THE ECONOMIC IMPACT OF REDUCING GREENHOUSE GAS EMISSIONS IN WA

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Abstract

This study analyses the general-equilibrium impacts of a number of possible allocation schemes for greenhouse gas emission permits on the Western Australian economy. It finds that emissions would fall by up to 11 percent from the base level in Western Australia. However, such environmental benefits emanate at some costs to the state economy; in terms of foregone gross state product, the costs are up to 3 percent of the base level. Indeed, the actual costs and benefits depend on the precise design of the permit allocation scheme as well as on the policies within which it operates. For example, when emission quota permits are sold to industries and no tradeable carbon credits (i.e. credits for the carbon sequestrated in Kyoto forests) are granted, emissions decline by about 8 percent and GSP falls by about 3 percent of the base levels. If carbon credits are tradeable, however, the environmental benefits could be increased and the GSP-cost could be reduced substantially. Also, the reduced economic activity caused by emission abatement results in a modest fall in net government revenue, despite the additional revenue from permit sales in some cases. Accordingly, government's fiscal package surrounding the emission permits would influence the emission abatement impacts on the economy. With regard to the effects on the structure of the state economy, the Oil & gas industry suffers only a slight contraction but the energy-supplying sector as a whole contracts substantially. It is therefore not surprising that the impacts on the WA economy of curbing emissions by energy and transport industries alone are quite significant when compared to those resulted from all industries' compliance with the abatement scheme.

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1. Introduction

In December 1997 at Kyoto, the parties to the United Nations Framework Convention on Climate Change signed an agreement, popularly known as the Kyoto Protocol, whereby the developed countries (listed in Annex B of the Protocol) agreed to reduce collectively their greenhouse gas (GHG) emissions to at least 5 percent below 1990 levels over the period 2008 to 2012. For Australia, however, it was agreed that GHG emissions had to be no more than 108 percent of the 1990 level. According to the Australian Greenhouse Office (2000), in 1998 Australia already emitted about 17 percent above the 1990 level. Recognising the difficulty of meeting the Kyoto targets, the treaty includes some market-based provisions known as the "flexibility mechanisms", one of which is the international trading of GHG emissions rights.[1] If implemented, these provisions are expected to reduce the global costs of emission abatement significantly by shifting the cuts to regions/countries where they are the cheapest. While the signatories have agreed in principle on the provisions, the array of technical issues involving the principles and operational guidelines for the schemes are a subject of intense, ongoing negotiations. This is particularly so for emission trading. The Australian Government will not implement a mandatory domestic emission-trading scheme unless the Kyoto Protocol is ratified by Australia and an international emission-trading regime has already been established.

Available estimates for Australia show that the introduction of an emission-trading regime would inflict substantial costs on the economy in terms of lost output and employment opportunities (see, e.g., Brown *et al.*, 1999, and Allen Consulting, 2000). As for the Western Australian economy, which relies much more on the energy-intensive resource-based industries than any other state, it is highly likely that the costs of the emission-trading scheme will be quite substantial. The objective of this study is to carry out a systematic analysis of the likely effects of a number of possible emission-trading scenarios on the WA economy.

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1 In addition to emission trading, the Kyoto provisions include a "clean development" mechanism that would allow industries in the Annex B countries to earn credits for emission-lean investment projects in poor countries, and a "joint implementation" scheme that would award credits for projects carried out jointly with Annex B countries.

2. The Analytical Framework: An Economy-Wide Perspective

To analyse the impacts on the economy of emission-trading schemes, the study employs an economy-wide framework that captures the specific structure of the WA economy and its salient features. This approach takes into account the inter-industry linkages and recognises that the structure of the WA economy differs significantly from that of the national economy due to the export-orientation of WA and the substantial role of the minerals and energy sectors. A computable general equilibrium model for WA, called WAE, has been developed at the UWA Economic Research Centre.[2] WAE is a single-region, multi-sectoral model of the state economy. The theoretical structure of the model is similar to that of ORANI (Dixon *et al.*, 1982), except that ORANI refers to Australia as a whole. Not only does WAE capture the specific interdependencies among WA industries, it also takes into account the behavioural responses of various economic agents to particular policies, as well as capturing the important links between energy markets and factor markets. More specifically, the model incorporates explicitly the decisions made by producers and consumers, embodies relevant government policies, allows substitution between energy and primary factors of production, and recognises the constraints the economy confronts, such as limited supplies of the factors of production.

WAE has 105 industries, each of which produces a commodity (or commodities) combining capital, labour, energy and materials according to a given production technology. The technology specifies that each of the non-energy material inputs is used in a fixed proportion to the level of output. However, the technology does allow for substitution between various forms of energy as well as between energy and primary factors. Appendix 1 presents further details on the technologies. All producers face competitive markets and minimise their costs of production. WAE considers consumers who own primary factors, and a consolidated government which collects revenue and spends on current consumption. The pattern of household consumption is based on the assumption of utility maximisation. All goods are distinguished according to their source of supply, WA and non-WA, and locally-sourced goods are treated as imperfect substitutes for imports. At the core of WAE

[2] The major economic studies of greenhouse gas abatement in Australia all use computable general equilibrium models of one form or the other (see, e.g., Brown *et al.*, 1999, Allen Consulting, 2000, and McKibbin, 1999).

are (i) input demands by industries and their commodity supplies; (ii) demands for commodities by households and government; (iii) the external sector comprising imports into and exports from WA; and (iv) greenhouse gas emissions by industries and households.

The WAE equations are expressed in terms of percentage changes of the variables and involve numerous shares (mostly revenue and cost shares) and elasticities. The model uses the 1992/93 input-output table for Western Australia (Islam and Johnson, 1997) to calculate the shares. The inter-fuel and fuel-factor substitution elasticities are carefully chosen from the existing literature and are presented in Figures A.1 and A.3 in Appendix 1. The values for other elasticities are adapted from Ahammad and Islam (1999), Dixon *et al.* (1982) and Ye (1998).

