GREENHOUSE GAS ASSESSMENT
PROPOSED BIODIESEL FACILITY, PORT BOTANY

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Prepared for
Vopak Terminals Sydney Pty Ltd and Natural Fuels Australia Ltd

by

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1 INTRODUCTION

This brief report has been prepared by Holmes Air Sciences for Vopak Terminals Sydney Pty Ltd and Natural Fuels Australia Ltd (NFAL) who together are proposing to construct and operate a biodiesel facility within an existing chemical and petroleum handling facility at Port Botany NSW. The report provides an estimate of greenhouse gas emissions during construction and operation of the facility.

The proponent operates two bulk liquid storage terminals in Port Botany, approximately 13 km south of the Sydney CBD. The first is known as the Site A Terminal and is located at 49 Friendship Road. The second facility, known as the Site B Terminal, is located at 20 Friendship Road. Both sites store petroleum products. The proposal would take place upon land at the Site A Terminal but would integrate with other existing facilities, including the Site B Terminal.

2 GREENHOUSE GAS EMISSIONS

A number of conventions on the determination, assessment and the reporting of greenhouse gas emissions from human activity have been developed. These are discussed in the Australian Greenhouse Office (AGO) Factors and Methods Workbook (**AGO, 2006**). The Workbook adopts the reporting approach known as the *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* which will be referred to as *The GHG Protocol.* This divides emissions into three categories or Scopes referred to as Scopes 1, 2 and 3.

The GHG Protocol defines the three scopes of emission as follows:

Scope 1 covers direct emissions from sources within the boundary of an organisation such as fuel combustion and manufacturing processes.

Scope 2 covers indirect emissions from the consumption of purchased electricity, steam or heat produced by another organisation. Scope 2 emissions result from the combustion of fuel to generate the electricity, steam or heat and do not include emissions associated with the production of fuel. Scopes 1 and 2 are carefully defined to ensure that two or more organisations do not report the same emissions in the same scope.

Scope 3 includes all other indirect emissions that are a consequence of an organisation's activities but are not from sources owned or controlled by the organisation.

The estimation and reporting of greenhouse gas emissions are calculated via a number of different methods. The procedures specified in the AGO Workbook (**AGO, 2006**) have been used here. These are consistent with internationally applied methods.

The protocol identifies greenhouse gases as follows:

1. carbon dioxide (CO_2);
2. methane (CH_4);
3. nitrous oxide (N_2O);
4. hydrofluorocarbons (HFCs);

5. perfluorocarbons (PFCs); and
6. sulfur hexafluoride (SF_6).

Carbon dioxide and N_2O are formed and released during the combustion of gaseous, liquid and solid fuels. The most significant gases for the Project are CO_2 and N_2O, which will be liberated when fuels are burnt in diesel-powered equipment and in the generation of the electrical energy that will be used by the Project.

Inventories of greenhouse gas emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (potentials) and emission factors take into account the global warming potentials of the gases created during combustion.

The global warming potentials assumed in the AGO (**AGO, 2006**) emission factors are as follows:

1. CO_2 – 1
2. CH_4 – 21
3. N_2O – 310
4. NO_2 – not included.

When the global warming potentials are applied to the estimated emissions then the resulting estimate is referred to as a "CO_2-equivalent emission".

The emission factors published by the AGO (**AGO, 2006**) have been used to convert liquid fuel usage, natural gas usage and electricity consumption into CO_2-equivalent emissions. The relevant emission factors are:

- Natural gas usage (small user <100,0000 GJ per annum) – (see Table 2 of the AGO workbook **AGO (2006)**)
  - *Scope 1*: 51.7 kg CO_2-equivalent/GJ
  - *Scope 3*: 19.5 kg CO_2-equivalent/GJ
  - *Full fuel cycle:* 71.5 kg CO_2-equivalent/GJ

It has been assumed that the energy content of natural gas is 39.5 MJ/m^3.

- Diesel usage – (see Table 3 of the AGO Workbook **AGO (2006)**)
  - *Scope 1*: 2.7 kg CO_2-equivalent/litre
  - *Scope 3*: 0.3 kg CO_2-equivalent/litre
  - *Full fuel cycle:* *3.0* kg CO_2-equivalent/litre

- Petrol usage – (see Table 3 of the AGO Workbook **AGO (2006)**)
  - *Scope 1*: 2.4 kg CO_2-equivalent/litre
  - *Scope 3*: 0.3 kg CO_2-equivalent/litre
  - *Full fuel cycle:* *2.6* kg CO_2-equivalent/litre

- Electrical energy used in NSW – (see Table 5 of the AGO Workbook **AGO (2006)**).
  - *Scope 2*: 0.893 kg CO_2-equivalent/kWh
  - *Scope 3*: 0.176 kg CO_2-equivalent/kWh

- *Full fuel cycle:* *1.068* kg CO_2-equivalent/kWh

Emissions will occur during the construction and operational phases of the Project.

