Energy Strategies

Greenhouse gas emissions associated with the proposed Newlands Wollombi No. 2 Project

Report prepared for an objections hearing in the Queensland Land and Resources Tribunal

Tribunal numbers: AML 207/2006 and ENO 208/2006
Tenure Identifier: 4761-ASA 2

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Manuka, ACT

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1. Introduction

Purpose of report

I have been asked by the Queensland Conservation Council Inc to provide an expert opinion of the likely greenhouse gas emissions from the mining, transport and use of the coal from the proposed extension of the Newlands Coal Mine, Wollombi No. 2 Surface Area, at Suttor Creek approximately 129 km west of Mackay, known as the "Newlands Wollombi No. 2 Project" ("the Project"). My letter of instructions is attached to this report as Appendix 1.

Relevant expertise

My resume is attached as Appendix 2. In summary, I hold a degree in science from Adelaide University and a PhD from Cambridge University. I have authored of a book on Australian energy policy, *Energy in Australia*, and over 70 scientific papers, monographs and articles on energy technology and environmental policy.

I am the managing director of Energy Strategies, a nationally recognised leader in providing analysis and advice on the sustainability of energy systems at all levels from the global down to individual projects and buildings. We have been centrally involved in the formulation of national energy policy since establishment (initially as Energy and Economic Analysis Pty Ltd) in 1982. The bulk of this consulting work over the last few years has been in analysing and developing policy for governments, (especially the Commonwealth Government,) on greenhouse gas emissions and renewable energy, developing workbooks, for example for the Electricity Supply business, and work of a more technical nature such as the compilation of the National Greenhouse Gas inventory for energy related emissions.

Before founding the company in 1982, I held research positions at Sydney University and the Australian National University, and was seconded to the Commonwealth public service for two years. I also spent some years in the early 1970s working in London and Rotterdam with a leading British firm of economic and management consultants. My first work on energy policy was in the UK, in 1973, at the time of the first oil shock, and this has been my main professional interest since.

Duty to the Tribunal

I note that I have received, read and understood the Tribunal's practice direction No. 11 of 2000. I understand that:

- I have overriding duty to assist the Tribunal on matters relevant to my area of expertise;
- I am not an advocate for a party; and
- my paramount duty is to the Tribunal and not to the person retaining me.

Description of the Project

My knowledge of the Project comes from reading the documents supplied to me, including, particularly, relevant extracts of the environmental impact statement for the Project prepared by Sinclair Knight Merz, dated December 2005 ("the EIS").

From these documents I understand that the Project will produce up to 2.5 million tonnes per annum ("Mtpa") of run of mine black coal for a nominal annual average of 1.9 Mtpa product coal over a 15 year mine life, or 28.5 million tonnes ("Mt") of product coal in total. The coal from the mine will be transported to domestic and/or export markets for electricity production (thermal or steaming coal) and/or steel production (metallurgical or coking coal).

I note, however, the EIS is confusing in what exactly constitutes the "project" that is the subject of the EIS. The project the subject of the proceedings before the Tribunal is the extension Newlands Coal Mine into the "Newlands Wollombi No. 2 Project" area. Much of the data in the EIS on production, fuel use, greenhouse gas emissions, etc, is confused and inconsistent. At times the information in the EIS relates to the whole mine and at times, apparently, to half. I understand that the production of 28.5 Mt of product coal relates to the whole of the proposed mine. This is termed "the Project" in the remainder of this report and all the analysis is based on a lifetime production of 28.5 Mt.

I note also that I have been provided with correspondence from the solicitor of the proponent, dated 11 January 2007, stating that "the estimated percentages of coking and steaming coal to be produced from the Wollombi No. Project over the project life are as follows:

Coking: approximately 65%

Steaming: approximately 35%."

2. How the proposed mine will contribute to the global greenhouse effect

The global greenhouse effect (strictly speaking, the enhanced greenhouse effect) is caused by the increase in concentration in the atmosphere of gases which prevent the escape from the earth, by re-radiation, of heat supplied to the surface of the earth by the sun's radiation. Human induced, i.e. anthropogenic, activity is putting a number of these gases into the atmosphere at faster rates than they can be removed form the atmosphere by natural processes. Consequently, the concentrations of these gases is increasing steadily.

Carbon dioxide (CO_2) is the most important anthropogenic greenhouse gas and most CO_2 emitted to the atmosphere derives from the combustion of fossil fuels to provide energy. Fossil fuels are complex mixtures of organic, i.e. carbon containing, compounds, of which the main elemental constituents are carbon and hydrogen. They are derived from the fossilisation of the remains of plants and animals that lived many millions of years ago – hundreds of millions in the case of black coal. Combustion of fossil fuels results in the formation of CO_2 and water. The higher the ratio of carbon to hydrogen, the higher the emissions of CO_2 per unit of energy released. Coal has the highest ratio of carbon to hydrogen of all fossil fuels, and hence the highest emissions of CO_2 per unit of energy. All this CO_2 is released when the coal is burnt to provide useful energy. Section 6 of this report provides an estimated of the total quantity of CO_2 that will be released to the atmosphere by combustion of the coal that is expected to be produced by the Project.

The production of the coal itself by open cut mining, and its transport to market, will require the use of energy and consequent emission of CO_2. In addition, quantities of methane, another greenhouse gas, trapped in the coal, are released when the coal is mined. Section 4 provides an estimate of these operational greenhouse gas emissions, based on information contained in the EIS.

3. Business and industry practice in accounting for greenhouse gas emissions

In recent years, the Greenhouse Gas Protocol (the *Protocol*), developed jointly by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute, has emerged as the de facto working standard for estimating corporate greenhouse gas emissions. The WBCSD explained the context and two part structure of the *Protocol* as follows:[1]

> "The Greenhouse Gas Protocol Initiative's (GHG Protocol) goal is to help businesses better manage their greenhouse gas (GHG) emissions, create a GHG accounting platform to ensure that different trading schemes and other climate related initiatives adopt consistent approaches, and to generally expand GHG accounting capacity around the world.
>
> The GHG Protocol Initiative has developed two documents to facilitate the accounting and reporting of GHG emissions from corporate inventories and GHG reduction projects:
>
> - The Corporate Accounting and Reporting Standard (Corporate Standard) provides step by step guidance for companies and other organisations to identify, calculate, and report their GHG footprint in a consistent, transparent, and credible manner. The requirements contained in this document provide the backbone for GHG corporate accounting practices around the world.
> - The GHG Protocol for Project Accounting (Project Protocol) provides specific principles, concepts, and methods for quantifying and reporting GHG reductions—that is, the decreases in GHG emissions or the increases in GHG removals—from climate change mitigation projects."

