Appendix 1. Terms of Reference for Comparison of Transport Fuels – Stage 2

A1.1 Background

The Australian Greenhouse Office (AGO) supported the development of the Diesel and Alternative Fuels Grants Scheme (DAFGS) which maintains price relativities between diesel and alternative fuels following the reduction in the diesel fuel excise rate and the provision of grants for diesel used for on-road transport from July 2000.

The Scheme is administered by the Australian Taxation Office (ATO) but the Chief Executive of the AGO is responsible for certifying additional alternative fuels as being eligible under DAFGS. This analysis will assist in determining the eligibility of several fuels currently not eligible under the Scheme. The study will also provide a profile of emissions for a broad range of conventional and alternative fuels under Australian conditions that will inform future policy for transport fuels.

Further information about DAFGS can be found using the search facility on the ATO website www.ato.gov.au and information about the AGO transport programs are available from www.greenhouse.gov.au/transport

The Stage 1 study (referred to in section 4) was based on the assessment of existing studies of transport emissions. Stage 2 builds on this work and requires extensive liaison with industry, government and other key stakeholders when developing the emissions profile.

A1.2 Definition

For the purpose of this study, "full fuel cycle emissions" are emissions of a fuel product generally from when a raw material is extracted (for fossil fuels) or planted (for renewable fuels) to when the fuel is combusted. The study of full fuel cycle emissions would include the following processes:

- extraction
- production;
- transportation and storage;
- fuel processing;
- conversion;
- fuel transportation, storage and distribution; and
- vehicle operations that involve fuel combustion or other chemical conversions.

The processes that precede vehicle operations are generally referred to as upstream activities; and vehicle operations are referred to as downstream activities.

A1.3 Objectives

The objective of Stage 2 is to examine the emissions and other characteristics of transport fuels that will assist the Chief Executive of the AGO to determine which additional alternative fuels should be considered for eligibility under the DAFGS, and to provide a profile of each transport fuels' emissions (both current and projected to 2006).

The objective will be achieved through:

1. a comparison of road transport fuel emissions through a full fuel cycle analysis of greenhouse gas emissions and emissions affecting air quality; and,

2. for each fuel, an assessment of current and near future (ie to 2006):

- viability and functionality;
- health related issues; and
- environmental issues (including ecologically sustainable development) not related to greenhouse or air quality issues.

A1.4 Scope

Stage 1 Analysis

The analysis of alternative fuels is being conducted in two stages. Stage 1 was limited to an overview of Australian and overseas studies that assess the emissions characteristics of alternative and conventional fuels that are or may be suitable for use in road vehicles from 4.5 tonnes gross vehicle mass (GVM).

The fuels assessed in Stage 1 were compressed natural gas (CNG), liquefied petroleum gas (LPG), liquefied natural gas (LNG), recycled waste oil, canola oil, ethanol, as well as a range of blends of these fuels, including biodiesel and conventional fuels such as low and ultra low sulfur diesel.

The greenhouse gases assessed in the Stage 1 analysis included carbon dioxide, nitrous oxide, and methane. Air pollutants assessed were carbon monoxide, oxides of nitrogen (the NOx group), oxides of sulfur (SOx), non-methane volatile organic compounds (NMVOCs), visible smoke and particulates. The analysis also examined greenhouse gas emissions and air pollutants in the upstream activities of a fuel's life cycle. Stage 1 has been completed and a copy of the report is on the AGO website at: www.greenhouse.gov.au/transport/pdfs/lifecycle.pdf

Requirements for Stage 2

Stage 2 will:

- conduct a full fuel cycle analysis of emissions for onroad transport fuels;
- determine whether any fuel has significant potential to compromise vehicles' compliance with gazetted ADR standards for the period to 2006 (inclusive);
- examine the viability and functionality of the fuels;
- examine significant health related issues from the use of the fuels; and
- examine other significant environmental issues resulting from the use of the fuels including ecologically sustainable development.

Stage 2 will include the following.

Full Fuel Cycle Analysis

1. Collect data on emissions for the specified fuels from production to combustion in onroad vehicles taking into account Australian conditions for fuel production.

2. Objectively assess the emission characteristics of the specified fuels.

3. Determine whether any fuel has significant potential to compromise vehicles' compliance with gazetted ADR standards for the period up to and including 2006.

Low sulfur diesel (ie 500ppm or less) will be used as an emissions benchmark against which other fuels are compared. Section 5 *Full Fuel Lifecycle Analysis* describes in detail the requirements for the analysis.