3. Greenhouse Gas Emissions in WAE

The WA model includes anthropogenic emissions (and sinks) of greenhouse gas (GHG) from fossil fuel combustion (i.e., burning of fossil fuels such as coal, oil, natural gas and petroleum products) and due to mining, agricultural and cement production (referred to as "fugitive" emissions). The anthropogenic GHG emissions arise from both production and consumption processes.[3] It is assumed that production activities in WAE generate both combustion and non-combustion emissions while residential consumption emits GHGs through the combustion of fossil fuels only. WAE considers the three major GHGs, namely, carbon dioxide, methane and nitrous oxide.[4] All GHGs are expressed in a common greenhouse unit, called CO_2-equivalent, on the basis of their global warming potential (GWP).[5]

For each of the 105 individual industries, WAE accounts for the GHGs emitted from fuel combustion as well as for fugitive emissions. For each fuel type, the

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3 Emission estimates from "land clearing" (i.e. forest and grassland conversion) are highly uncertain (NGGIC, 1998) and hence are excluded from this study.

4 Other GHGs -- namely, hydroflurocarbons, perfluorocarbons, sulphur hexafluride, carbon monoxide, oxides of nitrogen and non methane volatile organic compounds -- are insignificant for WA or do not have any global warming potential and hence are not considered.

5 GWPs of individual gases vary over the time horizon under consideration. For policy analysis, typically a 100-year time horizon is considered. The values of parameters which convert the GHGs into their CO_2-equivalent are based on Houghton *et al.* (1996).

emissions from fuel combustion are expressed as the product of (a) the amount of the fuel used, (b) an emission coefficient and (c) a CO_2-conversion factor. Non-combustion emissions, which only result from the production activities, are taken to be directly proportional to the output of the industries. In what follows, we set out the modelling procedures in details.

Let E^C_{gej} denote the volume of GHG of type g emitted from the combustion (the superscript C stands for "combustion") of fossil fuel e by industry j, and X_{ej} represent the amount of fuel of type e used in industry j. We can then write $E^C_{gej} = \mu_{gej} X_{ej}$, where μ_{gej} is the non-negative factor of proportionality (i.e., the emission intensity) for GHG of type g in relation to the e type fuel used by industry j. We define the volume of GHG g originating from the useage of all various fuels in industry j as $E^{C/}_{gj} = \sum_e E^C_{gej} = \sum_e \mu_{gej} X_{ej}$. The volumes of different GHGs cannot be added together without expressing them in a common greenhouse unit, the CO_2-equivalent. Let the CO_2-equivalent of $E^{C/}_{gj}$ be denoted by E^C_{gj}, so that $E^C_{gj} = \omega_g E^{C/}_{gj}$, where ω_g is the non-negative GWP for GHG of type g.[6] In CO_2-equivalent terms, the gross emmisions from fuel combustion in industry j, denoted by E^C_j, can therefore be measured as

$$(1) \qquad E^C_j = \sum_g E^C_{gj} = \sum_g \omega_g E^{C/}_{gj} = \sum_g \sum_e \omega_g \mu_{gej} X_{ej},$$

where the variables and parameters are as defined before.

As regards the fugitive (i.e., non-combustion) emissions by industry j, the CO_2-equivalent is given by

$$(2) \qquad E^F_j = \sum_g \omega_g \mu_{gj} Y_{\bullet j},$$

6 Note that while the emission intensities, μ_{gej}, vary across industries, the GWPs of individual GHGs, ω_g, do not depend on the emitting industry, so that these coefficients do not have an industry subscript j.

where E_j^F denotes the volume of fugitive emissions (the superscript F denotes "fugitive") by industry j, in CO_2-equivalent terms; ω_g, as before, denotes the GWP of gas g; μ_{gj} denotes the fugitive-emission intensity for gas g in industry j; and $Y_{\bullet j}$ denotes the aggregate level of output produced by industry j. Equations (1) and (2) added together determine the total emissions (fuel-combust plus fugitive) by industry j. However, we define industry j's net emissions as

$$(3) \qquad E_j = E_j^C + E_j^F - O_j ,$$

where O_j denotes the amount of offsets in CO_2-equivalent terms generated by industry j.

Residential emissions (all from fuel combustion activities) are modelled as proportional to the amount of fuels consumed (representing the emission intensities in household consumption) and are expressed in CO_2-equivalent terms by using the relevant GWPs; i.e.,

$$(4) \qquad E^H = \sum_g \sum_e \omega_g \mu_{ge} X_e^H ,$$

where E^H denotes the volume of emissions by households (from fuel combustion), in carbon dioxide equivalent terms; ω_g, as before, denotes the GWP of gas g; μ_{ge} denotes the residential emission intensity for gas g associated with the combustion of fuel e; and X_e^H denotes the amount of fuel e consumed by households.

Using equations (3) and (4) above, we can define the GHG emission function for the economy as a whole in CO_2-equivalent terms, denoted by E, as

$$(5) \qquad E = \sum_j E_j + E^H .$$

Under the Kyoto agreement, the level of total emissions has been set for Australia. If domestic emissions exceed the limit set under the Kyoto Protocol, the excess must be met through one or a combination of the Kyoto "flexible mechanisms". Accordingly, the non-residential emission restriction on the economy can be specified as

$\Sigma_j E_j = \overline{E} + E^T$, where $\overline{E}$ is the volume of non-residential emission quota set under the Protocol; and E^T is the amount of emissions over an above the quota that is to be obtained through the flexible mechanisms including the international emission trading. Although nothing has yet been decided as to the way the national emission quota is to be allocated across industries in Australia, for emission modelling purposes we adopt the following approach. Let $\overline{E}_j$ denote the quota assigned to industry j by the government, so that this industry's emission restriction can be written as

$$(6) \qquad E_j = \overline{E}_j + E_j^T .$$

The last term in equation (6), E_j^T, denotes the amount of emissions traded in the emission market by industry j.