A copy of *The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard* is attached as Appendix 3 to this report.

The *Protocol* is widely used by companies around the world, including many Australian businesses. In particular, the Australian Greenhouse Office ("AGO"), part of the Australian Government Department of the Environment and Heritage, has harmonised its methods for calculating direct and indirect greenhouse gas emissions, set out in the *AGO Factors and Methods Workbook*, to be consistent with the *Protocol*.[2] A copy of the *AGO Factors and Methods Workbook* (December 2006 edition) is attached as Appendix 4 to this report.

I consider that the *Protocol* constitutes the most appropriate basis for estimating emissions from the Project. *The Greenhouse Gas Protocol Corporate Accounting and Reporting Standard* is the appropriate standard for estimating emissions from the Project. The *Greenhouse Gas Protocol for Project Accounting* is used only for estimating reductions in emissions that will result from projects specifically designed to

[1] See http://www.ghgprotocol.org/ (viewed 4 January 2007).
[2] AGO, *AGO Factors and Methods Workbook* (AGO, Canberra, December 2006), pp. 1-2.

reduce emissions (greenhouse gas mitigation projects). This coal mine project is not a mitigation project.

A key feature of the *Protocol* is the approach it takes to setting what are called operational boundaries for an emissions inventory, that is defining what emissions sources are to be included and which not included in reporting an inventory for a corporation, or part of a corporation, such as an individual mine. The *Corporate Accounting and Reporting Standard* of the *Protocol* defines the issue in the following terms.

> "For effective and innovative GHG management, setting operational boundaries that are comprehensive with respect to direct and indirect emissions will help a company better manage the full spectrum of GHG risks and opportunities that exist along its value chain.
>
> **"Direct GHG emissions** are emissions from sources that are owned or controlled by the company.
>
> **"Indirect GHG emissions** are emissions that are a consequence of the activities of the company but occur at sources owned or controlled by another company." (p. 25)

The *Protocol* goes on to allocate emissions to one of three so-called scopes. Scope 1 includes all direct emissions. Scope 2 includes indirect emissions from the generation of purchased electricity consumed by the company. Scope 3 includes all other indirect emissions.

The *Protocol* states: "Companies shall separately account for and report on scopes 1 and 2 at a minimum" (p. 25). This minimum approach has been followed in developing the estimate of emissions included in the EIS and is undertaken in Section 4 below.

Regarding scope 3 emissions, the *Protocol* states: "Scope 3 is an optional reporting category that allows for the treatment of all other indirect emissions" (p. 25). It provides a list of emission source categories which may be included within scope 3 reporting, one of which is "Use of sold products and services" (p. 29). The *Protocol* goes on to state that, in deciding whether to report scope 3 emissions, companies should follow the following procedure.

> "Determine which scope 3 categories are relevant. Only some types of upstream or downstream emissions categories might be relevant to the company. They may be relevant for several reasons:
>
> - They are large (or believed to be large) relative to the company's scope 1 and scope 2 emissions
> - They contribute to the company's GHG risk exposure
> - They are deemed critical by key stakeholders (e.g., feedback from customers, suppliers, investors, or civil society)
> - There are potential emissions reductions that could be undertaken or influenced by the company." (p. 30)

On this basis, it is clear that emissions associated with use (combustion) of coal produced by the Project constitutes a category of scope 3 emissions from the Project and that these emissions are relevant at lest with respect to the first and third of the above criteria.

Appendix D of the *Protocol* "lists greenhouse gas sources and activities along the value chain by scopes for various industry sectors." (p. 27) and "provides an overview of direct and indirect greenhouse gas emission sources organized by scopes and industry sectors that may be used as an initial guide to identify major greenhouse gas emission sources." (p. 41). Appendix D provides the following Scope 1, 2 and 3 emissions sources for the coal mining industry (for energy production only) and for iron and steel production (p. 92):

SECTOR	SCOPE 1 EMISSION SOURCES	SCOPE 2 EMISSION SOURCES	SCOPE 3 EMISSION SOURCES
ENERGY			
Coal Mining	• Stationary combustion (methane flaring and use, use of explosives, mine fires) • Mobile combustion (mining equipment, transportation of coal) • Fugitive emissions (CH_4 emissions from coal mines and coal pits)	• Stationary combustion (consumption of purchased electricity, heat or steam)	• Stationary combustion (product use as fuel) • Mobile combustion (transportation of coal / waste, employee business travel, employee commuting) • Process emissions (gasification)
METALS			
Iron and Steel	• Stationary combustion (coke, coal and carbonate fluxes, boilers, flares) • Process emissions (crude iron oxidation, consumption of reducing agent, carbon content of crude iron / ferroalloys • Mobile combustion (on-site transport) • Fugitive emission (CH_4, N_2O)	• Stationary combustion (consumption of purchased electricity, heat or steam)	• Stationary combustion (mining equipment, production of purchased metals) • Process emissions (production of ferroalloys) • Mobile combustion (transportation of raw materials / products / waste and intermediate products) • Fugitive emissions (CH_4 and CO_2 from waste landfills)

Consequently, while the users of the coal from the Project would account for the emissions from using the coal as Scope 1, the proponent of the mine accounts for them as Scope 3 emissions. Emissions from transporting the coal from the mine to users are also Scope 3 emissions for the proponent of the mine.

The Scope 3 emissions from transportation and use of the coal from the Project are calculated in sections 5 and 6 below.

4. Likely greenhouse gas emissions from operation of the Project (scope 1 and scope 2 emissions)

The major sources of greenhouse gas emissions from mining operations are:

- consumption of diesel fuel by mining equipment (e.g. dump trucks, dozers, front end loaders),
- consumption of electricity by mining equipment (e.g. dragline),
- fugitive emissions from exposed coal,
- explosives (ammonium nitrate/fuel oil, abbreviated as ANFO).

The project emissions inventory supplied by the proponent (undated, prepared by Sinclair Knight Merz) estimates project emissions by assuming the same rates of consumption (or emission) for all of these emission sources as currently apply to the existing Newlands mine operations. All data are provided on an annual basis, and are then related to annual production of raw (or run of mine – ROM) coal. Emission factors are taken from the *AGO Factors and Methods Workbook*, December 2006 edition.[3]

Total lifetime output of raw coal from the Project is taken to be 37.5 Mt. This figure is calculated by reference to the following information in the EIS:

- Table 2-6, p. 2-18 for average annual output of 2.5 Mt raw coal, and
- p. 2-1 for project operating life of 15 years.