The emissions which resulted from the production of the feed stock for the process have not been accounted. The sustainability of palm oil for biodiesel production is an important issue, but lies outside the scope of this assessment.

3 EMISSION CALCULATIONS

Vopak has provided information on fuel and electricity consumption during the contruction and operational phases of the Project.

3.1 Construction phase

Electricity

It has been estimated that 187,000 kWh hour of electricity would be consumed to supply power to construction sheds, air conditioning units, computers etc. This would result in the emission of 199,716 kg CO_2-e [1.068 kg CO_2-e/kWh x 187,000 kWh]. This includes the emission for the full fuel cycle in generating the electricity.

Diesel use

Diesel equipment would include cranes, forklifts, delivery vehicles and welding generators. Diesel usage has been to be of the order of 100 litres/ day with a construction timeframe of 113 weeks @ 6 days which equates to 678 days. Therefore the total diesel usage for construction is estimated to be 67,000 litres.

This would result in GHG emissions of 203,400 kg [67,800 L x 3.0 kg/L] for the full fuel cycle in producing the diesel.

Petrol use

It has been estimated that 60 workers per day for 678 days would travel 20km to/from the site. Assuming an average of 10 litres/100 km gives:-

60 workers x 678days x 4 litres petrol = 162 720 litres

This would result in GHG emissions of 423,072kg [162,700 L x 2.6 kg/L] for the full fuel cycle in producing the petrol.

Summary

In summary the greenhouse gas emissions during construction in tonnes of CO_2-equivalent, from each of the sources discussed above would be:

Electricity usage	199.716 t
Diesel usage	203.400 t
Petrol usage	423.072 t
Total	**826.188 t**

3.2 Operational phase

Electricity

The following estimates have been made of annual consumption of electricity:

Power to unload trucks	3,400 kWh
Power to load trucks	34,760 kWh
Pumps for transfers	116,300 kWh
Pumps for boiler	120,000 kWh
Fans for cooling towers	3,504,000 kWh
Biodiesel plant	4,650,000 kWh
Lighting	70,000 kWh
Wastewater disposal	3,000 kWh
Total	**8,501,460 kWh**

This would result in the emission of 9,195,859 kg CO_2-e [1.068 kg CO_2-e/kWh x 8,501,460 kWh]. This includes the emission for the full fuel cycle in generating the electricity.

Diesel use

Annual diesel usage including delivery of raw material to plant, delivery of product from production site to storage site and delivery of by-product off-site. The distance travelled between sites A and B was assumed to be 20 km in each direction. A total of 116,300 litres of diesel are estimated to be used each year.

This would result in GHG emissions of 348,900 kg [116,300 L x 3.0 kg/L] for the full fuel cycle in producing the diesel.

Petrol use

It has been estimated that 8 workers per day on a 24-hour shift would travel20km to/from the site. Assuming an average of 10 litres/100 km gives:-

8 workers x 365days x 4 litres petrol = 11,680 litres

This would result in GHG emissions of 30,368 kg [11,680 L x 2.6 kg/L] for the full fuel cycle in producing the petrol.

Natural gas

There will be two 8-MW boilers each consuming 5,952,420 m^3 of gas per year. This is a total of 470,241 GJ (2 x 5,952,420 m^3x 0.0395 GJ/m^3). This would result in GHG emissions of 33,622,244 kg [470,241GJ x 71.5 kg/GJ] for the full fuel cycle in producing the gas.

3.3 End use of the biodiesel

This section provides an estimate of the GHG emissions from the end use of the biodiesel. Biodiesel would typically contain 76.3% carbon which when burnt would release CO_2-equivalent 2.798 kg/kg of fuel [0.763 x 44/12]. For a production rate of 120,000 tpa, the GHG emissions would be 335,720 tpa.

Table 1: Summary of estimated CO_2 emissions during operation			
	Emission category	**Emission factor**	**Annual CO_2-e (t/y)**
Fuel Combustion (natural gas)		kg CO_2-e/GJ	
	Scope 1	51.7	24311.5
	Scope 3	19.5	9169.7
	Total	71.3	33,622.2
Diesel Usage		t CO_2-e/kL	
	Scope 1	2.7	314.0
	Scope 3	0.3	34.9
	Total	3	348.9
Petrol usage		t CO_2-e/kL	
	Scope 1	2.4	28.0
	Scope 3	0.3	3.5
	Total	2.6	30.4
Electricity Usage		t CO_2-e/kWh	
	Scope 2	0.893	7591.8
	Scope 3	0.176	1496.3
	Total	1.068	9079.6
End use of biodiesel			335,720
Total			**421,750**

On an annual basis, it has been estimated that the proposed development, including the end use would release less approximately 0.42 Mt/y CO_2-e. The annual greenhouse emissions in NSW for 2005 were 158.2 Mt (**AGO, 2007**). Therefore, the proposed development represents approximately 0.27% of the total NSW greenhouse gas emissions.