It is assumed that the WAE industries internalise the costs of GHG emissions and that households do not pay directly for the residential emissions.[7] For industry j, we define the effective price of emission, P_j^E, as follows: Let α_j denote the j[th] industry's proportion of the total emissions accounted for by the industry specific quota, i.e., $\alpha_j = \overline{E}_j / E_j$. The effective price of emissions (per tonne of CO_2-equivalent) for industry j can then be defined as $P_j^E = \alpha_j P^{\overline{E}} + (1-\alpha_j)P^T$, where $P^{\overline{E}}$ is the price per unit of emission quota in Australia and P^T is the market price of emission. One obvious possibility is the free allocation of emission quotas among industries, i.e., $P^{\overline{E}} = 0$, in which case the above equation reduces to $P_j^E = (1-\alpha_j)P^T$, so that the effective price of emission for industry j depends on its proportion of total emissions purchased from the open market, $(1-\alpha_j) = E_j^T / E_j$, and the market price for emissions, P^T. With emission costs internalised, the zero-profit condition for industry j is[8]

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7 However, indirectly households pay to the extent effected through changes in commodity prices resulting from the internalisation of emission costs by industries.

8 The assumptions of profit maximisation by industry j facing a CRS production technology and perfectly competitive markets assure zero normal profits.

$$(7) \qquad \sum_{i=1}^{g} P_i^O Y_{ij} = \sum_{i=1}^{g} \sum_{s=1}^{2} P_{ij}^{Is} X_{ij}^{Is} + \sum_{m=1}^{3} P_j^{Fm} X_j^{Fm} + P_j^E E_j ,$$

where Y_{ij}, X_{ij}^{Is} and X_j^{Fm} are the quantity variables representing the output i (i = 1, …, g) produced by industry j, the (energy and non-energy) intermediate input i (i = 1, …, g) from source s (s = 1, 2, representing local and foreign sources) used by industry j and the primary factor m (m = 1, 2, 3, representing labour, capital and land) employed by industry j; and P_i^O, P_{ij}^{Is} and P_j^{Fm} represent the corresponding price variables; the upper-case superscripts to the above variables, i.e., O, I and F denote output, intermediate input, and primary factor, respectively.[9] Accordingly, the term on the left-hand side of equation (7) represents industry j's total revenue, while the three terms on the right-hand side represent that industry's costs for materials, primary inputs and net emissions, respectively.

Note that, with a non-zero effective price for emission, the last term on the right-hand side of equation (7) represents a tax on (subsidy to) industry j if its net GHG emission is positive (negative). Furthermore, an industry in WAE can reduce its emissions through price-induced substitutions between energies and primary factors, as well as through adjusting its production levels. For example, the electricity industry may use more energy from natural gas and less from coal, and thereby reduce the emissions of GHGs. However, WAE does not allow for emission-saving technological invention. In other words, it is not possible for a WAE industry to switch to new technologies that will enable it to reduce GHG emissions per unit of energy (say, natural gas) used.

One of the many thorny issues in the Kyoto Protocol relates to the awarding of tradeable credits for the carbon sequestrated in Kyoto forests ("carbon credits" for short). As new and growing plants absorb carbon from the atmosphere and hold on to it for a long time, the advocates for carbon credits argue that afforestation, reforestation or reduced deforestation will cut a country's net emissions and therefore deserve credits. This also applies to changes in land usage. While the rules and methodologies governing the awarding of such credits are far from being finalised, we have included mechanisms into WAE to allow for the possibility of carbon credits for

9 The variable denoting output price, P_i^O, does not have an industry subscript as the producer's price of good i is assumed to be the same irrespective of the industries that produce it.

Kyoto forests, in which case the last term on the right-hand side of equation (7) for j = the forestry industry, $P_j^E E_j$, measures a subsidy to that industry.

We have developed the emissions database for WAE using as the starting point the GHG inventory for WA prepared by the Australian Greenhouse Office (NGGIC, 1998). The database refers to 1992/93 and consists of three emissions matrices for WA corresponding to the three major GHGs -- carbon dioxide, methane and nitrous oxide.[10] For each WAE industry, the matrix shows fugitive emissions and sinks, as well as emissions from combustions of various types of fossil fuels. For some details of the emissions data, see Appendix 1.

4. The WAE Simulations

We use the WAE model to carry out a number of simulations representing two emission-trading scenarios. The two scenarios are labelled "permit sales" and "grandfathered permit allocations". According to "permit sales", the government sells permits for 108 percent of 1990 emissions in line with Australia's "assigned amount" under the Kyoto Protocol. As Australia is a small emitter, with the international emission trading scheme in operation, the permit price will not exceed the international price of emissions. Based on the available estimates (e.g., Allen Consulting, 2000), it is assumed that industries in Western Australia pay $35 per tonne of CO_2-equivalent GHGs emissions. We consider the permit-sales case under alternative assumptions regarding carbon credits (i.e., credits for the carbon sequestrated in Kyoto forests) and the position of the government budget. On the other hand, "grandfathered permit allocations" imply that industries receive free tradeable permits for 108 percent of their 1990 emissions (or 35 percent less than their projected "business as usual" emissions) while to cover the total emissions they would purchase additional permits in the market at a price of $35 per tonne of CO_2 equivalent. We again assume that the $35 price of emission is set by the international emission trading scheme.

[10] The year 1992/93 is chosen because the most recent input-output table for WA, which forms the database of WAE, is also for 1992/93.

Essentially, the above refers to four different simulations, a brief description of which follows:

Simulation 1 represents a sales scheme of emission permits, under which each industry pays $35 per tonne of CO_2-equivalent GHG emissions. The scheme is assumed to allow the trading of credits for the carbon sequestrated in Kyoto forests. It is stipulated that such credits will be granted for plantation forests only.

Simulation 2 represents a program similar to that in Simulation 1 in terms of permit sales and carbon credits. However, it is now assumed that government maintains its previous budgetary position through lump-sum transfers to households. Accordingly, the additional revenue received from permit sales results in additional transfers back to households. Additionally, if the sales scheme results in a downturn in economic activity which causes net government revenue to fall, in order to maintain fiscal neutrality, lump-sum transfers to households fall.

Simulation 3 is equivalent to Simulation 1 but without any carbon credits for Kyoto forests.

Finally, simulation 4 represents a grandfathered allocation program. Here each industry receives free permits equal to 65 percent of its base-level emissions and can then purchase additional permits at $35 per tonne of CO_2-equivalent. While different industries are allocated differentiated targets (determined by base-level emissions), they can purchase or sell as many emission permits as they like at the price of $35 per tonne under this regime.