Emissions from each source are calculated by multiplying the consumption of the source material (the activity figure) by the relevant emission factor. Activity levels and emission factors are shown in the table below. In the case of fugitive emissions of methane, the emission factor for methane, measured as kg of methane released per tonne of raw coal mine, is multiplied by a further factor, called the Global Warming Potential (GWP), which equates the greenhouse effect of a given mass of methane with the effect of the same mass of CO_2. The GWP of methane is 21, meaning that methane is 21 times more greenhouse "potent" than CO_2 on a tonne for tonne basis.

I note that at various points, notably p. 2-2, the EIS contains apparently inconsistent statements about Project output. However, the assumptions I have used about project appear to be consistent with those used in calculating the emissions inventory from Year 15 operations, as set out on p. 6-16 of the EIS.

On the basis of the above assumptions and methodology, I calculate emissions from mining operations over the entire 15 year life of the Project to be 1.37 Mt CO_2-e, made up as follows:

[3] The *AGO Factors and Methods Workbook* adopts the methodology of the *Protocol* in which "emissions factor" is defined as "a factor allowing greenhouse gas emissions to be estimated from a unit of available activity data (e.g. tonnes of fuel consumed, tonnes of product produced) and absolute greenhouse emissions." This is in turn based on the approach used by the Intergovernmental Panel on Climate Change, in its *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.*

Table 1: Direct greenhouse gas emissions from mining operations

Emission source	Activity level over Project life	Emission factor (CO2-e per unit of activity)	Emissions (kt CO_2-e)
Diesel consumption	84.1 ML	2.75 t/kL	231
Electricity consumption	456 GWh	1.046 t/MWh	477
Fugitive methane	37.5 Mt raw coal	17.0 kg/t raw coal	638
ANFO consumption	59.6 kt	0.167 kg/t	10
Heavy ANFO consumption	63.1 kt	0.178 kg/t	11
Total emissions			1,367
Average annual emissions (for 2.5 Mt raw coal)			91.1
Unit emissions (per tonne of raw coal)			36.4 kg

It should be noted that, in terms of emissions per tonne of raw coal produced, these figures are almost identical with those given in Table 6-10, p. 6-16 of the EIS. The small difference relates to the emission factor for electricity consumption, for which I have used the value in the December 2006 edition of the *AGO Factors and Methods Workbook*. The EIS calculation uses the August 2004 edition, which contained slightly different value for this parameter.

Interpretation of these figures should take account of the following qualifications.

1) The emission factor for diesel is for direct combustion emissions of CO_2 only. Combustion also gives rise to emissions of methane (CH_4) and nitrous oxide (N_2O), but these are very small relative to emissions of CO_2, and the error in ignoring them is trivial. The emission factor also excludes so-called upstream emissions arising from the production and shipping of crude oil and its processing to produce diesel fuel. These are classified as Scope 3 emissions under the *Greenhouse Gas Protocol*, which are discussed in the following section.

2) The emission factor for electricity is determined by the mix of power stations supplying the Queensland electricity system. At present, supply is overwhelmingly from conventional coal fired power stations, resulting in a high emission factor for supplied electricity. The Queensland government has in place a policy to increase the share of electricity supplied from gas fired power stations. Over time, this policy will have the effect of reducing the average emissions intensity of electricity supplied in Queensland. Other current, and possible future policies, supporting greater use of electricity from renewable sources, will have the same effect. For this reason, actual life time emissions from operation of the mine will probably be somewhat less than the figures shown here, based on the current emissions intensity of Queensland electricity. However, it is not possible to estimate the extent of any such future decrease in emissions intensity.

3) The estimate of fugitive methane emissions, which is the largest single emission source, is subject to very high uncertainty. The emission factor in the *AGO Factors and Methods Workbook* is for all open cut coal mines in Queensland, and is based at

a limited set of field measurements made at a small number of mines. In practice, emissions will vary widely from mine to mine, and over time at an individual mine, depending on characteristics of the coal being mined. It appears that the operators of the Newlands mine have not made any measurements to determine whether, in fact, emissions from Newlands are consistent with the emission factor used in these calculations.

5. Emissions from transporting coal (scope 3 emissions)

Coal will be transported by rail from Newlands to Abbott Point. This service is provided by Queensland Rail, using diesel electric locomotives. It will then be shipped to overseas markets. Since the proponent does not own or operate either the rail of the shipping services, emissions associated with transporting coal to market constitute scope 3 emissions under the *Greenhouse Gas Protocol*. (The proponent is operator, but not owner, of the Abbott Point coal terminal, but since energy use and emissions associated with coal loading are very low, they are ignored here.)

For the rail transport leg, the EIS states that the distance is approximately 200 km (p. 1-2) but contains no information about energy consumption per tonne km transported, as would be needed to estimate these emissions. In 2003 the average Australian fuel consumption for rail freight was 0.31 MJ/tonne-km for general ("hire and reward") freight operations[4] (Apelbaum Consulting Group, 2005). The corresponding figure for so-called ancillary freight, meaning an operation where an entity, such as a mining company, runs its own in-house freight operation, was 0.09 MJ/tonne-km. Queensland Rail operates the Newlands to Abbott Point freight service on a hire and reward basis, but the dedicated nature of the service, suggests that average fuel consumption may be lower than the national average for all freight services.

Assume for illustrative purposes that fuel consumption for Newlands to Abbott Point is 0.2 MJ/tonne-km, or 40 MJ/tonne for the whole route. This route is operated by diesel locomotives, so corresponding emissions are about 2.8 kg/tonne or 79,800 tonnes of CO_2-e for the total 28.5 Mt of coal transported. This would add about 8% to the operating emissions estimated in the previous section.

Data for the fuel consumption and emissions for sea freight are from Abbott Point to Japan (which I understand to be the most likely market for most of the output from the Project) are not readily available. However, sea freight is significantly more energy efficient than rail transport and so, despite the much greater distance involved, emissions will be quite modest.

[4] Apelbaum Consulting Group, 2005. *Australian Rail: The 2004 Productivity Report*, Australasian Rail Association, Canberra. Available from: http://www.ara.net.au/stat/stats.php.

6. Likely greenhouse gas emissions from use of coal produced by the Project (scope 3 emissions)

Emissions of CO_2 that will arise from combustion of the coal produced by the Project can be estimated by use of the data provided in Table 2-4 (p. 2-11) of the EIS.

The coal from the Project will be sold for use as steaming coal, for electricity production, and coking coal, for steel production. Both of these uses ultimately result in virtually all of the carbon contained in the coal being emitted into the atmosphere as a greenhouse gas. The key figures for how much greenhouse gas will be emitted are the amount of coal for each use and the amount of carbon contained in the coal.

