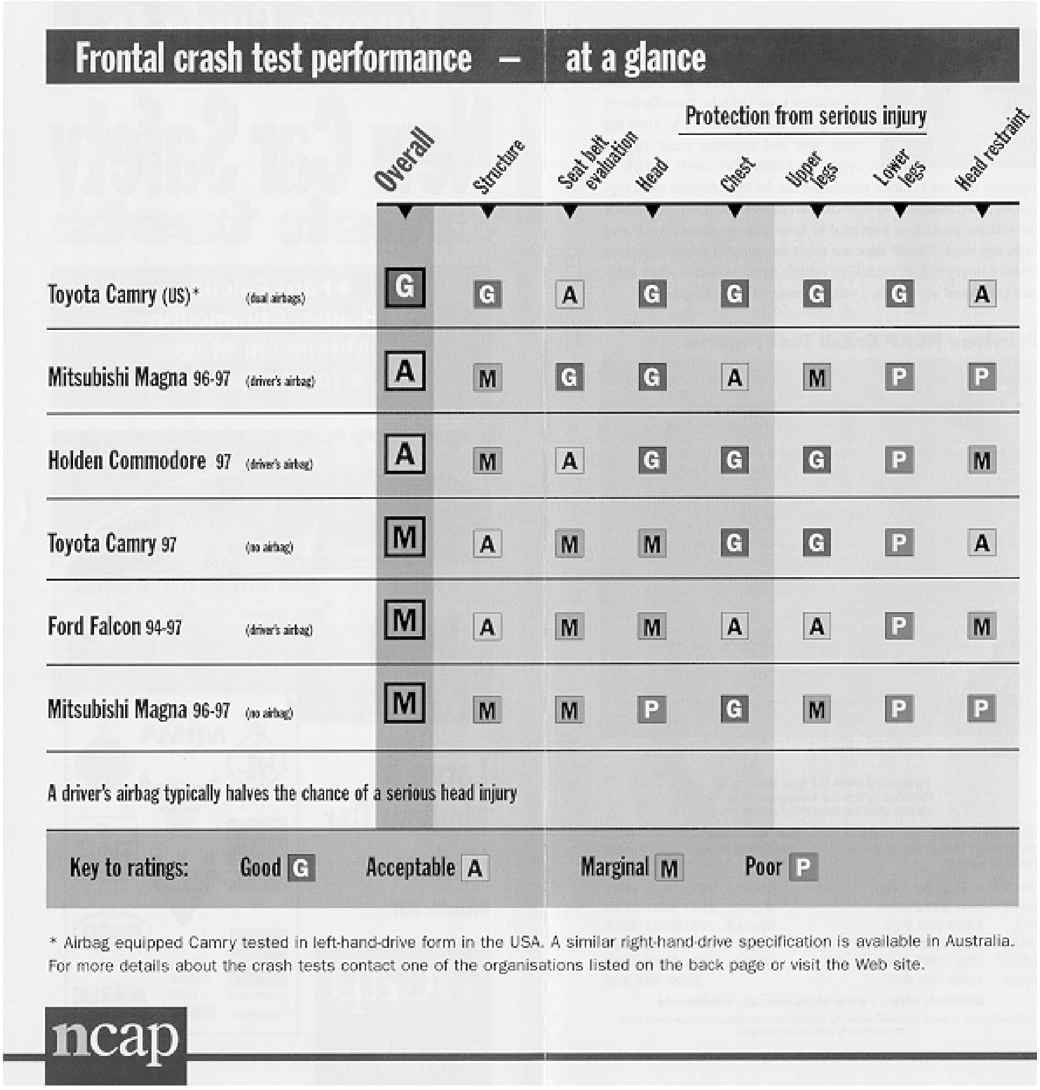
The Australian New Car Assessment Program (ANCAP) has tried a range of methods of presenting the results of crashworthiness tests. Samples are included in Figures C8 to C10,. derived from an ANCAP paper (Case et al, 1998).

Frontal crash test performance

All vehicles have been subjected to a 56km/h full frontal test unless otherwise noted.

Large Medium Cars		Overall
OFFSET TEST 64 km/h		
Toyota Camry (US) 9/97-on	(dual air bags)	G
Volvo 850 (US) 95-97	(dual air bags)	G
Mitsubishi Magna 96-on	(driver's air bag)	A
Honda Accord 94-97	(driver's air bag)	A
Holden Commodore 9/97-on	(driver's air bag)	A
Toyota Camry 9/97-on		M
Ford Falcon 94-98	(driver's air bag)	M

Figure C10 - ANCAP Summary Brochure, 1998.



Frontal crash test performance – at a glance

	Overall	Structure	Seat belt evaluation	Head	Chest	Upper legs	Lower legs	Head restraint
			Protection from serious injury					
Toyota Camry (US)* (dual airbags)	G	G	A	G	G	G	G	A
Mitsubishi Magna 96-97 (driver's airbag)	A	M	G	G	A	M	P	P
Holden Commodore 97 (driver's airbag)	A	M	A	G	G	G	P	M
Toyota Camry 97 (no airbag)	M	A	M	M	G	G	P	A
Ford Falcon 94-97 (driver's airbag)	M	A	M	M	A	A	P	M
Mitsubishi Magna 96-97 (no airbag)	M	M	M	P	G	M	P	P

A driver's airbag typically halves the chance of a serious head injury

Key to ratings: Good G Acceptable A Marginal M Poor P

* Airbag equipped Camry tested in left-hand-drive form in the USA. A similar right-hand-drive specification is available in Australia. For more details about the crash tests contact one of the organisations listed on the back page or visit the Web site.

ncap

Figure C11- ANCAP Large/Medium Vehicle Results, 1997.

Current ANCAP Presentation

During 1999 ANCAP aligned its test and assessment procedures with thise of Euro-NCAP. Under this system each vehicle is assigned a score based on the results of two types of crash test. The best possible score is 32 points. Up to 4 stars are allocated, according to the score.

ANCAP releases a summary brochure for each series of tests. These brochures are distributed from motor registries and NRMA offices. The latest brochure is very simple. It graphically illustrates the score and star rating earned by each vehicle (figure C10).

Figure C12. Summary table from current ANCAP brochure

If consumers require more information about a particular vehicle they can visit the ANCAP website or obtain a copy of a one-page handout for the vehicle concerned. This contains a description of the test outcome and a table of the dummy injury measurements. If further information is required then the detailed assessment report can be provided to consumers. This shows the derivation of the scores for each crash test. The following page shows a recent ANCAP detailed sheet.

Crash Tests

New Car Safety

SUBARU LIBERTY

1999 on **Dual airbags**

Overall Evaluation

Overall rating 86%

Variant: GX Sedan. Engine: 4 Cyl. 2 litre.

Kerb weight: 1410 kg Category: LARGE/MEDIUM CAR

Vehicles built: July 1999

OVERALL EVALUATION : 4 Stars

The Subaru Liberty performed well in both crash tests. The passenger compartment held its shape very well in the offset crash test. The driver and passenger had airbags and were well protected from serious head injury. Protection from serious lower leg injury was marginal for the driver.
The vehicle also performed well in the side impact crash except that protection from serious chest injury was marginal.

Safety features

Dual airbags are standard equipment.
The front seat belt buckles are mounted on the seats and the upper anchorages are adjustable. These features improve the fit of the seat belt. Lap/sash (3 point) seat belts are fitted to all seats, including the centre rear seat.
Hazard warning lights activated during the crash.

STRUCTURE : GOOD

Offset crash test

The passenger compartment held its shape very well in the offset crash test. The front part of the driver's floor was pushed rearwards 7cm and was only slightly deformed. The brake pedal moved rearwards by 10cm. The dash moved 3cm towards the driver. The width of the driver's doorway shortened by 3cm. All doors remained closed during the crash. After the crash extra effort was required to open the driver’s door. The other doors opened easily.

Side impact crash test

The passenger compartment held its shape well in the side impact crash test.]

RESTRAINTS

Offset crash test

Airbags cushioned the head of the driver and passenger and movement was well controlled. The driver's knees hit the dash and steering column cover. The passenger's knees hit the glove box.