Viability and functionality

4. Taking into account existing and emerging technologies* examine:

- handling, transport, storage and safety issues focussing on significant risks associated with the use of the fuel;
- engine manufacturers' acceptance of the fuel for warranty purposes;
- the functionality of the fuel under the full range of Australian conditions (eg consider: the significance of problems associated with the cloud point temperature or the fuel's affinity for water; the effect of fuels on engine seals; and engine and other components' longevity);
- fuel energy density and vehicle operational range;
- refuelling requirements;
- issues affecting the availability of fuel and;
- other issues (except for price/excise/grant/cost related issues) that may affect the viability or functionality of the fuel.

* Refer to *Review of Fuel Quality Requirements for Australian Transport* Chapter 2 (commissioned by Environment Australia) for a definition of existing and emerging technologies applying to diesel engines. A copy can be found at: http://environment.gov.au/epg/fuel/transport.html

Health Issues

5. Examine key health issues resulting from the production, transport and use of the fuel. Among other issues, special attention should be paid to: occupational health and safety issues; particulates; vapour pressure (the main concern being evaporative emissions) and the following air toxins:

   - benzene;
   - 1,3 butadiene;
   - formaldehyde;
   - acetaldehyde;
   - polycyclic aromatic hydrocarbons (PAH);
   - toluene; and
   - xylene

Environmental Impact and Benefits

6. Examine significant environmental impacts not included under the fuel cycle analysis resulting from the production, transportation or use of each fuel. This section of the study will include, but not be limited to an examination of:

   - the use of technologies or additives associated with the fuel;
   - whether any of the principles of ecologically sustainable development are at risk of being compromised through the production, distribution and use of the fuel (refer to section 3A of the Environment Protection and Biodiversity Conservation Act 1999 for the definition of ecologically sustainable development - copy attached)
   - the sustainability of fuel production and use (eg impact on land used for biofuels); and
   - spillage issues including groundwater contamination.

A1.5 Fuel Types

The fuels to be examined and their specifications are:

- Low sulfur diesel (LSD) meeting either Euro II fuel specifications or the fuel specifications for LSD proposed by the Commonwealth for implementation in 2002. Refer to http://www.environment.gov.au/epg/fuel/pdfs/fuel0900.pdf *
- Ultra-low sulfur diesel (ULSD) meeting either Euro IV specifications or the fuel specifications for ULSD proposed by the Commonwealth for implementation in 2006. Refer to http://www.environment.gov.au/epg/fuel/pdfs/fuel0900.pdf
- Compressed natural gas (CNG) as defined in Australian standards.
- Liquefied petroleum gas (LPG) autogas grade from any source meeting the voluntary ALPGA specification or European standard EN589.
- LPG - HD5 grade from any source. Refer to Californian Air Resources Board specifications http://www.arb.ca.gov/regact/lpgspecs/lpgspecs.htm
- Ethanol - hydrated - from renewable sources (wheat, sugar cane, molasses and wood) and one source of ethanol from a non-renewable resource.
- Ethanol - anhydrous - from renewable sources (wheat, sugar cane, molasses and wood) and one source of ethanol from a non-renewable resource.
- Diesohol from APACE Research. The fuel is known as E15 and consists of 84.5% diesel, 15% hydrated ethanol (ethyl alcohol containing approximately 5% water) and 0.5% emulsifier.*
- Liquefied natural gas (LNG) as defined by European or US standards.
- Canola oil (ie not biodiesel).
- Biodiesel. Examine biodiesel meeting either of two major fuel specifications - European DIN V 51606 standard or the US standard ASTM PS121. Consider biodiesel produced from a range of feedstocks including tallow, recycled waste cooking oil, canola, rapeseed and soybean.*
- Synthetic diesel derived from natural gas using the Fischer Tropsch method.
- Hydrogen derived from a range of production methods and feedstock sources likely to be used in Australia. It is acknowledged that hydrogen is an energy carrier rather than a fuel but for the purposes of this study it will be described as a fuel. The study would only examine the upstream emissions.
- Premium Unleaded petrol (PULP) (95 RON) meeting either the Euro II specification for unleaded petrol or the fuel specifications for PULP proposed by the Commonwealth for implementation in 2002. Assume that this fuel does not contain ethanol and that it is used in light vehicles as defined in ADR 79/00 and 79/01. Refer to http://www.environment.gov.au/epg/fuel/pdfs/fuel0900.pdf
- PULP (95 RON) as specified above but with 10% ethanol. Assume that it is used in light vehicles.
- A-55. The fuel consists of 30-55% water, 45% naphtha, and small amounts of a blending agent. Developed in the USA in 1994 by Rudolph Gunnerman *of Clean Fuels Technology Inc* and is being promoted in Australia by *A-55 Australia*. **(Note: this fuel may be deleted from the list at any time up to 30 April 2001 and so should be considered last.)**

* Asterisked fuels will be examined first to enable a decision to be made about their possible inclusion under the Diesel and Alternative Fuels Grants Scheme. LSD will also be examined in the first group as it will be the emissions benchmark.