The simulations discussed above are based on the assumption that all industries take part in the emission abatement scheme. Often, the energy-supplying and transport industries are singled out as among the worst GHG emitters in an economy. This is also true for WA (see Figures A.4 and A.5), where these industries account for about 60 percent of the net emissions in CO_2-equivalent terms.[11] In order to isolate

[11] In this study, energy-supplying industries include Coal mining, Oil & gas mining, Petroleum & coal products manufacturing, Electricity supply, and Gas supply, and transport industries include all types of transports -- air, rail, road and water.

the impacts on the WA economy of only energy and transport industries' compliance with the emission abatement scheme, we have carried out some further analysis. We assume that only these industries pay $35 for each tonne of GHG emitted and other industries pay nothing. The purchase of emission permits does increase the costs of production for the energy and transport industries and these industries may or may not opt to contract their levels of output. Accordingly, two simulations labelled "Response 1" and "Response 2" are carried out. It is also assumed that in both these simulations, there are no carbon credits so that the situation corresponds to the one underlying "Simulation 3" above.

All the above simulations are carried out in an economic environment characterised by an unchanged nominal exchange rate and given nominal wages. This broadly agrees with the workings of Australia's federal system whereby the exchange rate and wages for WA are largely determined by the rest of Australia. It is also assumed that no autonomous changes occur in consumers' demands (due to, for example, changes in tastes and attitudes), or in investment expenditure. Except for Simulation 2, government policies with regard to tax rates are also assumed to remain unchanged.

Before turning to the results, it is appropriate to discuss briefly their interpretation. The simulations refer to how the economy is likely to change, relative to the base level, as a result of the introduction of the relevant permit allocation scheme. All other factors which could affect the economy (e.g., population growth, productivity enhancement, unforseen national and international events, etc.) are held constant. The results, which are expressed as percentage differences from base levels, can be thought to represent deviations from what otherwise would happen provided no new shocks impact on the economy. Accordingly, the results are to be understood to be *ceteris paribus* and not unconditional forecasts.

5. The Results

Table 1 summarises the distinguishing features of the first four simulations discussed above, and presents the key simulation results. As can be seen, WA's total emissions fall by 3 to 11 percent of the base level, depending on the assumptions about the particular permit allocation scheme, carbon credits and what happens to the government budget. The reduction in emissions represents a benefit to environment. However, the costs of the emissions abatement, in terms of the foregone gross state product (GSP) and consumption, are not insignificant. GSP falls by 1 to 3 percent, while consumption declines by 2 to 6 percent. By way of comparison, the recent study by Allen Consulting (2000) projects a 3 percent decline in WA's GSP. Given the differences between WAE and the model used in the Allen Consulting (2000) study, it is difficult to make a precise comparison of our results with those of the Allen study. However, roughly speaking, Simulation 3 in this study comes close to Allen's adopted approach and projects a fall in GSP by about 3 percent as well.

As already pointed out, the actual impacts of emission abatement schemes depend on the precise design of the permit allocation scheme, granting of tradeable carbon credits as well as on government's fiscal engineering. For example, under the grandfathered allocation program, which essentially represents a situation underlying Simulation 3 but with industries now being given back dollar-for-dollar all the government's proceeds from the sales of permits, the contraction of the economy can be substantially dampened (columns 3 and 4). However, this would mean a smaller reduction in GHG emissions than otherwise (emissions would fall by 3 percent, rather than 8 percent). Also, granting tradeable credits for the carbon sequestrated in Kyoto forests not only enhances the environmental benefits (in terms of reduced emissions), it also reduces the costs to the economy significantly. This can be seen by comparing columns 1 and 3 of Table 1. Column 3 indicates that with no tradeable carbon credits, emissions fall by about 8 percent and GSP by about 3 percent. For column 1, with tradeable credits but the other assumptions the same as before, now emissions fall by more, 11 percent, and GSP by less, 2 percent. This is not surprising because tradeable carbon credits are equivalent to a subsidy to the forestry sector, which causes the sector to expand substantially, and hence contribute more to GSP. Finally, with regard to government budget, if the base-year budgetary surplus is to remain unaltered, the costs to the economy are slightly more than otherwise (see columns 1 and 2). This is because the emission abatement policy leads to an overall contraction of economic activity, which causes a decline in net government revenue in spite of the

TABLE 1

EFFECTS OF PERMITS ALLOCATION SCHEMES ON WA

	Simulation 1 (1)	Simulation 2 (2)	Simulation 3 (3)	Simulation 4 (4)
Key assumptions				
1. Emission allocation scenarios[a]	Permit sales	Permit sales	Permit sales	Grandfathered allocation
2. Carbon credits[b]	Granted	Granted	Denied	Denied
3. Gov. budget surplus	Adjusts	Maintained	Adjusts	Adjusts
Key results (%)[c]				
Macroeconomic				
GSP	-1.87	-2.07	-3.10	-1.09
Consumption	-4.54	-5.16	-5.88	-2.07
CPI	-2.50	-2.91	-3.52	-1.23
Employment	-3.51	-3.87	-5.88	-2.07
Exports	-1.73	-1.58	-2.00	-.70
Imports	-4.32	-4.64	-5.22	-1.82
Emissions	-11.19	-11.20	-8.02	-2.80
Selected sectoral output[d]				
Energy				
Coal	-5.85	-5.84	-6.50	-2.27
Oil & gas	-.26	-.26	-.28	-.10
Petro & coal prod.	-8.75	-8.94	-9.76	-3.41
Electricity	-5.67	-5.69	-5.75	-2.01
Gas supply	-18.41	-18.55	-19.25	-6.74
Total	-4.40	-4.45	-4.67	-1.64
Transport	-4.45	-1.31	-1.58	-.55
All industries	-2.49	-2.65	-3.73	-1.31

Notes:
a. Wherever it applies, the price per tonne of CO_2-equivalent emissions is set at $35.
b. Wherever applies, the tradeable carbon credits are granted for plantation forests only, which account for approximately 5 percent of the Forestry and logging industry in WAE.
c. The simulation results are expressed as percentage deviations from the base case.
d. The shares in GSP of the energy sectors are: Coal .4 percent, Oil & gas 6.4 percent, Petroleum & coal products .3 percent, Electricity 2.6 percent, Gas supply .3 percent. The Transport sector comprises air, road, rail and water, and accounts for about 3.1 percent of GSP.

additional revenue from the permit sales. Under such circumstances, for the government to maintain its budgetary surplus, transfers to households must fall, which causes a further contraction in the economy.