Side impact crash test (no front passenger)

The driver's head rocked outside the side windows, which had shattered. Rebound was well controlled.

INJURY MEASUREMENTS

Refer to the information sheet “How the test are done”	**Offset Crash Test at 64km/h**		**Side Impact Crash Test at 50km/h**
	Driver	**Passn**	**Driver**
Head HIC	433	284	38
Acceleration (g for 3ms)	48.7	39.7	31.4
Neck - Shear (kN)	-	-	-
Tension (kN)	1.7	1.3	-
Extension (Nm)	-	-	-
Chest Accln (g for 3ms)	38.9	35.4	-
Compression (mm)	31.8	32.5	29.7
Viscous criterion (m/s)	0.1	0.2	0.42
Abdomen - Force (kN**)**	-	-	0.9
Pelvis - Force (kN)	-	-	2.1
Upper legs Force Left	3.4	0.5	
(kN) Right	1.4	0.5	
Knee displ (mm) Left	0.4	0	
Right	0.4	2.3	
Lower legs Comp Left	2.6	1.6	
(kN) Right	1.4	1.6	
Index (Upper/Low) Left	0.52/0.72	0.35/0.33	
Right	0.41/0.45	0.26/0.26	
Injury Risk#	8.2%	6%	

#“Injury risk” is the probability of receiving a life-threatening injury. It is based on dummy head and chest measurements in the offset test.

Other crash test presentations

Euro-NCAP

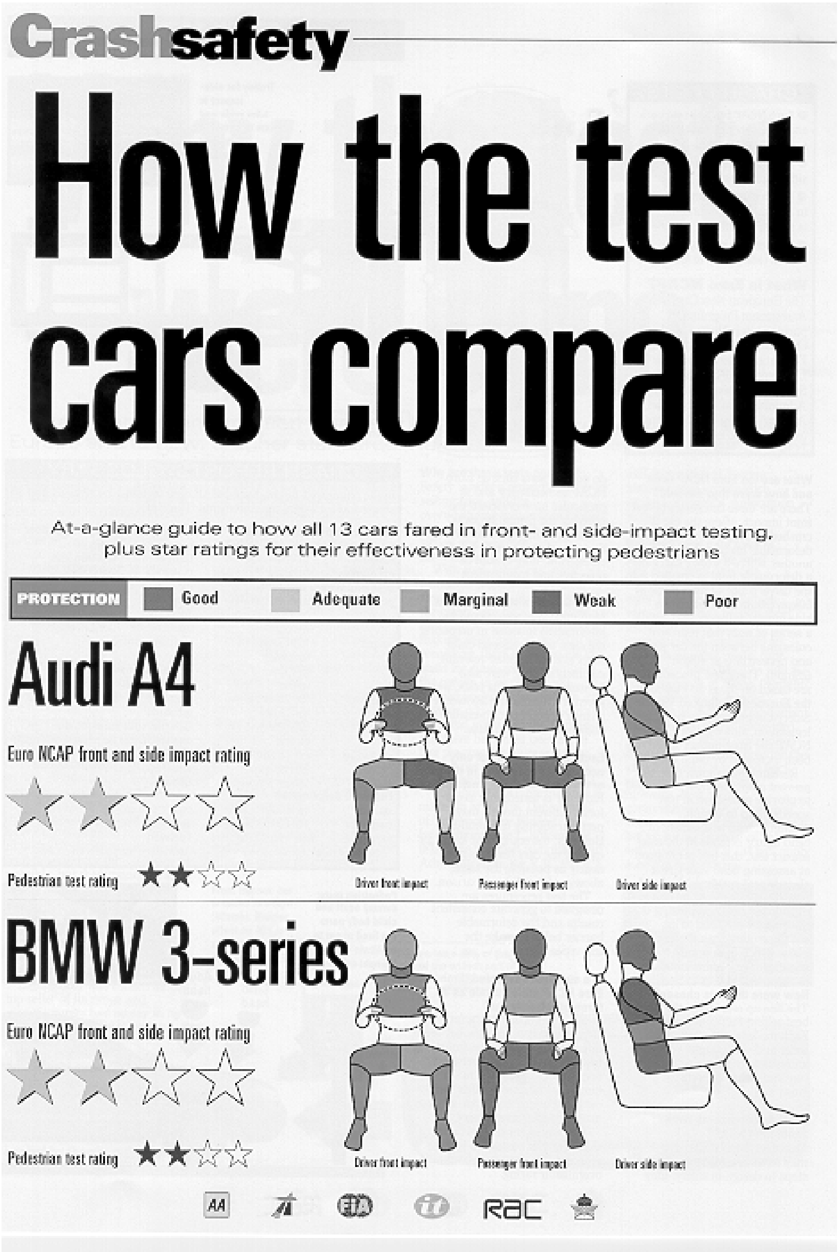


Figure C13. Euro-NCAP summary chart

Insurance Institute for Highway Safety (USA)

GOOD G
ACCEPTABLE A
MARGINAL M
POOR P

				INJURY MEASURES					
	OVERALL EVALUATION	Structure/ Safety Cage	Restraints & Dummy Kinematics	Head/Neck	Chest	Leg/Foot, Left	Leg/Foot, Right	Head Restraint Design	Bumper Performance
A BEST PICK TOYOTA SIENNA 1998-2000 models	G	G	G	G	G	G	G	P	M
HONDA ODYSSEY 1999-2000 models	G	A	A	G	G	G	G	M P [1]	A
FORD WINDSTAR 1999-2000 models	G	A	A	G	G	A	G	A P [1]	A
DODGE GRAND CARAVAN PLYMOUTH GRAND VOYAGER CHRYSLER TOWN & COUNTRY 1996-2000 models	M	A	A	G	G	P	P	M P [2]	P

Figure C14. IIHS Summary Table

National Highway Transportation Safety Administration - US Government

Figure C15 - NHTSA crash test web page

OSA - Japanese road safety organisation

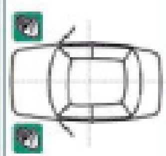
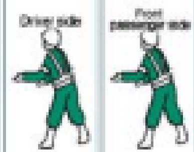
Test Vehicle ( ) :Test years	Vehicle with equivalent performance	Results of crashworthiness test for frontal collision (55km/h)					
		(1)Injury Risk (Risk of occupants being seriously injured)		(2)Door open-ability	(3)Rescuability		(4)Fuel leakage after the test
		Driver	Front seat passenger				
#LOGO G 3Door('97) Honda Motor Co., Ltd. Weight : 856kg Engine : 1,343cc ABS : Provided Driver's air bag : Provided Front passenger's air bag : Provided Seat belt pretensioner : Not provided Sold from October 1996 to November 1998	Non	AA	AA				

Figure C16. OSA (Japan) summary table

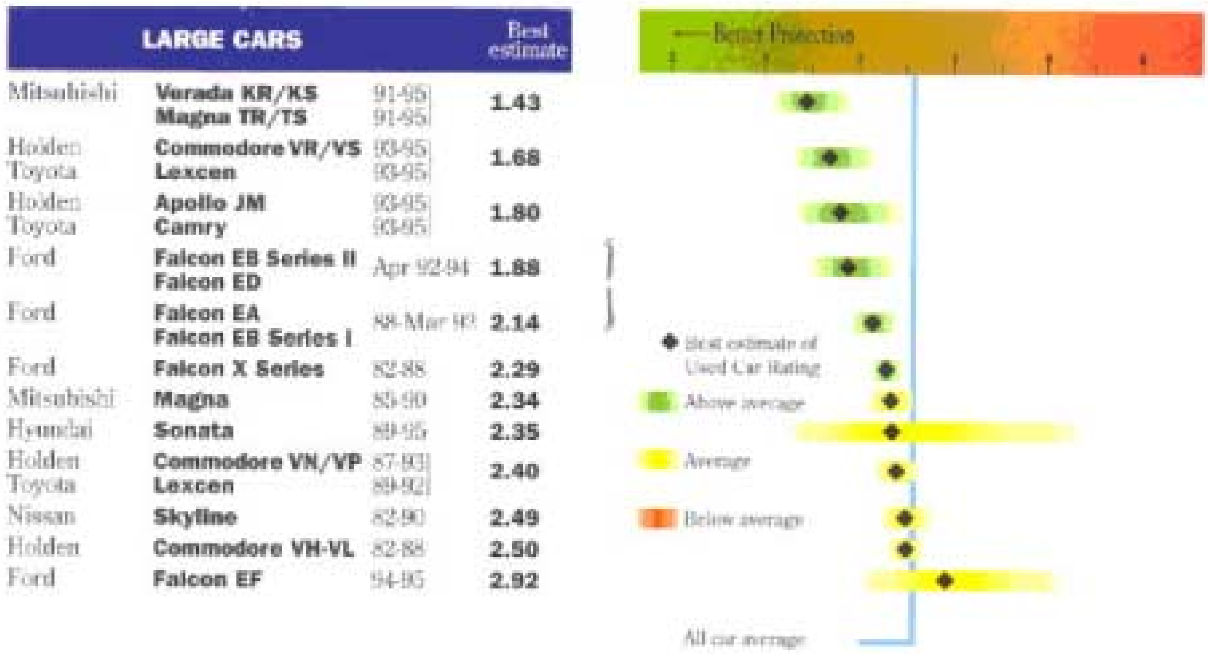
Vehicle Design and Research - Consolidated list of offset crash tests