3.4 Environmental impact of GHG emissions

To assess the effects of the greenhouse gas emissions associated with the Project, it is useful to consider the contribution of total emissions from both production and burning of the biodiesel to global warming.

The International Energy Agency (**IEA, 2006**), estimates that in 2004, the global emissions of CO_2-equivalent from burning fossil fuels was 26,583.3 Mt and Australia's emissions of CO_2 from burning fossil fuels (energy sector) was 387.2 Mt CO_2-equivalent (i.e. 1.46% of the global emission due to total fossil fuel use). The IEA figure is consistent with estimates published by the Oak Ridge National Laboratories (http://cdiac.ornl.gov/trends/emis/tre_glob.htm) which estimates that CO_2 emissions due to burning fossil fuels and cement production in 2003 was 26.777 Gt.

There are other sources of greenhouse gas emissions namely land clearing, agriculture and waste disposal. When these are taken into account Australia's emissions for 2004 were 564.7 Mt. An equivalent figure is not available for global emissions. If it is assumed that land clearing, agriculture and waste account for similar proportions of emissions in the rest of the world then the global CO_2-equivalent emissions in 2004 would be of the order of 40 Gt. Thus, the emissions of 0.42 Mtpa would be 0.000001% of global emissions. Therefore, the Project could be considered to contribute 0.000001% to the increase in global temperatures caused by the increase in GHG emissions as they are currently. This invites the question as to what temperature rise might be attributed to the GHG emission arising from the Project.

Arguably, the most authoritative and comprehensive documents dealing with the science of global warming are the scientific assessment reports produced approximately every five years by the Intergovenmental Panel on Climate Change (IPCC). To date, the IPCC has published three reports, the most recent being in 2001 (**IPCC, 2001**). These documents are essentially the scientific community's consensus view on climate change. As the relationship between global warming and greenhouse gas concentrations is not linear[1] there is no accepted method to determine the contribution that a given emission of greenhouse gases might make to global warming. (To understand this point it is useful to consider the discussion from Section 1.3.1 of the Second Assessment Report prepared by the IPCC (**IPCC, 1996**), which explains the relationship between the concentration of greenhouse gases and global temperature.) However, in the interim the following approach can be used.

The estimated quantity of carbon stored in the atmosphere now is approximately 750 Gt, which is equivalent to 2,750 Gt of carbon dioxide (**Seinfeld and Pandis, 1998**). Based on the IPPC estimate, a doubling of the CO_2-equivalent concentration in the atmosphere would lead to a 2.5 ^{o}C increase in global average temperature, and that the current global CO_2 load is 2,750 Gt, we can estimate that the emissions from the Project would lead to an increase in global temperature of 0.0000004 ^{o}C [(0.42 x 10^6/2,750 x 10^9) x 2.5 ^{o}C].

There will clearly be no measurable environmental effect due to the emissions of GHG from the Project even when the customer's use of the biodiesel is taken into account. Any environmental assessment would conclude that the effects of the emissions from the Project are unmeasurable.

In practice of course, the effects of global warming and associated climate change are the cumulative effect of many thousands of such sources and it is the cumulative effects that pose a threat to Environmental Sustainable Development (ESD) principles.

This analysis highlights the problem of dealing with climate change on a project-by-project basis. Nevertheless, the calculation of greenhouse emissions identifies activities which contribute most to greenhouse gas emissions and where potential savings can be made. The most significant contributors for this project are emissions associated with gas and electricity consumption.

It is recommended that Vopak prepare and implement an Energy Savings Action Plan according to guidelines developed by the Department of Energy, Utilities and Sustainability (**DEUS, 2005**). The plan should include monitoring of gas and electricity consumption and investigation of ways to make this usage more efficient. Reporting of any abatement measures would form part of the plan.

Ultimately, the control of GHG emissions is likely to occur via economic instruments such as carbon taxes set as suggested in the recently released Stern Review and elsewhere (**Stern, 2006**). These taxes, set at appropriate levels, would encourage increases in efficiencies in the way that carbon-based fuels are used, encourage the development of carbon capture and sequestration and encourage the development of

[1] The warming effect of a given quantity of greenhouse gases to the atmosphere is less and less as the concentration becomes higher and higher (see Section 1.3 of **IPCC (1996)**).

renewable forms of energy generation, the use of alternative fuels such as biodiesel and improve the efficiency with which fossil fuels are used.

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