Most of the industries in WA seem to contract due to the introduction of the emission-trading scheme. In particular, all the energy-supplying industries contract significantly more than the average for all industries, with the only exception of the Oil & gas industry which is adversely affected but not much. Interestingly, except for Simulation 1, the contraction in transport sector is much less than the industrial average. For further details on sectoral results, see Appendix 2.

6. Further Results

Table 2 presents the results when only energy and transport industries comply with the emission abatement scheme. It can be seen that, when energy and transport industries are able to adjust their own output, the economy-wide impacts of energy and transport industries' compliance with the abatement scheme are anything but modest (column 1); the combined output of energy and transport industries falls by about 3.8 percent which leads to a 1.3 percent decline in GSP and a 7.1 percent fall in emissions; these impacts are quite remarkable particularly in comparison with the corresponding results in column 3 of Table 1. However, the economy-wide effects vary significantly depending on the energy and transport industries' own responses to GHG abatement policy. As columns 1 and 2 of Table 2 show, the economy-wide effects are dampened quite significantly when, in response to the higher costs associated with emission abatement, energy and transport industries choose to keep their outputs unchanged (but rearrange their input mixes).

Another noteworthy feature of the results in Table 2 is that a significant proportion of the overall reduction in GSP in column 1 is due to indirect (or flow-on) effects. As the energy and transport industries together account for about 14 percent of GSP, it follows that the direct effect of a fall in these industries' production of 3.8

TABLE 2

EFFECTS OF RESPONSES OF ENERGY AND TRANSPORT SECTORS TO EMISSION POLICY ON WA

	Response 1 (1)	Response 2 (2)
Key assumptions		
1. Energy & transport sectors' output[a]	Falls by 3.79%	Unchanged
2. Permit costs for energy & transport sectors (% of base-year total costs)[b]	9.07	9.07
Key results (%)[c]		
Macroeconomic		
GSP (real)	-1.33	-.47
Consumption	-3.07	-2.25
CPI	-1.41	-1.62
Employment	-2.64	-1.70
Exports	-.58	.74
Imports	-2.48	-1.06
Emissions	-7.14	-3.37
Selected sectoral output[d]		
Energy		
Coal	-.86	*
Oil & gas	-.28	*
Petro & coal prod.	-7.12	*
Electricity	-5.42	*
Gas supply	-13.80	*
Total	-3.66	*
Transport		
Road	-4.07	*
Rail	-4.02	*
Water	-3.26	*
Air	-4.87	*
Total	-4.10	*
All industries	-1.77	-.41

Notes:
a. The fall in energy and transport output given in row 1 is a projection from WAE.
b. In both cases, the costs of production in the energy and transport sectors rise due to the payments for GHG emissions.
c. The simulation results are expressed as percentage deviations from the base case.
d. The symbol '*' means that the industry output under "Response 2" is held fixed at the base level.

percent would mean a (3.8 × .14) ≈ .53 percent reduction in GSP. The remaining (1.3 -.53) = .77 percent reduction can be thought of as the indirect effects flowing from energy and transport industries' linkages with the rest of the economy. A similar magnitude of indirect effects is projected when the energy and transport industries decide not to cut their own production at all, in which event GSP falls by about .5 percent (column 2).

The simulation results presented in Tables 1 and 2 are based on our preferred set of values for elasticities and parameters of the WA model. In order to examine how sensitive are the simulation results to these values, we have carried out a number of simulations using different values for some key elasticities. For brevity, we report in Table 3 the sensitivity of the results of Simulation 1 in Table 1 (column 1). For convenience, the relevant results of Simulation 1 from Table 1 are reproduced in column 1 of Table 3, with the top three entries of the column representing the preferred values for substitution elasticities underlying the production technologies in electricity and non-electricity industries (see Figures A.1 and A.3). In the remaining three columns of Table 3 we have changed the values of these elasticities, one at a time. First, we have changed the inter-technology substitution elasticity in the electricity industry from a value of .8 to 5.0 which has been chosen from McDougall (1993) and have labelled the simulation "Sensitivity 1". In the simulation labelled "Sensitivity 2", in addition to the above (i.e., changing the value of the inter-technology substitution elasticity in the electricity industry) we have doubled the value of 1.2 for inter-fuel substitution elasticities in non-electricity industries. Finally, we have changed the values of all the three elasticities under consideration -- the values for the inter-technology (in the electricity industry) and inter-fuel (in the non-electricity industries) substitution are set as above and the substitution elasticities between capital and energy composite in the non-electricity industry are doubled from our preferred value of .5.

As can be seen from columns 1 and 2 of Table 3, except for the total GHG emissions, the simulation results seem to be quite sensitive to the degree of ease with which electricity industry can switch from one technology to another in generating electricity -- a six-fold increase in the value of the inter-technology substitution

TABLE 3

SENSITIVITY ANALYSIS WITH RESPECT TO KEY ELASTICITIES

	Simulation 1 (1)	Sensitivity 1 (2)	Sensitivity 2 (3)	Sensitivity 3 (4)
Key elasticity				
1. Inter-technology substitution elasticity in the electricity industry	.8	5.0	5.0	5.0
2. Inter-fuel substitution elasticity in the non-electricity industry	1.2	1.2	2.4	2.4
3. Substitution elasticity between capital and energy composite in the non-electricity industry	.5	.5	.5	1.0
Key results (%)				
Macroeconomic				
GSP	-1.87	-2.97	-2.97	-3.91
Exports	-1.73	-4.47	-4.32	-6.83
Emissions	-11.19	-10.34	-10.73	-18.75
Selected sectoral output				
Energy				
Coal	-5.85	.89	2.71	-6.07
Oil & gas	-.26	-.29	-.28	-.29
Petro & coal prod.	-8.75	-5.57	1.53	-6.76
Electricity	-5.67	-48.95	-61.19	-68.22
Gas supply	-18.41	-19.66	-17.13	-26.37
Total	-4.40	-16.51	-18.68	-22.99
Transport	-4.45	-1.79	-1.85	-2.41
All industries	-2.49	-5.65	-5.81	-7.90

elasticity leads to an approximately eight-fold decrease in electricity supply and a two-fold decrease in the total production of the economy. Surprisingly, the inter-fuel substitution elasticity in the non-electricity industries does not seem to alter all that much the model projections for broad aggregates (columns 2 and 3). However, the simulation results appear to be most sensitive to the extent of substitution possibilities between labour and the energy-capital composite in the non-electricity industry (columns 3 and 4).