Steaming coal produced by the Project is expected to comprise 87.0% carbon, on a dry ash free basis. Since the product coal is expected to have an ash content of 14%, this carbon content equates to 76.3% in product steaming coal.

For coking coal, the corresponding figures are 88.0% carbon dry ash free basis, 9.5% ash content of product coal, hence 80.4% carbon content in product coking coal.

Tonnes of CO_2 emitted per tonne of coal are calculated by the following simple equation:

Emissions = (mass fraction of carbon) x 44/12

44/12 is the ratio of the molecular weight of CO_2 (44) to the atomic weight of carbon (12). For coking coal the equation becomes:

Emissions per tonne of coking coal = 0.804 x 44/12
= 2.95 tonnes CO_2

Clearly, the exact emissions from coal produced by the Project will depend on the relative proportions of steaming and coking coal produced. Depending on this range, total emissions could be between 80 Mt CO_2-e (for 100% steaming coal) and 84 Mt CO_2-e (for 100% coking coal) from the 28.5 Mt of product coal estimated to be produced over the life of the Project. On the basis of currently estimated proportions of 65% coking, 35% steaming coal, total emissions from the Project will be 82.5 Mt CO_2-e and average annual emissions 5.5 Mt CO_2-e.

I point out that this calculation of emissions yields a higher figure than would be the case if the default emission factor given in the *AGO Factors and Methods Workbook* were used. Coals vary widely in their chemical composition, calorific value, ash content and other characteristics, with a corresponding variation in emission factors. It is always more accurate to calculate emissions using actually chemical content data, where that is available as, in this case, it is. The default value should only be used when such data is not provided.

There will be additional emissions of methane and nitrous oxide. However, these emissions will depend on the type of equipment in which coal is used, and on how that equipment is operated, and will in any case be small (less than 2% in CO_2-e terms) relative to CO_2 emissions. Therefore no effort has been made to estimate these emissions.

7. Putting Project emissions in context

Based on the calculations set out in sections 4-6 of this report, total average annual emissions from mining, transporting and using the coal produced by the Project will be about 5.6 Mt CO_2-e for the 15 year life of the Project or 84.0 Mt CO_2-e in total as shown in the following table:

Table 2: Greenhouse gas emissions from mining, transport and use of the coal

Source of emissions	Annual emissions (Mt CO_2-e)	Total emissions (Mt CO_2-e)	Percent of total emissions from mining, transport and use for each emission source (%)
Mining operations	0.091	1.37	1.63
Transport	0.005	0.08	0.09
Use of coal	5.5	82.5	98.3
TOTAL	5.6	84.0	100 %

Comparison with Australia's national emissions

The greenhouse gas emissions from the Project can be compared with Australia's national emissions. The most recent available data on Australia's national direct greenhouse gas emissions are contained in the *National Greenhouse Gas Inventory 2004*. Following the Guidelines for compiling national emissions inventories, developed by the Intergovernmental Panel on Climate Change and used by all States Parties to the *United Nations Framework Convention on Climate Change*, national inventories include only emissions occurring within the boundaries of the nation. Thus they do not include, for example, emissions arising from the combustion in Japan of coal that has been imported from Australia.[5] Australian emissions in 2003-04 are set out on the following table.

[5] There is one exception, relating to the deemed fate of harvested timber, but that is not relevant in this case.

Table 3: Australia's greenhouse gas emissions in 2003-04[6]

Sector	Emissions (Mt CO_2-e)
Energy	387.5
Stationary Energy	279.9
Transport	76.2
Fugitive Emissions	31.0
Industrial Processes	29.8
Agriculture	93.1
Land Use, Land Use Change and Forestry	35.5
Waste	19.1
Australia's Net Emissions	564.7

The annual greenhouse gas emissions from the mining, transport and use of the 28.5 Mt of coal from the Project (5.6 Mt CO_2-e/yr) are, therefore, equivalent to approximately 1% of Australia's direct, annual emissions based on 2004 levels of emissions (of 564.7 Mt CO_2-e).

The total greenhouse gas emissions from the mining, transport and use of the 28.5 Mt of coal from the 15 year life of the Project (84 Mt CO_2-e) are, therefore, equivalent to approximately 15% of Australia's direct, annual greenhouse gas emissions based on 2004 levels of emissions (of 564.7 Mt CO_2-e).

Comparison with international greenhouse gas emissions

Based on national inventory submissions to the Secretariat for the *United Nations Framework Convention on Climate Change*, total global emissions in 2000 (excluding emissions from land use, land use change and forestry, which are subject to high uncertainty) are estimated to have been nearly 34 Gigatonnes of CO_2 equivalents (Gt CO_2-e)[7] (1 Gt equals 1,000 Mt)). Just over half this total, 17.5 Gt was from industrialised countries, including Australia (termed Annex I Parties to the Framework Convention). By 2004, emissions from industrialised countries had grown to 17.9 Gt.[8]

The annual greenhouse gas emissions from the mining, transport and use of the 28.5 Mt of coal from the Project (5.6 Mt CO_2-e/yr) are, therefore, equivalent to approximately

[6] Sourced from the AGO's *Australian Greenhouse Emissions Information System (AGEIS)*, http://www.greenhouse.gov.au/inventory/index.html, (viewed 3 January 2007) and AGO (2006) *National Greenhouse Gas Inventory 2004*.
[7] World Resources Institute, Climate Analysis Indicators Tool (CAIT) Version 4.0. http://www.wri.org/climate/ (accessed 19 December 2006)
[8] United Nations Framework Convention on Climate Change, 2006. National greenhouse gas inventory data for the period 1990–2004 and status of reporting. FCCC/SBI/2006/26. (http://unfccc.int/resource/docs/2006/sbi/eng/26.pdf)

0.02% of international annual emissions based on 2000 levels of emissions (of 34 Gt CO_2-e).

The total greenhouse gas emissions from the mining, transport and use of the 28.5 Mt of coal from the 15 year life of the Project (84 Mt CO_2-e) are, therefore, equivalent to approximately 0.24% of international annual greenhouse gas emissions based on 2000 levels of emissions (of 34 Gt CO_2-e).