___MAKE___&___MODEL___	____YR_____	__AIRBAGS__	RATING	TEST_BY
CHEV BLAZER(US)	1995 on	(dual airbags)	--------P	IIHS
HONDA CR-V(US)	1998 on	(dual airbags)	-----M	IIHS
HONDA CRV	1999 on	(dual airbags)	G	ANCAP
HONDA PASSPORT(US)	1996 to 97	(dual airbags)	--------P	IIHS

Figure C17 Consolidated list of offset crash tests (WWW)

Used Car Safety Ratings

Each year the results of real-world crashes are analysed to provide an indication of the crashworthiness of vehicles. The results are presented in a brochure."User Car Safety Ratings". The brochure is divided into vehicle categories. In includes a table showing the score for each vehicle and a graph which illustrates the score, the error margin and the "all vehicle average" (figure C16). The graph is, perhaps, too overwhelming for consumers.



LARGE CARS			Best estimate
Mitsubishi	Verada KR/KS Magna TR/TS	91-95 91-95	1.43
Holden Toyota	Commodore VR/VS Lexcen	93-95 93-95	1.68
Holden Toyota	Apollo JM Camry	93-95 93-95	1.80
Ford	Falcon EB Series II Falcon ED	Apr 92-94	1.88
Ford	Falcon EA Falcon EB Series I	88-Mar 92	2.14
Ford	Falcon X Series	82-88	2.29
Mitsubishi	Magna	85-90	2.34
Hyundai	Sonata	89-95	2.35
Holden Toyota	Commodore VN/VP Lexcen	87-93 89-92	2.40
Nissan	Skyline	82-90	2.49
Holden	Commodore VH-VL	82-88	2.50
Ford	Falcon EF	94-95	2.92

Figure C18. Used Car Safety Ratings

Discussion

Amount of information presented

The ANCAP approach of providing several levels of information has merit. It is considered that a widely distributed publication should be as simple as possible but it should describe ways in which more detailed information can be obtained. The Internet provides a simple way for consumers to "click" and obtain more information. With ANCAP they can also telephone an enquiry number and have detailed sheets posted or faxed to them.

The latest ANCAP brochure, which illustrates the crash test scores as horizontal bars and divides the graph into star ratings, appears to get the message across about the range of performance between the listed vehicles. It is similar to the graphical presentation in the Used Car Safety Ratings (UCSR). One item from the UCSR graph that might be useful for a Green Car Rating is the "all car average". Earlier versions of the UCSR also included a class average but this made the graph too confusing. Consumers can judge the approximate class average for themselves, particularly where the vehicles are listed in order of performance.

A simple graphical presentation is considered to be more appealing than the numerical tables used in the Fuel Consumption Guide and the ACEEE Green Guide.

Sorting order

Eventually there will probably be dozens of vehicle models/variants to list. These will need to be divided up to make the tables more manageable. Vehicle class is an obvious division. Within each vehicle class it would be desirable to list vehicles in order of performance, as ANCAP does with crash tests. A difficulty with this approach may be the large number of vehicles to be listed. The fuel consumption guide lists a number of variants for each model (sedan/wagon, auto/manual etc).

ACEEE takes a similar approach with variants. On the other hand, ANCAP and What Car select one variant from each model for testing and reporting purposes (ANCAP usually chooses the most popular variant for the model, based on the VFACTS statistics).

Options for the vehicle selection process for the proposed Green Car Guide are covered in the section "Implementation". If a similar approach to that of ANCAP is taken (i.e. it only covers one variant for each model) then a listing of vehicles in order of environmental performance is recommended.

APPENDIX D - POTENTIAL SOURCES OF DATA

A draft data model has been developed showing the range of information that might contribute to a Green Car rating system. The model is illustrated in Figure D1. Note that *it is unlikely that all of the data items will be used in the final rating system* - the main purpose of the model is to identify potential avenues for arriving at a rating. The following notes cover possible sources for the main items of data in the system.

Table numbers refer to the ACEEE report on their methodology. All values have been converted to metric (ACEEE uses a confusing mix of metric and imperial values).

A.Vehicle Manufacturer

A1. Data item: Manufacturers Green Initiatives
Description and notes: For a given manufacturer an range of Green initiatives could be considered for incorporation in the Green Score, or reported separately.
Example: Whether a low-emission-vehicle is in production or under development. Active recycling programs. Whether ISO140001 environmental management systems are implemented at factories.
Potential sources of data: Survey of manufacturers. Media reports.
Uncertainty and difficulties: Will rely on advice from manufacturers. Environmental benefits might not be realised.

B.Vehicle and Embodied Emissions

B1. Data item: Vehicle Model
Description and notes: Data relevant to the vehicle model, rather than variants within the model. This will probably be supplementary information since emissions depend on engine specs and other factors that are specific to variants.
Example:
Potential sources of data: see B2
Uncertainty and difficulties:

B2. Data item: Vehicle Variant
Description and notes: A particular combination of engine, transmission and are specs within a model. Generally as tested by the manufacturer to emissions ADRs.
Example: 1.5 litre 4 cyclinder fuel injected engine. 3 door hatch body style. Kerb mass 900kg. City fuel consumption 8 l/100km.
Potential sources of data: New Vehicle Specification sheets published by FORS. Motoring magazine lists of new car specifications.
Uncertainty and difficulties: Keeping up-to-date with model and variant changes.

B3. Data item: Estimated emissions from vehicle assembly (not materials)
Description and notes: Emissions associated with producing the vehicle. This relates mainly to the energy consumed on the production line.
Example: ACEEE estimates that 1.1MJ of electricity per kg of vehicle mass is used in vehicle assembly. Other fuels are assumed to be negligible. (table A3b)
Potential sources of data: ACEEE
Uncertainty and difficulties: Relies on ACEEE estimate

B4. Data item: Estimated material content of the vehicle
Description and notes: The total amount of each of the materials that make up a motor vehicle is determined. This is used to estimate embodied emissions. It includes energy consumption.
Example: ACEEE estimates that a typical vehicle is 45.1% plain carbon steel, by mass. (table A3a)
Potential sources of data: It is unlikely that manufacturers will be forthcoming with the material content of each model. The estimates provided by ACEEE could be used.
Uncertainty and difficulties: There could be wide variation in the actual material content of vehicles, or differences between US and Australian vehicles. There appears to be no easy way to resolve this. The current system does not appear to give credit to materials recycling..

B5. Data item: Emissions from component materials
Description and notes: For each material used in a vehicle an estimate is made of the emissions per kg of material. This includes emissions from energy consumption.
Example: ACEEE estimates that the production of 1 kg of plain carbon steel uses about 30MJ of energy. (table A3a)
Potential sources of data: ACEEE estimates energy consumption, and the proportion of each type of energy source (gas, coal, electricity etc) for each material. This, in turn, is used to estimate emissions. ACEEE estimates of direct emissions from all materials are lumped together as a Toxic Releases Inventory (TRI) factor of 3.23g of "toxic emissions" per kg of vehicle.
Uncertainty and difficulties: Assumptions on energy consumption for various materials. Assumptions about direct emissions. Note that ACEEE does not try to quantify the health costs of TRI "toxic emissions" but adds them to particulate emission estimates for the purpose of deriving the EDX.