7. Conclusions

This study has analysed the likely economy-wide effects of the introduction of an emission-trading scheme, using a general equilibrium model of the WA economy called WAE that emphasises economy-environment interactions. It is found that GHG emissions would fall by 3 to 11 percent depending on the precise specification of the permit allocation scheme. For example, when emission permits are allocated at a price (i.e., no grandfathering) and no tradeable carbon credits granted, emissions fall by 8 percent. However, the benefits of GHG abatement comes at a considerable cost to the economy. In terms of the loss of GSP, the costs are up to 3 percent. If, however, the tradeable credits for the carbon sequestrated in Kyoto forests are allowed for under emission-trading scheme, the GSP cost would be substantially less. Furthermore, as the introduction of the emission trading scheme leads to reduced economic activity, there will be a slight decline in net government revenue, despite any additional revenue from the permit sales. This points to the need for a well-designed fiscal package to minimise the overall abatement costs to the economy.

The introduction of the emission-trading scheme not only affects the size of the state economy, it also changes the structure of it. With the exception of Oil & gas, all the energy-supplying industries suffer a substantial contraction due to the introduction of the emission-trading scheme. The Oil & gas industry is also adversely affected by the trading scheme but not significantly. Furthermore, the impacts on the WA economy of curbing emissions by energy and transport industries only are quite remarkable in comparison with those when all industries are subject to the emission trading policy.

Appendix 1: WAE -- An Economy-Wide Model for WA

Section 2 of text presented an overview of the computable general equilibrium model for the WA economy, WAE, and Section 3 laid out the modelling of greenhouse gas emissions in WAE. This appendix provides more detail of other key aspects of the model.

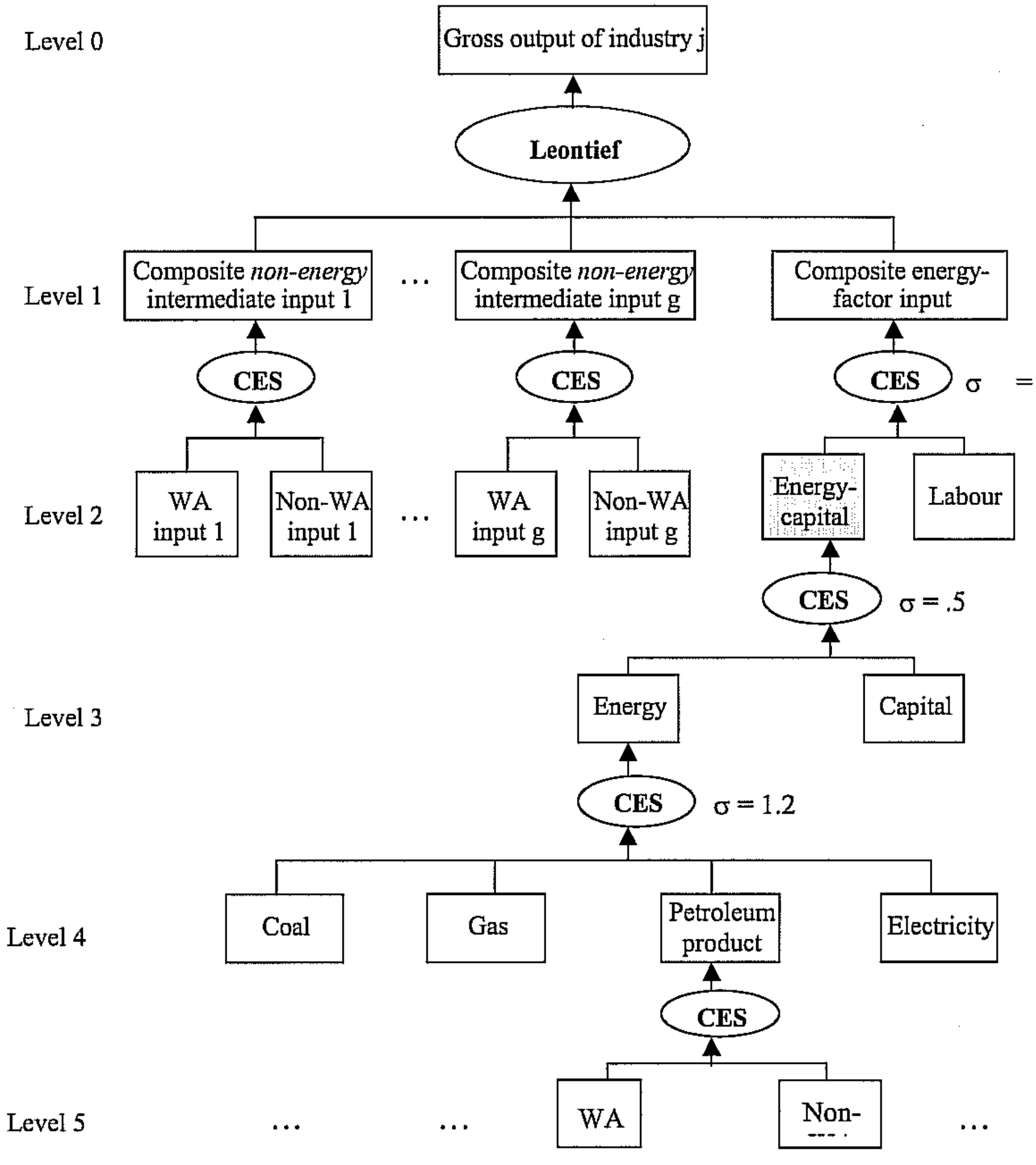
Inter-Fuel and Fuel-Factor Substitution

Published econometric studies indicate that there is substantial short-run and long-run substitutability between labour and capital on the one hand, and also between labour and energy on the other. On the issue of energy-capital substitutability or complementarity, however, empirical estimates seem to be more of a problem. A widely held opinion in this area is that perhaps energy and capital are complements in the short run, but substitutes in the long run (Truong, 1999). Following the general practice in modelling inter-fuel and fuel-factor substitution in studies on GHG emission issues (see, e.g., Burniaux et al., 1992, McDougall, 1993 and ABARE, 1997), capital and energy are treated as substitutes in this study.

