Appendix 2. The GREET model and the SIMAPRO model

The GREET model, available at http://www.transportation.anl.gov/ttrdc/greet/ , or http://greet.anl.gov is the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model developed by Michael Q. Wang at Argonne National Laboratories in the United States.

GREET was developed as a multidimensional spreadsheet model in Microsoft Excel. The first version of GREET was released in 1996. Since then, Argonne has continued to update and expand the model.

For a given engine and fuel system, GREET separately calculates the following:

- Consumption of total energy (energy in non-renewable and renewable sources), fossil fuels (petroleum, natural gas, and coal), and petroleum
- Emissions of CO_2-equivalent greenhouse gases - primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)
- Emissions of five criteria pollutants: volatile organic compounds (VOCs), carbon monoxide (CO), nitrogen oxide (NOx), particulate matter with size smaller than 10 micron (PM10), and sulfur oxides (SOx).

GREET includes more than 30 fuel-cycle pathways. It also includes these vehicle technologies

- Conventional spark- ignition engines
- Direct-injection, spark- ignition engines
- Direct injection, compression ignition engines
- Grid-connected hybrid electric vehicles
- Grid-independent hybrid electric vehicles
- Battery-powered electric vehicles
- Fuel-cell vehicles.

To address technology improvements over time, GREET separates fuels and vehicle technologies into near- and long-term options. The latter are assumed to have improved energy and emission performance compared with the former.

The version of GREET that is available is GREET 1.5, though a test version of GREET 1.6 was made available on 14 August 2001. In addition there is a heavy vehicle module, known as the GREET 3 series that is designed to estimate fuel-cycle energy use and emissions of heavy-duty trucks and buses. This is not available outside of Argonne.

The GREET model combines spreadsheet calculations with US specific life-cycle data for light vehicles. SIMAPRO was considered to be more suitable for use in the Australian context for the following reasons.

The GREET model is based on US data. Thus, for example, ethanol assumes production from corn, woody biomass and herbaceous biomass not grain and molasses, Biodiesel assumes production from soybean not canola, tallow, waste oil etc. Electricity production includes nuclear power in its assumptions.

The GREET 1 series is designed to estimate fuel-cycle energy use and emissions for passenger cars and utility vehicles only. The GREET 3 series (which is not yet available) is designed to estimate fuel-cycle energy use and emissions of heavy-duty trucks and buses.

In a number of cases Australian practice is sufficiently different (e.g. widespread pipeline transport of CNG) that substantial modification would have been needed to make GREET relevant to Australian conditions.

SIMAPRO has an extensive Australian database of manufacturing energy input and emissions available for it.

SIMAPRO is able to provide embodied energies and exbodied emissions from a greater range of pollutants than GREET presently does.

In the preparation of this report there has been widespread use of the technical information that underlies the GREET model. The work of Wang (1999), Wang and Huang (1999) and Wang et al. (1997, 1999, 2000) was used to estimate values for those input variables or parameters that were not quantified in the Australian database, and to provide a check on our results.

A great advantage of SIMAPRO is its ability to produce process trees. Figure A2.1 indicates a process tree obtained from the SimaPro software used to undertake the quantitative life-cycle components of the study. These trees indicate, in an abbreviated form, the upstream components used to evaluate each component of the life-cycle.

To interpret the process tree, one starts at the top. Thus, in Figure A2.1, the values in the box refer to the mass (in kg) of CO2-equ. To travel 1 km using LSD, there is a total of 0.926 kg emitted, as shown in the top box and summarised in Table 1.21 of Chapter 1 (Part 2). The fuel energy expended in travelling this 1 km is 10.8 MJ, as depicted in the second box down. The box below, which we shall call the fuel box, indicates that prior to combustion, the fuel tank contained 0.251 kg of fuel and that the upstream emissions of CO2-equ to manufacture this fuel amounted to 0.207 kg CO2-eq., as shown in Table 1.22 of Chapter 1 (part 2).

Two separate process trees are depicted below the fuel box. The left hand side shows the upstream emissions involved in refining crude oil to produce diesel fuel. The process tree on the right shows the upstream emissions involved in hydro-processing to reduce the sulfur content of the fuel. For clarity, not all upstream processes are shown. If various upstream processes are not included, this is apparent by examining the bottom of the box. Small lines (tick marks) indicate that the full analysis consists of upstream processes feeding in to that box.