Clearly, direct and indirect emissions from the Project are small relative to both total Australian emissions and total world emissions. Average annual emissions occurring within Australia, comprising scope 1 and 2 project emissions, plus scope 3 emissions associated with rail transport to Abbott Point, are only 0.02% of Australia's current total emissions. Average annual total direct and indirect emissions, including emissions from using the coal, are also about 0.02% of total global emissions. However, it is important to appreciate that both Australian and world emissions are made up of many millions of individual emission sources, any one of which may appear insignificant relative to the totals. For example, average annual per household emissions from energy used in Queensland households is about 8 tonnes CO_2-e, so direct and indirect emissions from the Project within Australia are equivalent to those from about 12,000 Queensland homes. Moreover, both Australian and world emissions are continuing to increase, notwithstanding the importance of beginning to reduce emissions, and this continued growth is the outcome of a very great many individual decisions made each year to undertake new activities with great emissions. Turning round the continued growth in emissions will require different decisions to be made in the many individual cases that arise each year, in all countries, including Australia.

Declaration

I have made all the inquiries which I believe are desirable and appropriate and no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Tribunal.

Appendix 1

Letter of instructions

ENVIRONMENTAL DEFENDERS OFFICE (QLD) INC.

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13 December 2006

Dr Hugh Saddler
Managing Director
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Also via e-mail:

Dear Dr Saddler

Queensland Conservation Council Inc ats Xstrata Coal Queensland Pty Ltd & Ors

Objection to Mining Lease Application for Newlands Coal Mine Expansion

We act for the Queensland Conservation Council Inc ("QCC") in relation to an application lodged by Xstrata Coal Queensland Pty Ltd for a coal mine expansion at Newlands Coal Mine. QCC will argue, in the Land & Resources Tribunal, that the coal mine expansion should not be approved without imposing conditions to avoid, reduce or offset the greenhouse gas emissions from the mining, transport and use of the coal.

Background

Xstrata Coal Queensland Pty Ltd ("Xstrata") and its joint venturers[1] have applied for a mining lease under the *Mineral Resources Act* 1989 (Qld) ("MRA") and an environmental authority (mining lease) under the *Environmental Protection Act* 1994 (Qld) ("EP Act") for an open cut coal mine (ML 4761). The applications are for an additional surface area for extension of the Newlands Coal Mine, Wollombi No 2 Surface Area, at Suttor Creek approximately 129 km west of Mackay, known as the Newlands Wollombi No. 2 Project ("the Newlands Coal Mine Expansion").

The mine will produce up to 2.5 million tonnes per annum ("Mtpa") of run of mine ("ROM") black coal for a nominal annual average of 1.9 Mtpa product coal over a 15 year mine life, or 28.5 Mt of coal in total.

The coal from the mine will be transported to domestic and/or export markets for electricity production (thermal or steaming coal) and/or steel production (metallurgical or coking coal).

1. Itochu Coal Resources Australia Pty Ltd, ICRA NCA Pty Ltd, and Sumisho Coal Australia Pty Ltd.

Subject to your expert opinion, we calculate that the greenhouse gas emissions from the full fuel cycle[2] of the mining, transport and use of the 28.5 Mt of coal from the mine for electricity production or steel production will be approximately 72.18 – 96.44 Mt of carbon dioxide equivalent ("Mt CO2–e") according to the calculation methods recommended by the Australian Greenhouse Office.[3] The majority of the greenhouse emissions from these projects will occur overseas when the coal is used.

Expert evidence

The key evidentiary issues QCC will address in expert evidence are:

1. What is global warming and climate change, how serious a problem is it, and how does the mining, transport and use of coal contribute to these processes?
2. The likely greenhouse gas emissions from the mining, transport and use of the 28.5Mt of coal from the mine (possibly just by using the Australian Greenhouse Office Workbook).
3. The contribution that the likely greenhouse gas emissions from the mining, transport and use of the coal from the mine will make to climate change and potential impacts of this.
4. The reasonable and practicable means to avoid, reduce or offset the likely greenhouse gas emissions from the mining, transport and use of the coal from the mine, including the costs of these measures being imposed.
5. The likely impacts of climate change on the Queensland economy.

We would very much value your assistance as an expert for QCC to address issues **2** and **3** as well as issue **4** in relation to measures to reduce greenhouse gas emissions that can be undertaken at the mine site, if any.

With respect to issue **1**, we would be very grateful if you were in a position to include in your report a brief explanation of what is global warming, how serious a problem it is and how coal contributes to global warming. For the purposes of your report, you could refer to works by other scientists. Please let us know if you are not in a position to address this issue.

With respect to issue **2**, the EIS reports that the pit activities would directly contribute 183,997 tonnes of carbon dioxide equivalents in 15 years of operations. Due to QCC's limited resources, please consider whether you agree with this figure without expending too much of your time on estimates of direct greenhouse gas emissions.

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2. Total emissions resulting from the use of a fuel including those emissions associated with the production and transport of the fuel.

3. Australian Greenhouse Office (AGO), *Australian Greenhouse Office Factors and Methods Workbook*, (AGO, Canberra, August 2005). Available at http://www.greenhouse.gov.au/workbook/pubs/workbook.pdf (viewed 12 December 2006). Based on the formula, Greenhouse Gas Emissions (GHG) (t CO_2–e) = Q x EC x EF/1000; where**:** Q = the quantity of fuel burnt in tonnes; EC = the energy content of fuel in GJ/tonne or GJ/kL; EF = the relevant emissions factor. According to Table 1, p 6 of the AGO workbook, the energy content of washed black coal for Queensland electricity generation is 27.0 GJ/t and the full fuel cycle emissions factor is 93.8 kg CO_2-e/GJ. The energy content of coal used in the steel industry is 30.0 GJ/t and the full fuel cycle emissions factor is 112.8 kg CO_2-e/GJ.

With respect to the calculation of the total carbon emissions from the mining, transport and use of the coal, please advise whether you require any further information than appears in Xstrata's EIS and supporting documents.

Documents

We refer you to the following documents:

1. The Land and Resources Tribunal Guidelines for expert witnesses (Practice Direction No 11 of 2000) – copy enclosed.

2. The objection dated 7 November 2006 lodged by QCC – copy enclosed.

3. Directions made by the Land and Resources Tribunal on 27 November 2006 – copy enclosed.

4. Further and better particulars filed by QCC – copy enclosed.

5. Extracts from the EIS for the Newlands Coal Mine dated December 2005, as follows:
    i. Executive Summary – pages ES-1 to ES-9
    ii. Table of Contents – pages i to xxxv
    iii. Introduction – pages 1-1 to 1-12
    iv. Description of the Project – pages 2-1 to 2-29
    v. Greenhouse Gas Inventory – page6-16 to 6-17

6. Xstrata's disclosed documents in relation to the greenhouse gas calculation. The documents are itemised in the Applicant's List of Documents dated 12 December 2006, also enclosed.

7. *Factual and Legal context of the QCC objection in the Queensland Land & Resources Tribunal to the Newlands Coal Mine Expansion* prepared by Chris McGrath, barrister.