We have adopted three distinct production technologies in WAE -- one for the non-electricity (and non-agriculture) sectors, one for the agriculture sector and the third for the electricity sector. The production technologies for all non-electricity (and non-agriculture) industries are represented by nested production functions similar to that used in ORANI-E (McDougall, 1993) and depicted in Figure A.1. At the deepest level (level 5) of the nest, local and imported fuels of each kind are combined to form a composite fuel. At level 4 of the nest, different fuel types are combined to produce an energy composite. At level 3 in the nest, the energy composite is combined with capital to form a capital-energy composite. At level 2, the capital-energy composite is combined with labour to form an energy-factor composite, which is combined with other non-energy intermediate inputs in fixed proportions to produce output at level 1. The agricultural technology is presented in Figure A.2. The rational for and the basic structure of the technology are laid out in Ahammad (2000). However, to allow for inter-fuel and fuel-factor substitutions, some modifications to the structure are carried out following the same nesting for the energy-capital composite in non-electricity (and non-agriculture) technology (Figure A.1). For electricity production, the "technology bundle" approach developed by ABARE (1996) is adopted, as shown in

FIGURE A.1

STRUCTURE OF PRODUCTION IN WAE: NON-ELECTRICITY (NON-AGRICULTURE) INDUSTRY

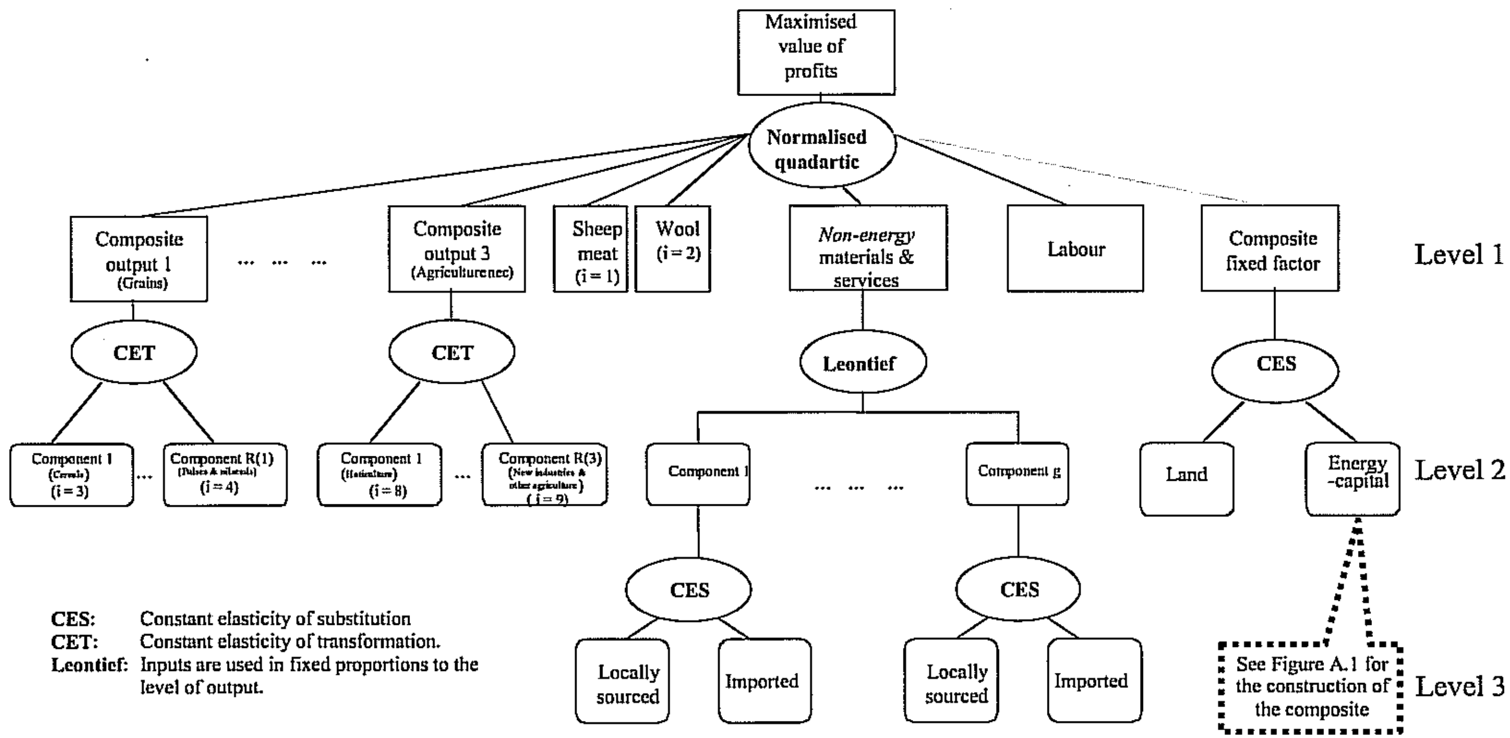


CES: Constant elasticity of substitution; σ is the elasticity of substitution.

Note: This figure is interpreted as follows: At level 5, fuels from local and foreign sources of each kind are combined. At level 4, the four fuels, coal, gas, petroleum product and electricity, are combined into a composite input of energy according to a CES functional form with the elasticity of substitution, which measures the degree to which one fuel can be substituted for another, set at 1.2. The composite energy input is then combined with capital into an energy-capital input at level 3, which again is combined with labour to create a composite energy-factor input at level 2. Finally, at level 1, the composite energy-factor input is used with other, non-energy material inputs in fixed proportions.