B6. Data item: Emissions from energy production
Description and notes: For each source of energy (coal, oil, electricity etc) an estimate is made of NOX, SO2, PM10 and CO2 (or CO2 equivalent) emissions during energy production. Generation and transmission inefficiencies should be taken into account in the case of electricity production. Fuel cycle emissions should be taken into account for hydrocarbon fuels. This data item can be used for other calculations involving energy consumption.
Example: ACEEE estimates that the emission of NOX from coal burning is 246 g per MJ of energy produced. (Table A3 - note possible conflict with table A2c)
Potential sources of data: ACEEE adjusted for the Australian energy industry.
Uncertainty and difficulties: Factoring in generation and transmission inefficiencies. Substituting hydro-electric power for nuclear power.

B7. Data item: Estimated embodied emissions
Description and notes: Estimates of production and materials emissions are combined to give an estimate of emissions per kg of vehicle mass. These emissions are converted to lifetime emissions per km by assuming a typical lifetime km travelled and multiplying by the vehicle mass. [(emissions in g/km)(kerb mass in kg)/(km travelled in lifetime)]
Example: ACEE estimates that for the "average" vehicle the embodied NOX emissions equate to 0.2 g / km over the vehicle lifetime (table 4c)
Potential sources of data: Derived from previous data.
Uncertainty and difficulties: The figure of 160,000 km (actually 100,000 miles) assumed by ACEEE might not apply to Australia

C.Fuel Consumption-and Related Emissions

C1. Data item: Fuel consumption
Description and notes: Amount of fuel consumed per 100km of travel. (litres for liquid fuels, MJ for electric vehicles).
Example: The average vehicle in the ACEEE analysis achieved 11.4 litres per 100km in the US EPA composite driving cycle.
Potential sources of data: Fuel consumption values published by Environment Australia. An alternative is to use fuel consumption from emissions tests.
Uncertainty and difficulties: Actual fuel consumption compared with measured values. Timeliness of AGO data. Mix between city and highway driving.

C2. Data item: In-use emissions dependent on fuel consumption
Description and notes: Evap HCs, SOX and Greenhouse gases (CH4, N2O and CO2) are assumed to be directly proportional to fuel consumption. This depends on the type of fuel.
Example: ACEEE estimates that 1.8 kg of CO2 is produced for every litre of *petrol* consumed. (table 4a & A2a)
Potential sources of data: ACEEE estimates
Uncertainty and difficulties: Relies on ACEEE estimates. Evap HCs may vary considerably between vehicles. It might be better to separately calculate fuel and energy consumption-related emissions rather than convert electric vehicle values to "gasoline equivalent".

C3. Data item: Fuel supply cycle emissions
Description and notes: The production, refining and distribution of fuels involves emissions. For each type of fuel an estimate is made of the emissions per litre of fuel.
Example: ACEEE estimate the NOX emissions from the petrol fuel cycle at 1.9 g per litre. (table 4)
Potential sources of data: ACEEE estimates.
Uncertainty and difficulties: ACEEE assumptions might not apply in Australia.

C4. Data item: Estimated fuel-related emissions per km
Description and notes: Items C2 and C3 are combined to give total emissions for each ltre of fuel consumed. This value is combined with fuel consumption to give emissions per km travelled.
Example: ACCEE indicates that the average vehicle emits, from the tailpipe, 255 grams of CO2 per km and fuel cycle emissions equate to an additional 76 g/km. The combined CO2 emissions associated with fuel consumption are therefore 331 g/km.
Potential sources of data: Inputs from C1, C2 and C3.
Uncertainty and difficulties: -

D.In use Emissions (dependent on km travelled)

For each type of pollutant, only ONE of the following three data items would serve as input into "estimated lifetime in-use emissions".

D1. Data item: Recognised vehicle emissions standard
Description and notes: The most stringent standard to which the vehicle is certified is used as a basis for estimating tailpipe emissions. It is assumed that the vehicle just passes the appropriate standard. This is most useful where there are several tiers of emissions standards available and manufacturers choose to certify to these standards. Adjustment factors are applied to derive estimated lifetime emissions.
Example: ACEEE estimates "on-cycle" NOX emissions of a petrol vehicle certified to the US "tier 1" standard at 0.26 g / km. (table A1a)
Potential sources of data: Actual limits in applicable emissions standards. ACEEE assumptions.
Uncertainty and difficulties: The preface to Table A1 indicates that "off-cycle" and "malfunction" tailpipe emissions scale with vehicle laden mass - factors are then applied to the calculations for various commercial vehicles. The actual methods/assumptions that ACEEE uses to derive its estimates of tailpipe emissions are not clear.

or

D2. Data item: Emissions test of a sample vehicle
Description and notes: One or more samples of the vehicle are subjected to an emissions test. The results are used to estimate lifetime tailpipe emissions. Note that the emissions test should also give fuel consumption figures.
Example: What Car magazine results (separate results for each pollutant are not published)
Potential sources of data: Arrange for tests of applicable vehicles. What Car? weighting of results.
Uncertainty and difficulties: Costs and logistics of testing. Credibility of the test procedure and interpretation of the results. Application of What car? assumptions to Australia.

or

D3. Data item: Actual results of ADR 37 emission tests
Description and notes: Obtain from manufacturers (or FORS) the actual results of ADR emission tests for each model/variant.
Example: Nil
Potential sources of data: Vehicle manufacturers or FORS
Uncertainty and difficulties: ADR results are commercial in confidence. FORS and most manufacturers are unlikely to provide data. However, some manufacturers might be prepared to provide exceptionally good results if they knew that other vehicles would be rated on the basis that they only just met the ADR. The credibility of results from manufacturers might be questioned. Other options are to require disclosure of emissions tests results as part of government fleet procurement and to require manufacturers to specify ranges rather than actual emissions (similar to CARB).

D4. Data item: Estimate of other in-use emissions
Description and notes: Depending on which of the previous three methods (D1, D2 or D3) is used, an estimate is made of the in-use emissions not covered by the particular method. This category might cover evaporative HCs, cold starts, hard acceleration, degradation and malfunction (with ACEEE, these examples are included in item D1). These items should not duplicate the emissions predicted from data item B2 (note that ACEEE separates Evap HCs into fuel-consumed and mileage components).
Example: None available.
Potential sources of data: Apply ACEEE methodology to the the relevant data source.
Uncertainty and difficulties: There could be considerable variation between vehicles for these "unregulated" factors. It may be better to ignore them rather than rely on questionable assumptions.

D5. Data item: Estimated lifetime in-use emissions
Description and notes: Output from either item D1, D2 or D3 and output from C4 and D4 (if any) are used to estimate lifetime in-use emissions in grams per km.
Example: ACEEE estimates lifetime NOX emissions of a petrol vehicle certified to the US "tier 1" standard at 1.04 g / km. (table A1a)
Potential sources of data: Outputs from items C4, D1, D2, D3 and D4. ACEEE assumptions or What Car? assumptions.
Uncertainty and difficulties: Depends on quality of input data.