Timeframe

There is a very tight timetable for the proceedings as follows:

1. Experts' affidavits are to be filed by **15 December 2006**;
2. Experts within similar field of expertise are to confer by **18 January 2007** with a view to resolving or narrowing any matters upon which they disagree;
3. Experts within similar field of expertise are to file and joint report by **22 January 2007** setting out the matters upon which they agree and any matters upon which they disagree, and the reasons for any disagreement;
4. The matter is set down for hearing in the Land and Resources Tribunal over three days commencing **31 January 2007**.

It may well be that the other parties will not rely on evidence from experts within your area of expertise and there will be no need for a joint meeting or joint report. At this stage, we do not know whether you will be required for cross-examination.

Your duty to the Tribunal

We emphasis that, in accordance with the attached guideline for expert witnesses:

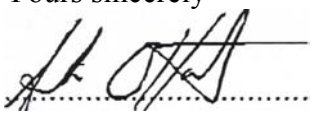
- You have overriding duty to assist the Tribunal on matters relevant to your area of expertise;
- You are not an advocate for QCC; and
- Your paramount duty is to the Tribunal and not to QCC.

We also emphasise that neither QCC nor its lawyers seek to influence your views in any way and we ask for your independent opinion to assist the Tribunal. Consequently, please note that any statements of fact or opinion in this letter of instructions, the above documents, or anything given or said to you by QCC or its lawyers relevant to the issues in your report do not constrain you in any way and are not intended to influence your views. We ask you to form your own opinion about the relevant facts and circumstances for the purposes of your report.

On behalf of the EDO and QCC, thank you very much for generously agreeing to act on your reduced pro-bono fee basis. Before undertaking work over $1,000.00, please provide an estimate of the total hours you expect will be involved in the preparation of your report.

If you have any queries, please do not hesitate to contact me on (07) 3289 7991.

Yours sincerely



Anita O'Hart
Solicitor

Environmental Defenders Office (Qld) Inc

Appendix 2

Resume of Dr Hugh Saddler

CURRICULUM VITAE

HUGH SADDLER

Energy Strategies
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Manuka
ACT 2603

Phone: 02 6260 6444
Fax 02 6260 6555
E-mail hugh.saddler@enerstrat.com.au

DATE OF BIRTH: 24 December, 1943

NATIONALITY: Australian

FORMAL QUALIFICATIONS: BSc(Hons) Adelaide, 1965; PhD Cantab., 1969

CURRENT EMPLOYMENT

1996- : Managing Director, Energy Strategies Pty Ltd

PREVIOUS CAREER

1982-97: Director, Economic and Energy Analysis Pty Ltd

1982-83: Visiting Fellow, Centre for Resource and Environmental Studies, Australian National University (part time).

1977-82: Research Fellow, Resource Economics Group, Centre for Resource and Environmental Studies, Australian National University.

1975-77: Seconded to the Commonwealth Department of Environment, Housing and Community Development as Research Officer, Ranger Uranium Environmental Inquiry.

1974-77: Research Fellow, School of Biological Sciences and Energy Research Centre, University of Sydney.

1972-74: General Secretary, British Society for Social Responsibility in Science, London; part time freelance consultant.

1969-72: Consultant, Scientific Planning Division, Metra Consulting Group, London.

1965-66: Research Assistant, Botany Department, University of Adelaide.

OFFICIAL APPOINTMENTS AND MEMBERSHIP OF PROFESSIONAL ORGANISATIONS

2005- : Member, Advisory Board, ARC Centre of Excellence for Solar Energy Systems, Centre for Sustainable Energy Systems, Australian National University

2002- : Member, ACT Environment Protection Technical Advisory Committee

2002-05 : Member, ACT Sustainability Expert Reference Group

2001- : Member, Committee EV/15 – Carbon Accounting, Standards Association of Australia.

2001: Member, Technical Panel, Second year review of CRC for Greenhouse Accounting.

1999-2003: Member, Australian CRC for Renewable Energy (ACRE) Energy Policy Group

1998-2002: Member, ACT Environment Advisory Committee

1998-2002 : Member, Experts Group on Emissions Trading

1998- : Member, ABS Environmental Statistics Advisory Group

1998-99: Adjunct Professor, Murdoch University

1995: Member of the Expert Selection Panel for the 1995 Special Round of the Cooperative Research Centres Program (renewable energy)

1991-95: Member of the Board, ACT Electricity and Water Authority.

1984-87: Member of Technical Standing Committee 7 (subsequently 4) (Economic, Social and Environmental Aspects of Energy), National Energy Research, Development and Demonstration Council.

1983: Member of Prices Advisory Committee under the Western Australian Prevention of Excessive Prices Act.

1979-83: Member, Committee EN/1 - Energy Auditing, Standards Association of Australia.

Fellow of the Australian Institute of Company Directors.

Fellow of the Australian Institute of Energy; Canberra Group Committee member, 1982-83, 1995-; Canberra Group representative on National Council, 1983.

Member, International Association of Energy Economists.

SELECTION OF CONSULTANCY ACTIVITIES UNDERTAKEN WITH ENERGY STRATEGIES (incomplete)

Development of methodology for energy related components of the National Greenhouse Gas Inventory and compilation of inventories for successive years.
Analysis of the potential impact of greenhouse gas emission abatement measures and projections of longer term trends in Australian emissions.
Energy sector member of expert teams reviewing national greenhouse gas inventories on behalf of the UNFCCC Secretariat.
Preparation of *A Clean Energy Future for Australia*, a major back-casting scenario study of demand, supply and greenhouse gas emissions from the stationary energy sector in 2040.
Advice on the development and assessment of options for the effective implementation of a mandatory renewable electricity target.
Preparation of a comprehensive life cycle analysis model and spreadsheet calculator for estimating greenhouse gas emissions from the production of fuel ethanol from molasses.
Identification and analysis of policy initiatives, both nationally and internationally, designed to facilitate increased uptake of cogeneration
Comprehensive review of the ACT Greenhouse Strategy.
Estimation of emissions abatement resulting from State and Territory actions under the National Greenhouse Strategy.
Preparation of a strategy for the implementation of an integrated sustainable energy program for the facilities of Biosphere-2, Arizona, USA.
Preparation of draft energy and greenhouse guidelines for use under the NSW Environmental Impact Assessment Act.
Preparation of workbooks for the Greenhouse Challenge Program;
Preparation of workbooks for CDM and JI projects for the International Greenhouse Partnerships Office
Development of indicators for the National Greenhouse Strategy
Provision of expert advice to the World Bank on the implementation of national strategy studies on CDM in various Asian countries

Projections of emissions from fugitive energy and analysis of policies for the mitigation of emissions from coal mine methane
Identification and analysis of policy initiatives designed to facilitate increased uptake of cogeneration
Provision of policy analysis and advice relating to various energy sector greenhouse gas emission reduction programs
Provision of advice on emissions and preparation of greenhouse gas inventories for a variety of organisations and projects in Australia and overseas
Management of the Sustainable Energy Industry National Survey
Management and delivery of the ACT Energy Advisory Service
Administration of the IEA cooperative programs CADDET and GREENTIE in Australia;
Production of text and oversight of production for *Australian Energy News*.