Where testing is undertaken by the consultant, the following information must be provided:

- for biodiesel, a certificate of analysis for the batch that identifies its density and cetane number or index, sulfur content and distillation point (degrees Celsius T90 and T95);
- for diesel or diesohol, a certificate of analysis for the batch that identifies its density and cetane number or index, sulfur content, polyaromatics and distillation point (degrees Celsius T90 and T95); and
- for gaseous fuels, a certificate indicating that they meet specifications as outlined above.

The successful tenderer will be responsible for managing and meeting all costs associated with sourcing the fuels required for any testing deemed to be necessary. A large-scale emission-testing program is not expected to be undertaken as a part of this project.

A1.6 Full Fuel Cycle Analysis

Upstream

The consultant is required to collect Australian data associated with all upstream activities of fuel cycle emissions for the fuels listed above. The derivation of the data should be clearly explained in a highly detailed manner utilising fuel cycle process trees and all assumptions must be fully explained. The data and data sources should be documented in a report that incorporates a comprehensive analysis of uncertainties regarding the data and how these uncertainties were resolved in order to determine values for the variables. All data collected will be made available in appendices and in electronic format.

To ensure the relevance of the upstream study to Australian conditions, it is crucial that extensive consultation be conducted with key Australian industry stakeholders involved in upstream activities associated with the fuel.

Where fuels have a range of production methodologies, the more common approaches used for fuels produced in, or imported into, Australia should be modelled. For example, biodiesel can be produced from an oilseed, recycled waste cooking oil and tallow. The greenhouse and air quality emissions from these approaches should be examined. A similar approach should be adopted for ethanol (which can be produced from sugar cane, molasses, wood, wheat and coal), LPG, hydrogen, LNG and other fuels which have more than one main upstream source.

For each fuel type with more than one upstream source, an indication of the likely Australian market share from each source within that fuel type will be indicated. The emissions from each upstream source will be modelled and combined with downstream emissions.

Downstream - Current and Future

A range of reputable and recent Australian and overseas studies will be considered in order to determine the relative downstream emissions of each fuel. Where possible, reports from sources using identical or similar testing methods should be used to enable the emissions to be compared. Allowances should be made for improvements in technology if reference is made to studies more than three years old.

It is important the Consultant collect certified emissions data produced by independent testing/measurement organisations using certified equipment/facilities following internationally recognised test methods/cycles. Collection of such data will have priority over collection of emissions data produced and/or funded by fuel producers, fuel users and industry associations.

Following consultation with key industry stakeholders, the consultant will comment about likely improvements in emissions from vehicles using each fuel in the near future as a result of improved fuels or technologies. This information will be included in a separate series of downstream emissions calculations. The consultant will also use this information as the basis for determining whether any fuel has significant potential to compromise vehicles' compliance with gazetted ADR standards for the period up to and including 2006 for both light and heavy duty vehicles.

Emissions

The nominated emissions to be considered in the analysis are:

- key transport greenhouse gases ie carbon dioxide, nitrous oxide, methane;
- oxides of nitrogen;
- oxides of sulfur (including a calculation of oxides of sulfur emitted following combustion);
- particulate matter less than 10 microns (also considering matter less than 2.5 microns and less than 1 micron if available);
- carbon monoxide;
- total hydrocarbons;

Emission measurements will be provided in:

- grams of emission type per megajoule.
- grams per tonne-kilometre for freight vehicles; and
- grams per passenger-kilometres for passenger transport.

All emissions affecting air quality will be weighted and combined into a single measure of air quality. The quantity of upstream emissions affecting air quality not produced in metropolitan areas will be included and will also be separately noted. This task involves the development of a weighting scheme for air quality. The consultant is required to develop and submit the weighting methodology to the Steering Committee for approval as soon as possible after the commencement of the project. No preliminary reports indicating weighted air quality results are to be discussed outside of the project team prior to the approval of the weighting methodology.

Greenhouse gas emissions will be weighted using IPCC 100 year global warming potentials.