E.Calculation of environmental damage

E1. Data item: Estimated lifetime emissions
Description and notes: Combine output from B7 and D5 to derive an estimate of lifetime emissions in g/km
Example: ACEEE estimates the total lifetime NOX emissions of the average vehicle at 1.12 g/km
Potential sources of data: Inputs from B7 and D5
Uncertainty and difficulties: Depends on quality of input data

E2. Data item: Pollutant
Description and notes: name of pollutant (CO, NOX etc)
Example: -
Potential sources of data: All possible pollutants that could be used in the rating
Uncertainty and difficulties: -

E3. Data item: Type of pollutant
Description and notes: Whether the pollutant is health or Greenhouse related or both. Whether it is regulated or unregulated.
Example: -
Potential sources of data:
Uncertainty and difficulties:

E4. Data item: Damage potential of pollutant
Description and notes: For each pollutant, the relative environmental damage, based on estimated health or Greenhouse damage (damage per gram). Separate indexes should be assigned for health and greenhouse damage if the pollutant affects both.
Example: ACEEE uses a NOX damage *cost* of 0.45 cents per gram for tailpipe emissions. The Australian system will avoid reference to costs and simply work from a relative damage index.
Potential sources of data: ACEEE assumptions. Australian health research. NEPC and NGGI.
Uncertainty and difficulties: ACEEE applies a "remoteness" factor to some non-vehicle emissions, such as NOX from the fuel cycle or power station (eg embodied NOX costs reduce to 0.09 cents/gram). It would seem better to apply these factors to items B7 and C3 and reduce the contribution of these items to estimated lifetime vehicle emissions (item E1). Similarly, Greenhouse gases are converted to "CO2 Equivalent" but it would seem better to separately cost these other Greenhouse gases.

The over-riding assumption in the ACEEE methodology is that total Greenhouse costs are equated to total health costs for the average vehicle. For example, the health costs for an average vehicle worked out at 0.82 cents per km. The Greenhouse costs (CO2 or equivalent) were therefore calculated at this rate (0.82 c/km). A problem with this approach is that the Greenhouse costs need to be adjusted each year to reflect changes in the health costs for the average vehicle. It would seem better to fix the Greenhouse costs at some reasonable value.

E5. Data item: Environmental Damage Index (EDX)
Description and notes: Output from E1 and E4 is combined to given an "environmental damage index" (damage per km). Note separate calculations for health and Greenhouse damage for some pollutants.
Example: The environmental damage index for the average vehicle was 1.64 cents per km. The Australian system will avoid reference to costs.
Potential sources of data: Output from E1 and E4.
Uncertainty and difficulties: See notes about E4.

E6. Data item: Green Score
Description and notes: The output from item E5 (EDX) can be converted to a Green Score scaled from 0 to 100.
Example: For ACEEE the Green Score for the average vehicle was 21 (based on an EDX of 1.64 c/km)
Potential sources of data: ACEEE formula on page 15 of the Methodology report.
Uncertainty and difficulties: Keeping it simple for consumers, while giving information which spreads the field. The value of a 0 to 100 scale needs to be considered. It may confusing to consumers. A difficulty is that the scale must be able to cover a huge range of environmental performance. It may prove better to simply report the EDX and a star rating, with the less damage awared the most stars.

E7. Data item: Additional ratings
Description and notes: Possibly calculate a separate rating for "smog" (health) and Greenhouse emissions so that consumers can decide on a weighting. Calculate a class ranking (relative position within the class of vehicle).
Example: What car? rates the Hyundai Sonata as 3 stars for "Global warming", 2 stars for "smog" and 3 stars "overall". ACEEE rates the Sonata as average in its class(EDX of 1.52 c/km)
Potential sources of data: Rating systems used by ACEEE (p52) and What Car?.
Uncertainty and difficulties: Keeping it simple for consumers, while giving information which spreads the field.

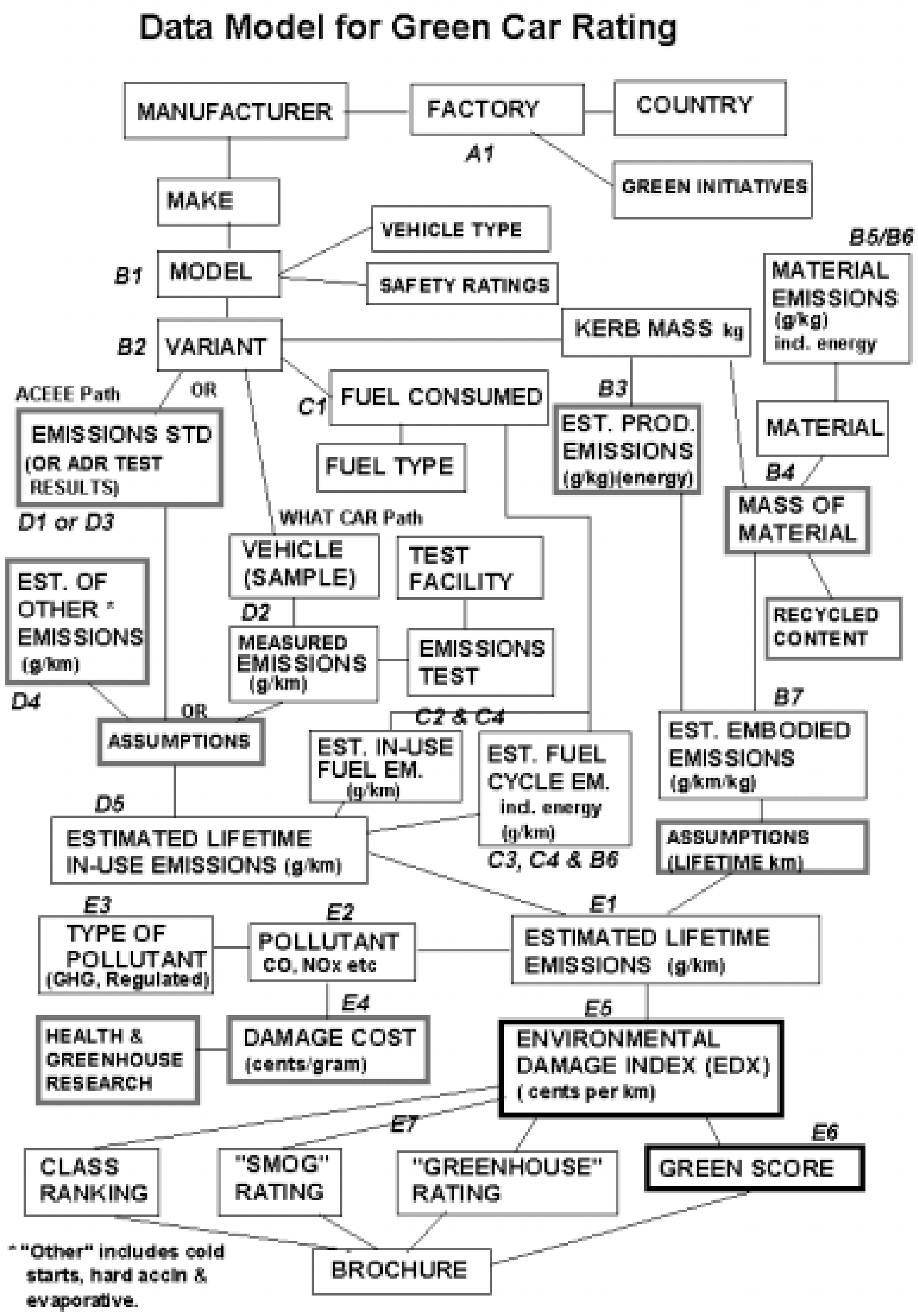


Figure D1 (Note "Damage cost" could be "Damage Index")

Appendix E Notes about pollutants

Carbon monoxide

Toxic at high concentrations. Possible health concerns at low concentrations. Indirect source of Greenhouse gases. 90% of human-sourced CO is from motor vehicles. Measured as part of ADR37/IM240.

Carbon Dioxide

Major source of greenhouse gases. 12% of human-sourced CO_2 is from motor vehicles. About 50% is from power stations. Carbon dioxide is measured as part of ADR37/IM240 testing but is not subject to a regulatory limit.

Oxides of Nitrogen

N_2O is a strong Greenhouse gas. NO and other oxides are indirect contributors. NO can produce $NOSO_2$ which is a strong Greenhouse gas and a respiratory irritatant. Oxides of Nitrogen also produce nitric acid and particulates and are a major contributor to photochemical smog. 82% of human-sourced oxides of nitrogen are from motor vehicles - half of these from light vehicles. Measured as part of ADR37/IM240.

Reactive Organic Compounds (ROC)

With vehicles, these are mainly hydrocarbons. They react to form photochemical smog. 41% of human-sourced ROCs are from motor vehicles - mainly light vehicles. Hydrocarbons measured as part of ADR37/IM240. Methane is usually discounted from the reported values for these tests but needs to be considered for a Green Rating because it is a Greenhouse gas. It is probably not practical to test for less common ROCs in very small quantities.