CONSULTANCY EXPERIENCE WITH ECONOMIC AND ENERGY ANALYSIS

Responsible for developing the company's expertise and undertaking consultancies in three broad areas.

(1) Energy, environmental and industry economics and policy: Electricity economics, mining and the environment, energy and the environment (including the greenhouse effect), efficient supply and use of energy, national energy policy, energy RD&D, new energy technologies, development assistance projects in the energy and minerals sector, including evaluation of government programs in many of these fields.

(2) Petroleum policy and pricing: Public policy development and implementation in relation to the petroleum product market and the pricing, supply and distribution of petroleum products.

(3) Fuel procurement and management for major transport operators and other large participants in the oil market: Comprehensive services including monitoring market developments, preparation of fuel tender documents, appraisal of tenders, client support in contract negotiations, contract administration and implementation of fuel management information systems.

EARLIER CONSULTANCY EXPERIENCE

While working in Europe, studies on the environmental and social costs of transport in Britain, of the costs and benefits of alternative sites for the third London airport, of the impact of a Channel tunnel on demand for cross-Channel car ferry services, of the effects of regional airports in stimulating industrial development in Europe, and of factors affecting the location of heavy process industries in north west Europe, with special reference to environmental pollution and implications for the further development of Rotterdam.

RESEARCH EXPERIENCE

1977-82. Research on various aspects of energy policy and related topics, including the following:

Analysis of the types of energy using processes employed by the major energy intensive industries in Australia
Study of various project aspects of petroleum industry policy in Australia at the Commonwealth and State Government level, including:
  the overall policy framework,
  policies relating to petroleum exploration and production,
  the process of technological change in oil refining from 1970;
A study of the costs and benefits of using lead in petrol in Australia;
Examination of the evolution of energy research and development policy in Australia;
Study of political decision making and policy development relating to uranium mining in Australia;
Review of the effectiveness of public inquiries on issues relating to technology and to the energy-environment interface.
Analysis of the retail demand for electricity in Tasmania and the projection of future demand.
Assessment of the costs and benefits of the proposed lower Gordon and Franklin Rivers hydro-electric power development.
A study of the economics of electricity supply in Tasmania.

Analysis of factors responsible for changes in costs experienced by the Australian electricity supply industry over the decade 1973-83.
Research for and writing of a book on Australian energy policy.

1974-75. Study of the economic and technical feasibility of converting plant material (crops and wastes) to synthetic liquid and gaseous fuels in Australia.

1966-69. Study of ionic regulation in the marine alga Acetabularia, involving measurement of radio-isotope tracer fluxes, membrane potential and resistance under various conditions.

1965-66. Study of ionic regulation in beetroot and barley root cells, using radio-isotope tracer flux and electric potential measurements.

1965. Design, construction and use of apparatus using the heat gradient method to measure the rate of flow of sap in plant stems.

TEACHING EXPERIENCE

1977-. Occasional lectures on energy, technology and environmental topics to undergraduate courses in Biochemistry, Human Sciences, Zoology and Politics and postgraduate courses in Resource and Environmental Studies, Administrative Studies and Public Policy at the Australian National University, to the undergraduate courses in Physics and Natural Resources at Canberra C.A.E. and to the undergraduate course in Government at Sydney University.

1975-76. A course on Economic Botany for second year biology students at Sydney University, dealing with physical and social factors influencing crop production and the nature of the world food crisis.

1969-. Numerous talks, lectures and research seminars to community groups, professional bodies, trades unions, school students, university students and scientific conferences in Australia, the U.K., the U.S.A., France, Brazil and Papua New Guinea.

PUBLICATIONS

The following list does not include numerous articles and opinion pieces published in newspapers and magazines, including the *Sydney Morning Herald*, the *Australian Financial Review* and the *Canberra Times*.

Books, journal articles etc.

Saddler, H. 2003. "Greenhouse policy – Implications for buildings and building designers". *Environment Design Guide*, May 2003, Royal Australian Institute of Architects, Melbourne.

Saddler, H. 1996. "Greenhouse policies and the Australian energy supply industries", in W. Bouma, G. Pearman and M. Manning (eds.), *Greenhouse: coping with climate change.* CSIRO, Melbourne.

Saddler, H., 1994. "Using energy efficiently in buildings and industry", in S. Dovers (ed.), *Sustainable energy systems: pathways for Australian energy reform.* Cambridge University Press, Melbourne.

Saddler, H., 1993. "Greenhouse gas emission abatement in Australia", in P. Hayes and K. Smith (eds.), *The global greenhouse regime: Who pays?*. United Nations University Press, Tokyo and Earthscan, London.

Contributor to Tolba, M. and O. El-Kholy (eds.), 1993, *The world environment 1972-93: Two decades of challenge*. Chapman and Hall and United Nations Environment Program, London.

Saddler, H. 1987. "Minerals and Energy Statistics", in Vamplew, W. (ed.), *Australian Historical Statistics*, Volume X of *Australians: A historical library*. Fairfax, Syme and Weldon, Sydney.

Donnelly, W. and H. Saddler, 1984. "The retail demand for electricity in Tasmania". *Australian Economic Papers* **23** (No. 42), 52-60.

Saddler H., 1983, 1988, 1995. Articles on "Electrical Energy", "Energy", "Oil and Gas", "North West Shelf" in the fourth, fifth and sixth editions of the *Australian Encyclopaedia*.

Saddler, H. and J. Kelly, 1983. "Australia's uranium decision: a case study in the politics of mining", in W. Richmond and P. Sharma (eds.) *Essays on mining in Australia*, Brisbane, University of Queensland Press.

Saddler, H., 1981. *Energy in Australia: politics and economics*. Sydney, George Allen & Unwin Australia.

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Saddler, H. and A. Ulph, 1980. "Liquid fuels: present situation and future prospects for Australia", in T. Van Dugteren (ed.) *Oil and Australia's future*, Sydney, Hodder and Stoughton.