New Models for Calculating Downstream Emissions

The AGO wishes to explore alternative approaches for approximating downstream emissions involving fuel and technology combinations (eg comparing the emissions from a CNG Euro II standard engine with a diesel Euro III standard engine). It is not considered that a large scale tailpipe emissions testing program is warranted. In addition, it is extremely difficult to arrange statistically valid samples for a broad range of fuel and technology combinations. Consequently such an approach is not being considered.

The consultant is required to identify and describe approaches that would enable the downstream emissions from fuel and technology combinations to be approximated without conducting a large scale tailpipe emissions testing program.

Information Required for a Downstream Model Using ADR Specified Emissions

The consultant is also required to undertake additional research outlined later in this section associated with a method for calculating emissions under which downstream emissions affecting air quality are deemed to be equal to the maximum emissions allowable under the ADRs to which vehicles have been certified.

It may be possible to calculate downstream greenhouse gas emissions from some ADR emission standards because they refer to key greenhouse gas emissions. For example:

- methane is referred to in ADRs 80/00 and 80/01 for gas fuelled heavy vehicles under the Euro III and IV European Transient Cycle (ETC) test emission limits;
- nitrous oxide is present in NO_x referred to under ADR emissions standards;

- the light duty vehicle emission test in ADR 37/01 provides the basis for calculating CO2 emissions provided that the carbon content of the fuel is known. (Carbon dioxide emissions for heavy vehicles should also be calculated.)

To assist with the exploration of this approach, the consultant is required to:

1. determine whether each fuel is likely to yield Euro standard "X" emissions when used in a Euro "X" designated engine for both light and heavy vehicle ADR emissions standards (without additional after treatment adopted for the specific fuel in question);
2. comment on the feasibility of reasonably approximating N_2O emissions from NO_x levels referred to in the Euro standards for both heavy and light vehicles across the specified fuel types. (If feasible, the calculations will be made and the margin of error indicated.);
3. determine the value of the CO_2 emission factor for each fuel (in grams per megajoule) which would be used to determine CO_2 emissions from the fuel (ie not the CO_2 *equivalent* emissions). (In order of preference the sources are to be used are: existing Australian Greenhouse Office data, IPCC data or primary data obtained from laboratory analysis of the carbon content of the fuel.); and
4. determine an average "grams of emission per megajoule" equivalent for both greenhouse emissions and air quality emissions for both light and heavy vehicle Euro Standards I to IV. (The light vehicle Euro Standards are measured in grams per kilometre and each of the light vehicle Euro standards has three vehicle categories.)

A1.7 References

The following references, among others, should be considered:

- *A Full Fuel Cycle Analysis of Energy and Emissions Impacts of Transportation Fuels Produced from Natural Gas* (US Department of Energy report dated December 1999) www.transportation.anl.gov/ttrdc/publications/pdfs/esd-40.pdf
- *Effects of Fuel Ethanol Use on Fuel Cycle and Energy and Greenhouse Gas Emissions* (US Department of Energy report, January 1999) - an electronic version is available from the AGO
- *Health and Environmental Assessment of the use of Ethanol as a Fuel Oxygenate* (US Department of Energy report, December 1999) http://www-erd.llnl.gov/ethanol
- *Air Quality Impacts of the Use of Ethanol in California Reformulated Gasoline* (California Environment Protection Agency, December 1999) http://www.arb.ca.gov/cbg/ethanol/ethfate/airq/mainf.pdf
- US EPA and National Biodiesel Board reports on biodiesel. Tier I (emissions) report completed March 1998 and Tier II (health) report produced mid 2000 (approximately May - June).
- reports from the *Diesel National Environment Protection Measure* which can be obtained through Environment Australia website http://www.environment.gov.au/
- *Alternatives to Traditional Transportation Fuels 1994 Greenhouse Gas Emissions* by the US Dept of Energy www.eia.doe.gov/cneaf/pubs_html/attf94_v2/exec.html#head4
- test results on diesohol will be available from APACE Research
- US EPA Tier I and Tier II and US DOE test results for other fuels should also be considered.

ATTACHMENT

Ecologically Sustainable Development

As indicated in these Terms of Reference, the consultant will be required to broadly consider the principles of ecologically sustainable development which are outlined section 3A of the Environment Protection and Biodiversity Conservation Act 1999.

Section 3A of the Environment Protection and Biodiversity Conservation Act 1999

3A Principles of ecologically sustainable development

The following principles are principles of ecologically sustainable development:

(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations;

(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;

(c) the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;

(d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making;

(e) improved valuation, pricing and incentive mechanisms should be promoted.