Particulates

Contribute to smog/haze and respiratory irritation. Provide an avenue for heavy metals to be absorbed into the body. Can cause regional cooling by reflecting sunlight. 31% of human-sourced particulates are from motor vehicles - mostly diesel-powered. Diesel smoke emissions measured under ADR30 but the particulate content of the emissions is not established. As at April 1999 NSW EPA uses a subjective observation method for determining breaches of the "10 second smoke rule". This is predominantly a maintenance issue.

Test methods are available for measuring the total mass of particulates from a driving cycle test (see "Parsons Australia"). Consideration also needs to be given to particle size since the smaller particles may be more of a health concern.

Lead

Toxic -neurological impairment. 90% of human-sourced lead is from motor vehicles running on leaded fuel. Not usually measured during vehicle tests. Estimates can be made from research reports (note that leaded petrol is not used in new vehicles).

Measurement not applicable. May be an issue with lead-acid batteries in electric vehicles (manufacture and disposal).

Sulphur

Sulphur compounds can cause respiratory irritation. They are a source of acid rain and the particulates can affect regional cooling. Negligible sulphur emissions from motor vehicles but power stations are a major source (particularly outside NSW, which has low-sulphur coal). Measurement not applicable. Estimates of power station emissions can be made from research reports.

CFC

Stratospheric ozone depletion. Not applicable to new vehicles. Concern about refrigerants in older vehicles. Consider giving credit to manufacturers with programs to recover CFCs from older vehicles. Unlikely to be an issue with new vehicles. Measurement not applicable.

Ozone

Lower atmosphere ozone is produced by reaction of NOX and ROCs and contributes photochemical smog. Ozone is a respiratory irritant. Negligible directly from motor vehicles. Measurement not applicable.

Appendix F

External Consultations - meetings in Canberra

On Tuesday 11 April Michael Paine travelled to Canberra and had separate meetings with four organisations, as set out below.

The aims were to discuss

- possible approaches to the rating system,
- sources of information and
- opportunities for collaboration.

It is stressed that these were informal meetings and they do not necessarily reflect the views or policy of any organisation.

Australian Automobile Association

AAA is looking at the possibility of an environmental rating for vehicles and the timing of my visit was fortuitous. No major problems with the draft protocol. AAA might be interested in becoming a partner in the project, if that was appropriate.

Environment Australia

Impressed with the methodology and would take a closer look at the derivation of values in the tables. At present there are no better estimates of the relative damage between pollutants but they would talk to some experts on the matter. There was a need to determine these values for several federal projects.

We discussed the opportunity to apply the proposed NSW approach at a national level and agreed there was no reason that it could not be adopted nationally. I suggested that, should NSW go ahead with the proposed, it should be treated as a pilot for a national program.

The CUE driving cycle developed by NPEC was a 30 minute test and that the contractors (Parsons) were currently looking at a short test, similar to IMI240. The resulting short test would be the appropriate one to use for diesel testing under the draft protocol.

Federal Chamber of Automotive Industries (FCAI)

The FCAI does not agree with comparisons of this type, particularly if they are based on testing a single vehicle. Manufacturers were highly unlikely to be prepared to supply ADR emission test results, or even ranges. We then discussed the methodology in a very constructive manner. Some key points are:

- FCAI would prefer vehicle classifications to be based on VFACTS
- Vehicles may need to have a minimum number of kilometres on the odometer before being tested - so that the engine is 'run in'.
- Concern that the proposal will discriminate against vehicles with larger engines - since these are seen as the mainstay of the local vehicle industry.

- Need to look further at the details for deriving an Environmental Damage Index (EDX). Commented that this was a somewhat negative term and they would prefer to see the presentation reversed (like the Green Score used by ACEEE).

(Federal) Dept Transport and Regional Services

DTRS has responsibility for an "Information program for efficient vehicle use" and the NSW initiative is highly relevant to that project. Subject to reading the draft protocol in more detail they agree with the methodology and confirm that ADR test information could not be made available from DTRS as an alternative to vehicle testing.

Given a copy of the "Explanatory Statement" accompanying the Road Vehicle (National Standards) Determination No2 of 1999, issued by the Minister for Transport and Regional Services in December 1999 (I was not aware of this document). Attachment D "Preliminary Economic Analysis of Adopting New Vehicle Emissions Standards" was prepared by the NSW EPA. The attachment contains a caution that the estimates are preliminary and "should considered as indicative orders of magnitude rather than as precise estimates of impacts". Subject to this caution the value derived from this report are compared with other sources in Appendix G.

It is recommended that relative weightings based on the EPA estimates for mobile sources be used in the protocol.

General points

There was mild concern from EA, FCAI and DTRS that NSW would be publishing fuel consumption values that differed from the AGO booklet. A clear explanation would need to be given in the NSW brochures. In the longer term is possible that an expanded NSW program would replace the AGO booklet.

Appendix G

Notes about derivation of values for rating protocol

These notes are intended to keep track of information and assumptions used for deriving values in the tables presented in the draft rating protocol.

Main sources of data

ACEEE Methodology report. May 1999. (booklet only)

Report of the National Greenhouse Gas Inventory, 1997. Workbooks 1 to3. http://www.greenhouse.gov.au/inventory/methodology/method_content.html

NSW EPA Regulatory Impact Statement and Pollution Control Regulation 1998 (available from EPA website)

"Explanatory Statement: Road Vehicle (National Standards) Determination No2 of 1999" issued by the Minister for Transport and Regional Services in December 1999

Fuel-consumption-related emissions

In-use fuel emissions

Table 1 presents values to be used for calculating emissions related to fuel consumption (evaporative emissions). It is based on Table A2a (pp43) of ACEEE methodology. Note that AGO NGGI is intended to derive fleet averages and therefore uses estimates of grams per kilometre travelled. We need to derive grams per litre of fuel consumed - since we will have values of fuel consumption for individual vehicles.

The AGO NGGI Workbook 3 (WB3) describes methodology for deriving fleet emissions. Table A6 (pp47) indicates post-1985 cars emit of total of 1.28 grams of NMVOC per kilometre. Table A11 (pp52) indicates the average fuel consumption for post-1985 cars is 0.115 litres per km. Therefore the emissions per litre of petrol are: 1.28 / 0.115 = 11.13 g / litre. This is substantially more than the ACEEE value of 3.7 g /litre (13.9 g/gal x 0.264 gal / litre).

WB3 Table A3 (pp44) sets out values for emissions in grams / km. The following table shows the NGGI values, the adjustment for fuel consumption (0.115 litres per km for petrol, 0.131 l/km for diesel cars and 0.166 l/km for LPG cars) and the corresponding values used by ACEEE. Diesel values used by ACEEE are shown in square brackets.

Table F1.Passenger Cars - Fuel consumption-related emissions - Petrol [Diesel] {LPG}

Pollutant	**NGGI WB3 g/km@**	**NGGI g/litre**	**ACEEE g/litre**
NMVOC	0.289 [0.53] {1.69}	2.5 [4.05] {10.18}	3.7 (33%) [zero]
SOX	-	0.51 [4.5] {0.21}*	0.42 (82%) [0.69]
CH4	0.058 [0.01] {0.087}	0.50 [0.76] {0.52}	1.2 (267%) [0.013]
N2O	0.122 [0.01] {0.0079}	1.06 [0.76] {0.05}	0.87 (207%) [0.092]
CO2	-	2260 #	2170 (96% !) [2610]
CO	3.85 [1.08] {21.6}	33.48 [8.24] {{130}+	-
NOX	0.45 [1.03] {1.94}	3.91 [7.86] {11.7}+	-

* NGGI Table 1 (pp68) give 0.015 g of SO2 per MJ of gasoline. Values are also given for diesel, LPG and CNG. For gasoline energy density is 34.2 MJ per litre therefore 0.015 g/MJ = 0.51 g/l. The corresponding values other fuels are: diesel = 4.5 g/l (about 10 times the petrol value) and LPG = 0.21. CNG is negligible.