Saddler, H., 1980. "The implications of the battle for the Alligator Rivers: land use planning and environmental protection", in R. Jones (ed.) *Northern Australia: Options and Implications*, Canberra, Research School of Pacific Studies, ANU.

Saddler, H., 1980. "Australian uranium: the environmental issues", in S. Harris and K. Oshima (eds.) *Australia and Japan: nuclear energy issues in the Pacific*, Canberra and Tokyo, Australia-Japan Economic Relations Project.

McCann, R. and H. Saddler, 1976. "Photobiological energy conversion in Australia", *Search* **7**, 17-23.

McCann, R. and H. Saddler, 1976. "The utilisation of cereal straw: a scenario evaluation", *J. Aust. Inst. Ag. Sci*, March 1976, 41-47.

Saddler, H., R. McCann and M. Pitman, 1976. "An assessment of crop production for energy in Australia", *Aust. Forestry* **39**, 5-15.

Saddler, H., 1971. "Spontaneous and induced changes in the membrane potential and resistance of *Acetabularia mediterranea*". *J. Membrane Biol*. **5**, 250-60.

Saddler, H. and Pitman, M., 1970. "An apparatus for the measurement of sap flow in unexcised leafy shoots". *J. Exp. Bot*. **21**, 1048-59.

Saddler, H., 1970. "Fluxes of sodium and potassium in *Acetabularia mediterranea*", *J. Exp. Bot*. **21**, 605-16.

Saddler, H., 1970. "The membrane potential of *Acetabularia mediterranea*", *J. Gen. Physiol*. **55**, 802-21.

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Pitman, M. and Saddler, H., 1967. "Active sodium and potassium transport in cells of barley roots". *Proc. Nat. Acad. Sc*. **57**, 44-49.

Other published papers

Saddler, H., F. Muller and C. Cuevas, 2006. *Competitiveness and carbon pricing: border adjustments for greenhouse policies*. Australian Institute Discussion Paper Number 86, Canberra.

Saddler, H. 2005. "Sustainable energy" in *Sustainability for the ACT: the future's in our hands*, Canberra, Office of Sustainability, ACT Government.

Saddler, H. 2005. *National Academies Forum: Internet forum on integrated sustainability assessment Response to Energy Systems paper by Ian Lowe*. http://www.naf-forum.org.au/papers.asp.

Saddler, H., C. Riedy and R. Passey, 2004. *Geosequestration: what is it and how much can it contribute to a sustainable energy policy for Australia*. Australian Institute Discussion Paper Number 72, Canberra.

Saddler, H., 2003. "Australia's energy choices", *Dissent* 13 (Summer 2003/2004), 41-42

Saddler, H., 2003. "What happens to oil during war", *The Diplomat* **1** (6), 36-37.

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Turton H., J. Ma, H. Saddler and C. Hamilton, 2002. *Long-term greenhouse gas scenarios*. Australia Institute Discussion Paper Number 48, Canberra.

Saddler, H. 2001 "Greenhouse gas emissions trading: a way forward", *ASX Perspective, Australian Stock Exchange magazine*, 1st Quarter 2001,Sydney.

Saddler, H. 1998. "Emissions trading – you can trade only what you can measure", *Engineering World*, August/September 1998 Sydney, 12-17.

Hamilton, C. and H. Saddler, 1997. *The genuine progress indicator: a new index of changes in well-being in Australia*. Australian Institute Discussion Paper Number 14, Canberra.

Wilkenfeld, G., C. Hamilton and H. Saddler, 1995. *Australia's greenhouse strategy: can the future be rescued?* Australian Institute Discussion Paper Number 3, Canberra.

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McCann, R. and Saddler, H., 1975. "A cassava-based agro-industrial complex - a new industry for Australia?", *Process and Chemical Engineering*, April/May 1975.

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1994. *Coal and climate change: opportunities for Australian industry to contribute to reducing international greenhouse gas emissions.* Department of Primary Industries and Energy, Canberra.

1994. *Solar and heat pump hot water systems: considerations for proposed financing program*. Energy Research and Development Corporation, ERDC 94/215, Canberra.

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1983. *Petrol pricing and related matters in Western Australia*. Department of Consumer Affairs, Perth.

1980. *An oil strategy for Australia*. TNC Energy Group, Oil Industry Project Reportback No. 2, TNC, Sydney.

Conference papers

Saddler, H., F. Muller and C. Cuevas, 2005. *Providing a carbon price signal while preserving economic competitiveness; practical options for Australia*. Greenhouse 2005 Conference, Melbourne, November 2005.

Saddler, H. 2003. *National emissions trading: constraints and requirements*. Presentation to National Emissions Trading Policy Workshop, sponsored by the Victorian Department of Sustainability and Environment, Melbourne, April 2003.

Saddler, H. and J. Ma 2002. *Industrial sector.* Paper presented to invited workshop on Energy efficiency: the potential for improvements and policy options, Canberra, December 2002.

Saddler, H. 2000 *Future directions for measuring and reporting greenhouse gas emissions*. Environmental Management in Oil and Gas conference, Fremantle September 2000.

Saddler, H. 1999 *Projections for the world population, economy and energy demand to 2050: implications for greenhouse gas emissions*. Seminar presented by the Australian Academy of Technological Sciences and Engineering, Western Australian Division, Curtin University November 1999.

Saddler, H. 1999 *Greenhouse gas emission trading: an introduction.* National Environmental Law Association Conference, Sydney September 1999.

Saddler, H. 1999 *Greenhouse gas emissions trading: options for issuing permits.* Emissions Trading Forum, Sydney August 1999.

Saddler, H. 1999 *The impact of greenhouse policies in the electricity supply industry – challenges and opportunities.* Third Annual Queensland Power Conference, Brisbane May 1999.

Saddler, H. 1999 *How can generators benefit from emissions trading?* National Summit on Power Generation, Surfers Paradise, February 1999.

Saddler, H., 1998. *Emission measurement requirements to support emissions trading*. Emissions Trading, IBC Conferences, Sydney, June 1998.

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Smith, B. and H. Saddler, 1982. *Substitution of non-exhaustible resources for fossil fuel energy and industrial raw material resources*. Proceedings of 12th Pacific Trade and Development Conference, Vancouver, 1981.

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McCann, R., Saddler, H. and Prince, R., 1976. *The efficient processing of photobiological material*. Annual Engineering Conference, Engineering 1976-2001, Institution of Engineers, Australia, Canberra.

Appendix 3

The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)

Available at: http://www.ghgprotocol.org/

(original in colour)

Appendix 4

AGO Factors and Methods Workbook (December 2006)

Available at:

http://www.greenhouse.gov.au/workbook/pubs/workbook2006.pdf