The computer software produces output in colour. On the right of each box there is a green line, with a red lower portion. The red lower proportion represents the proportion of the total value (0.926) accumulated up to that point. This can be seen by carefully examining the fuel box. The bottom 20% of the bar on the right of the box is darker than the remainder. The two top boxes have bars that are completely red.

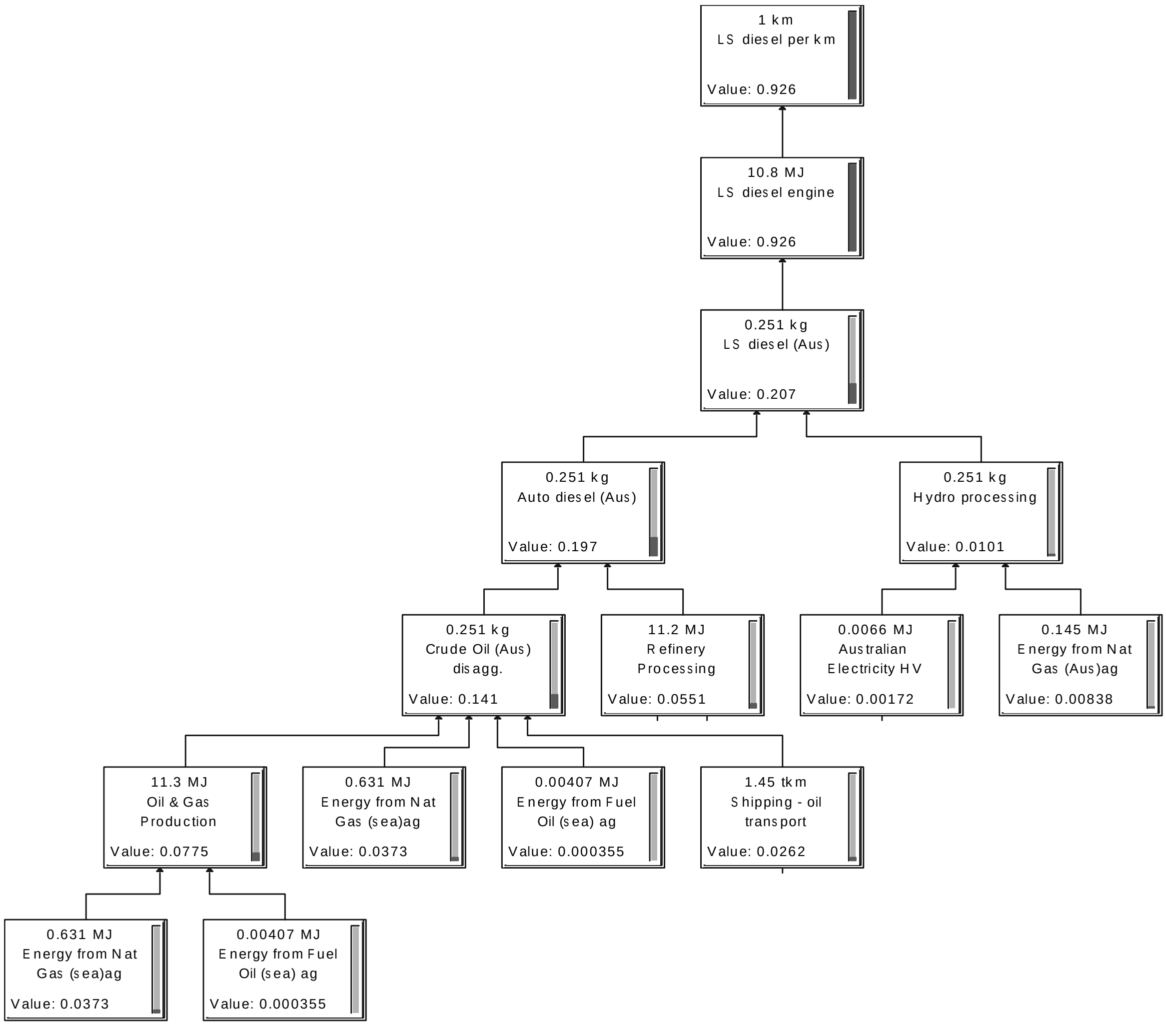

Figure A2.1
Exbodied greenhouse gases emissions (kg CO_2-eq) from LSD production, processing and use in vehicle. The value is given in the bottom of each box.

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