@ Derived from WB3 Table A3 for petrol (3 way catalysts) and Table A5 for diesel..

+ Not used. These parameters are to be derived from exhaust emissions.

Derived from WB3 Table A2 (pp43) . Gasoline 66 g/MJ x 34.2 MJ/l. The AGO 'Greenhouse Scorecard' uses 2460 g / litre. Corresponding values for other fuels are: diesel = 2690 g/ l (ACEEE = 2610) , LPG = 1527 g/l. CNG 54.4 g/MJ (compressible so no litre equivalent, ACEEE uses 47.4 g/MJ and converts to gallons of gasoline equivalent).

Summary: Petrol values derived from the NGGI WB3 are similar to those used by ACEEE. Diesel values are substantially more.

Electricity production emissions

To enable electric vehicles to be rated the values for emissions per kWh of electricity consumed are required. Table 2 of the draft Protocol includes these emissions factors.

ACEEE Table A2b (pp44) sets out values used in the ACEEE methodology. These values include allowance for transmission losses.

WB1 Table B1 (pp57) indicates NSW coal-fired power stations have an emissions factor of 91 Gg of CO2 / PJ (= 91 g/MJ). This is based on the energy of input (coal). The Greenhouse Challenge Workbook indicates an Australian average of 1 kg CO2-equivalent per kWh of electricity produced = 278 g/MJ. Dividing 91 by 278 gives a loss factor of 0.33, which is close to the ACEEE's assumption of generation efficiency for coal-fired power stations (34.5%). A factor of 3 (1/0.33) will therefore be used in the emissions estimates.

NGGI Workbook 1 (Stationary Sources) (WB1), Table B4 (pp60) sets out emission values (other than CO2) for NSW power stations and includes 'default' values that are used in the following table. They have been multiplied by the loss factor (3).

SO2 emissions from black coal are given in WB1 Appendix Table 1 (pp87): 0.37 Gg / PJ. This is also multiplied by 3 to obtain the delivered energy factor.

Table F2. Emissions from electricity production

Pollutant	NGGI WB2 g/ MJ produced#	ACEEE g/MJ produced*
NMVOC	0.005	0.003 (60%)
NOX	0.78	0.56 (72%)
PM10	-	0.019
SOX	1.11	0.59
CH4	0.0027	0.002 (74%)
N2O	0.0024	0.0075 (312%)
CO	0.033	0.026 (79%)
CO2	278	180 (65%)

#WB1 values are for input (coal) energy and do not include generation/distribution losses. These have been multiplied by a loss factor of 3.

*ACEEE includes distribution losses and uses g/kWh: 1 kWh = 3.6 MJ.

Summary: Electricity generation factors derived from NGGI values are generally about 50% more than those used by ACEEE, except that N2O is much less.

Damage indices

Table 3 of the draft Protocol sets out proposed damage indices to be used for each pollutant. Separate values are given for Greenhouse and smog/health effects. All indices are relative to CO2 Greenhouse damage. The Greenhouse indices are derived from NGGI 1997. The foreword to this report indicates that global warming potential of several GHG, as indicated in the following table.

Table F3. Global Warming Potential (Relative to CO2)

Pollutant	NGGI	ACEEE
NMVOC	0	2
NOX	0	4
PM10	0	0
SOX	0	0
CH4	21	22
N2O	310	355
CO	0	5
CO2	1	1

Summary: NGGI has zero values for several pollutants that are covered by ACEEE. Otherwise the values are close.

Smog/health

The *methodology* for smog/health values in Table 3 of the draft protocol are derived from ACEEE and are calculated on the basis that for the average vehicle the total Greenhouse damage equates to the total smog/health damage. ACEEE found that this formula led to a Greenhouse cost of 1.71 cents per kg of CO2 (Table 4, pp22). Other values are derived from this. For example, the smog/health cost of HC is 34 cents per kg (Table 3, pp20) therefore 1 kg of HC is equivalent to 34/1.71 = 19.89 kg of CO2, according to ACEEE-derived values. Similar conversions are done for the other pollutants.

The following table compares the various sources of health cost weightings. The ACEEE values are from their Table 3 (pp20 - Motor vehicle sources), converted to AU$ (=US$0.6).

Australian BTCE in its Report 94, Appendix 'Social costs of accidents and noxious emissions' (pp460) gives ranges for several pollutants. Their derived averages are shown in the table below, together with the ranges from research reports.

More recently the NSW EPA, in a report "Proposed pollution control regulation 1998: Regulatory Impact Statement" (pp52), looked at a range of studies in the USA and Europe and reported median values as follows: NOX $1385/t, VOC $1440/t and fine particulates $18,500/t. The report describes the background to the 'Pollution Control Regulaitons 1998" which include "pollutant weightings" (pp13). Appendix E of the report (pp90) covers the derivation of the weightings and includes a table of relative weightings of air pollutants. These are shown in the table below, scaled so that HC=50 (cents), for easy comparison with other references. *Note that the regulations are targeted at stationary sources*.

Attachment D of the document "Explanatory Statement: Road Vehicle (National Standards) Determination No2 of 1999" issued by the Minister for Transport and Regional Services in December 1999. The attachment contains a caution that the estimates are preliminary and "should considered as indicative orders of magnitude rather than as precise estimates of impacts". Subject to this caution, they appear to be the best available for Australia and have been used in the draft protocol.

Table F4. Smog/heath indices

Pollutant	**NSW EPA** **(Stationary sources)** Scaled so HC=144 cents/kg Regulation value	**BTCE Report 94** AU cents / kg (Range in reports)	**ACEEE** AUcents/kg	**NSW EPA** **(Mobile sources)** cents/kg
NMVOC	144	Urban 7 (1 to 70) Other 2 (0 to 23)	57	144
NOX	154	Urban 7 (1 to 70) Other 2 (0 to 23)	750	139
PM10	750	Urban 1250 (300 to 1800)	6000	3900

		Other zero		
SOX	19	Urban 1	2120	-
CO	-	Urban 2 (0 to 2) Other zero	5	1.2

These are for emissions at the vehicle exhaust. Under ACEEE methodology "Factory" sources are divided by 5 and power station sources (e.g. ACEEE Table 2) are divided by 10 to account for remoteness from population at risk. There is no adjustment for Greenhouse factors.

These values are converted to CO2-Greenhouse equivalents for the draft protocol. Damage "costs" (eg $/kg) are avoided in the protocol. The intention is to make the subtotal of Greenhouse damage indices equivalent to the subtotal smog/health damage indices, for the "average vehicle" (this is the basis of the ACEEE methodology and was agreed to by the project steering committee).

The emissions values for the ACEEE's "average" passenger car (24.6mpg, 1674kg kerb mass) were processed using the weightings in the last column of table F4 (EPA mobile sources). This enabled relative weightings to be derived such that the greenhouse sub-total equalled the smog/health sub-total (the Goal Seek function in an Excel spreadsheet was used – copy at the end of this appendix). The results are shown in Table 3 of the draft protocol. In brief, when the CO2 factor is set to 1 the HC factor becomes 190. The other smog/health values are derived from the relative values shown in Table F5 above. The greenhouse factors are derived from the relative values shown in table F3 (NGGI column).

Summary: NSW EPA values for mobile sources (as documented in "Explanatory Statement: Road Vehicle (National Standards) Determination No2 of 1999") are suitable for use in the draft protocol, subject to the concern that they are not precise estimates of impacts. Since the protocol is based on relative impacts this concern is reduced.

Star Rating

The star rating shown in Table 5 is based on the formula:

Stars = INT(1200 - 240xEDX) where EDX < 1200

This formula was chosen to give a reasonable spread of results, based on ACEEE data" (set out below). Note that this includes ACEEE estimates of embodied emissions but these extra emissions are likely to be offset by the generally higher emissions levels of new Australian vehicles, compared with US vehicles. *This formula will need to be reviewed when initial results for Australian vehicles are available*. The intention is to give similar results to those shown below.

- Average (US) car: 2.64 c/mile = 866 = 2 stars
- Best current passenger car (Honda Civic CVT): 1.9 c/mile = 623 = 3 stars
- LEV vehicle: 1.37 c/mile = 449 = 4 stars
- Average light truck: 3.26 c/mile = 1069 = 1 star
- Worst large SUV (4WD): 4.71 c/mile = 1545 = nil stars

- GM Electric Car: 0.85 c/mile = 279 = 4 stars
- Theoretical hydrogen fuel cell vehicle: 0.18 c/mile = 59 = 5 stars

Where 537 Aust EDX = 1 ACEEE US cents per km. *Costs are not used in the Australian system*.

Note also that, by definition, 1 Aust EDX = Environmental damage caused by 1 kg of CO2.

Summary: A star rating system based on EDX is proposed. The star breakpoints will need to be determined when initial results for Australian vehicles are available.

Future reference

Based on ACEEE values, the following items contribute relatively little to lifetime vehicle emissions and it is proposed that they be excluded from the protocol. They are recorded here for reference purposes. Some values were not available and are indicated by an X in the tables.

Fuel/energy production/distribution emissions

Fuel Cycle Emissions

Table 2 presents values to be used for calculating fuel cycle emissions, in grams per litre of fuel consumed. NGGI Workbook 2 'Fugitive Fuel Emissions (Fuel Production, Transmission, Storage and Distribution)' (WB2) includes estimates of fuel cycle emissions in Table 5 (pp43) - *these do not include production emissions*. These are compared with ACEEE values *that include production emissions* (Table A2b, pp44) below. ACEEE includes values for diesel and CNG based on gallons of gasoline equivalent (1 litre of petrol = 1.11 litre of diesel).

Table F5. Fuel Cycle Emissions - Petrol [Diesel]

Pollutant	**NGGI WB2 g/ litre ***	**ACEEE g/litre**
NMVOCl	3.14	1.6 (51%) [0.38]
NOX	-	2.2 [1.52]
PM10	-	0.26 [0.17]]
SOX	-	2.6 [1.33]
CH4	-	4.4 [3.12]
N2O	-	0.05 [0.026]
CO	-	1.7 [1.21]
CO2	-	647 [350]

* WB2: Does not include extraction and processing values:

WB 2: Natural Gas (pp32): Methane 7.91 g / kg produced, NMVOC 3.39 g / kg produced

WB2: Crude oil (pp85): Methane 0.578 g/kg of crude oil produced, NMVOC 0.007 g /kg of crude oil produced. How much crude oil (kg) goes in to a litre of gasoline?

NGGI CO_2 estimate based in industry advice: (WB2 pp100) total of 2368 Gg of CO_2 in 94/95 from oil and gas venting, 3100 Gg of CO_2 from oil and gas flaring. How much of this represented gasoline production?

Summary: Non-HC values for Australia are needed. Values are needed for diesel and LPG.

The following fuel-cycle emissions are assumed, based on each litre of fuel supplied at the bowser.

Table F6. Fuel Cycle Emissions

Grams per litre of fuel supplied *(indicative only)*

Pollutant	Petrol	Diesel	LPG
NMOG (HC)	1.6	X	X
NOX	2.2	X	X
PM10	0.26	X	X
SOX	2.6	X	X
CH_4	4.4	X	X
N_2O	0.05	X	X
CO	1.7	X	X
CO_2	647	X	X

(Caution: Indicative only - based on US data. Substitute Australian data, where available)

Excel Spreadsheet Calculations

ACEEE "Average Vehicle"					
24.6mpg, 1674kg			Smog	Smog	Greenhouse
			Remote	Damage	Damage
Pollutant	g/mile	g/km	Factor	per km	per km
Ex_CO (Exhaust)	9.5	5.90	1	9.34	0.00
Ex_HC	0.6	0.37	1	70.81	0.00
Ex_NOX	1.04	0.65	1	118.47	0.00
Ex_PM10	0.02	0.01	1	63.92	0.00
Fuel_HC (Fuel consump)	0.7	0.43	1	82.61	0.00
Fuel_SOX	0.08	0.05	1	1.25	0.00
Fuel_CH4	0.22	0.14	1	0.00	2.87
Fuel_N2O	0.16	0.10	1	0.00	30.81
Fuel_CO2	410	254.66	1	0.00	254.66
FC_HC (Fuel cycle)	0.3	0.19	0.2	7.08	0.00
FC_NOX	0.43	0.27	0.2	9.80	0.00
FC_PM10	0.05	0.03	0.2	31.96	0.00
FC_SOX	0.49	0.30	0.2	1.53	0.00
FC_CH4	0.83	0.52	0.2	0.00	10.83
FC_N2O	0.01	0.01	0.2	0.00	1.93
FC_CO2	122.5	76.09	0.2	0.00	76.09
EMB_NOX (Embodied)	0.33	0.20	0.2	7.52	0.00
EMB_PM10	0.06	0.04	0.2	38.35	0.00
EMB_SOX	0.41	0.25	0.2	1.28	0.00
EMB_CO2	93.7	58.20	0.2	0.00	58.20
EXH_SUBT				262.54	0.00
FUEL_SUBTOT				83.85	288.34
FC_SUBTOT				50.37	88.84
EMB_SUBTOT				47.15	58.20
SMOG_SUBTOT				443.91	
GH_SUBTOT					435.37
EDX OVERALL					**879.29**

INPUTS	GH	Smog		Smog
GHG Equivalents	factor	factor		relative
CO2	1	0		0.0
HC	0	190*		144.0
NOX	0	183		139.0
CO	0	2		1.2
CH4	21	0		0.0
N2O	310	0		0.0
SOX	0	25		19.0
PM10	0	5146		3900.0

* Using goal-seeking, the smog factor for HC is set so that the “SMOG SUBTOTAL” equals the “GH SUBTOTAL” on the previous page. After rounding a value of 190 is appropriate. This gives a Smog subtotal of 443.91 and a Greenhouse subtotal of 435.37.

Alternatives to presenting EDX as a rating

Concern has been expressed by the FCAI about the use of the term 'damage' in the EDX. There is also general concern about the very high EDX of current diesel vehicles - estimated to be about 10 times that of a petrol car. This occurs, in part, because of the high weight given to particulate measurements. It is evident that there is room for a great deal of improvement in particulate emissions from some Australian diesel vehicles. Also recent health research has reinforced the concern about particulates from road transport (for example see 'Public-health impact of outdoor and traffic-related air pollution: a European assessment' by N Künzli et al, The Lancet, Vol 356 September 2, 2000, page 795).

Options were considered for processing the EDX to obtain less "alarming" ratings for diesels:

- taking the square root of EDX or
- inverting the EDX to obtain a Green Score between 0 (worst case) and 100 (nil emissions). This is based on the formula devised by ACEEE but adjusted for the proposed Australian EDX calculation method.

The formula used for Green Score in the following table is:

Green Score = $A * (e^{-EDX / C}) / (1 + EDX / C)^{B}$

Where A=100, B=1.5 and C=2000

SUMMARY OF POSSIBLE EDX 'MAPPING' Vehicle	Est. EDX	Sqrt(EDX)	Green Score
A. ADR37/01 ULEV Car (HC 15% and NOX 50% of ADR 37 limits)	319	17.87	68.3
B. ADR37/01 LEV Car (HC 30% and NOX 50% of ADR 37 limits)	327	18.08	67.7
C. ADR37/01 Car (eg Holden Commodore)	575	23.97	51.4
D. Euro 4 4WD (NA eg diesel HiLux)	605	24.59	49.7
E. ADR37/01 4WD (MC eg petrol Landcruiser)	876	29.60	37.4
F. ADR79/ECE83 4WD (MC eg diesel Landcruiser from 2002)	1010	31.78	32.7
G. Euro 3 4WD (NA eg diesel HiLux)	1025	32.01	32.2
H. ADR70 4WD (NA eg diesel HiLux - in-service test results)	3237	56.90	4.7
I. ADR70 4WD (MC eg diesel Landcruiser - in-service test results)	5639	75.10	0.8

The other point of view is that consumers should be aware of the very poor performance of some diesel vehicles and that a rating based solely on EDX is appropriate. Use of a Green Score based on the above formula disguises such poor performance. The draft protocol uses EDX for the rating.