FIGURE A.2

STRUCTURE OF PRODUCTION IN WAE: AGRICULTURE



CES: Constant elasticity of substitution
CET: Constant elasticity of transformation.
Leontief: Inputs are used in fixed proportions to the level of output.

Notes:
1. The nine agricultural commodities denoted by i (i = 1, ..., 9) are Sheep meat, Wool, Cereals, Pulses & oilseeds, Beef cattle, Pigs, Poultry, Horticulture and New industries & other agriculture; the three CET composites are Grains, Beef & other meat, and Agriculture n.e.c.
2. At the top panel, the lighter line for the composite fixed factor denotes that the factor, unlike other netputs at the top level, is fixed in supply in the short run and not determined in the farm's profit maximisation process.
3. See Ahammad (2000) for further details.

Figure A.3. According to this approach, electricity is generated by a finite number of technologies with distinct fixed input requirements. This means that the pattern of input use is constrained to be consistent with the range feasible for the specified technologies. It is assumed that electricity can be produced by the following five technologies (i.e., T = 5): Steam turbine, gas turbine, combined cycles, renewable-energy-based, and other.

Greenhouse Gas Emissions

Figures A.4 and A.5 illustrate the emissions database.[12] As can be seen from Figure A.5, the three largest emitters are Road transport (where the use of petroleum is the dominant source of emissions), Electricity supply (significantly coal) and Agriculture (fugitive and petroleum).

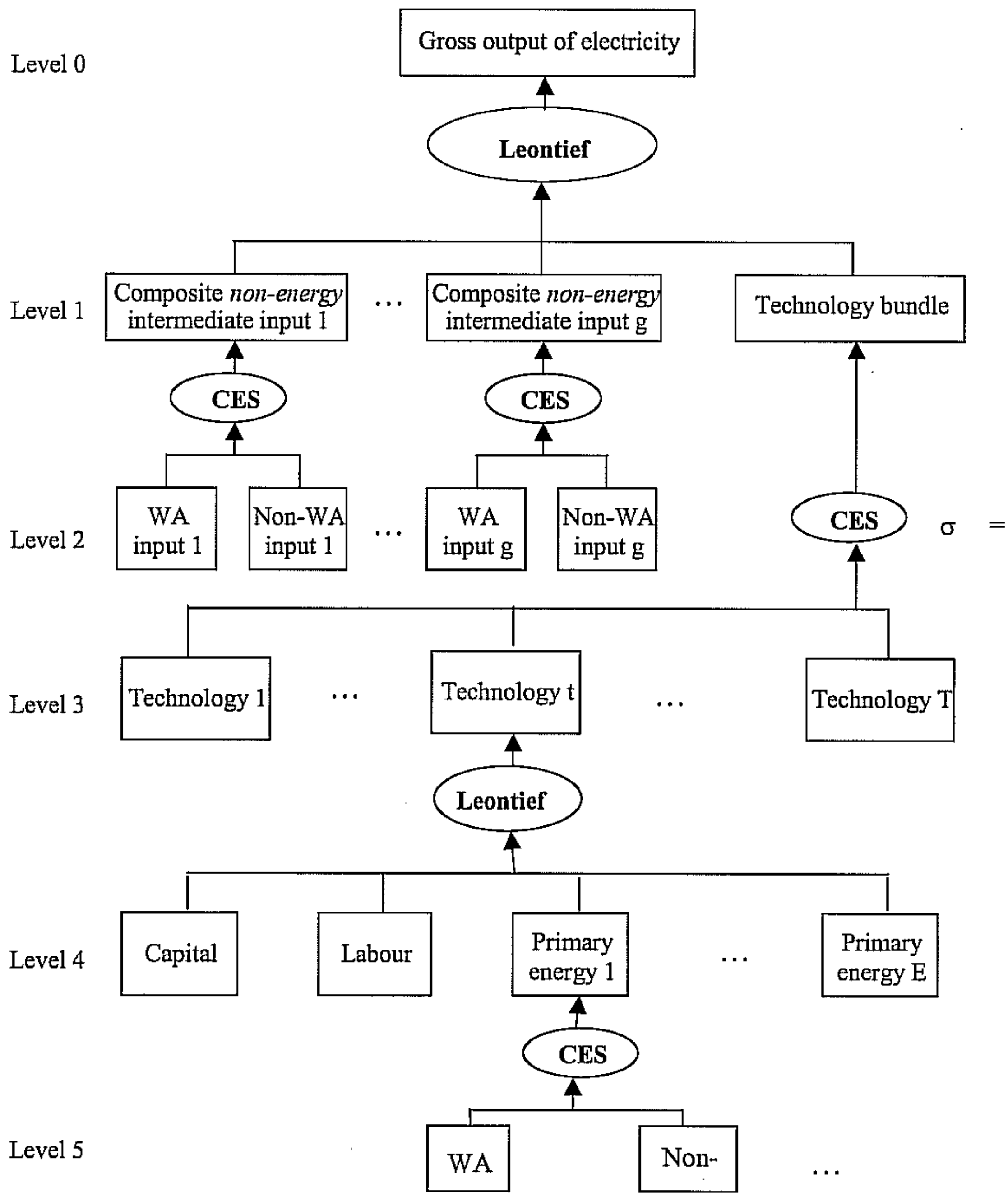
The Government Budget

WAE considers one consolidated government. Accordingly, the government income and expenditure accounts in WAE include the fiscal activities both at the Commonwealth and State levels. More specifically, the following items make up total government revenue: Income taxes, net taxes on inputs and final consumption, payroll taxes, taxes on fixed capital and property, trade taxes, as well as non-tax revenue (royalties, interests income, and the like) and the proceeds from emission permit sale. Government's expenditure includes: Purchases of goods and services by government, spending on welfare payments and net transfers to the rest of Australia.

12 Note that while WAE has 105 industries, Figure A.4 gives emissions for only 102 industries. The three industries not included in the figure are Forestry & logging, Sales by final buyers, and Complementary imports. Forestry & logging has a large negative entry (-8808 Kt of CO_2-e), representing carbon sinks, which cannot be graphed on a logarithmic scale. The other two are "fictitious" industries which do not emit any GHG.

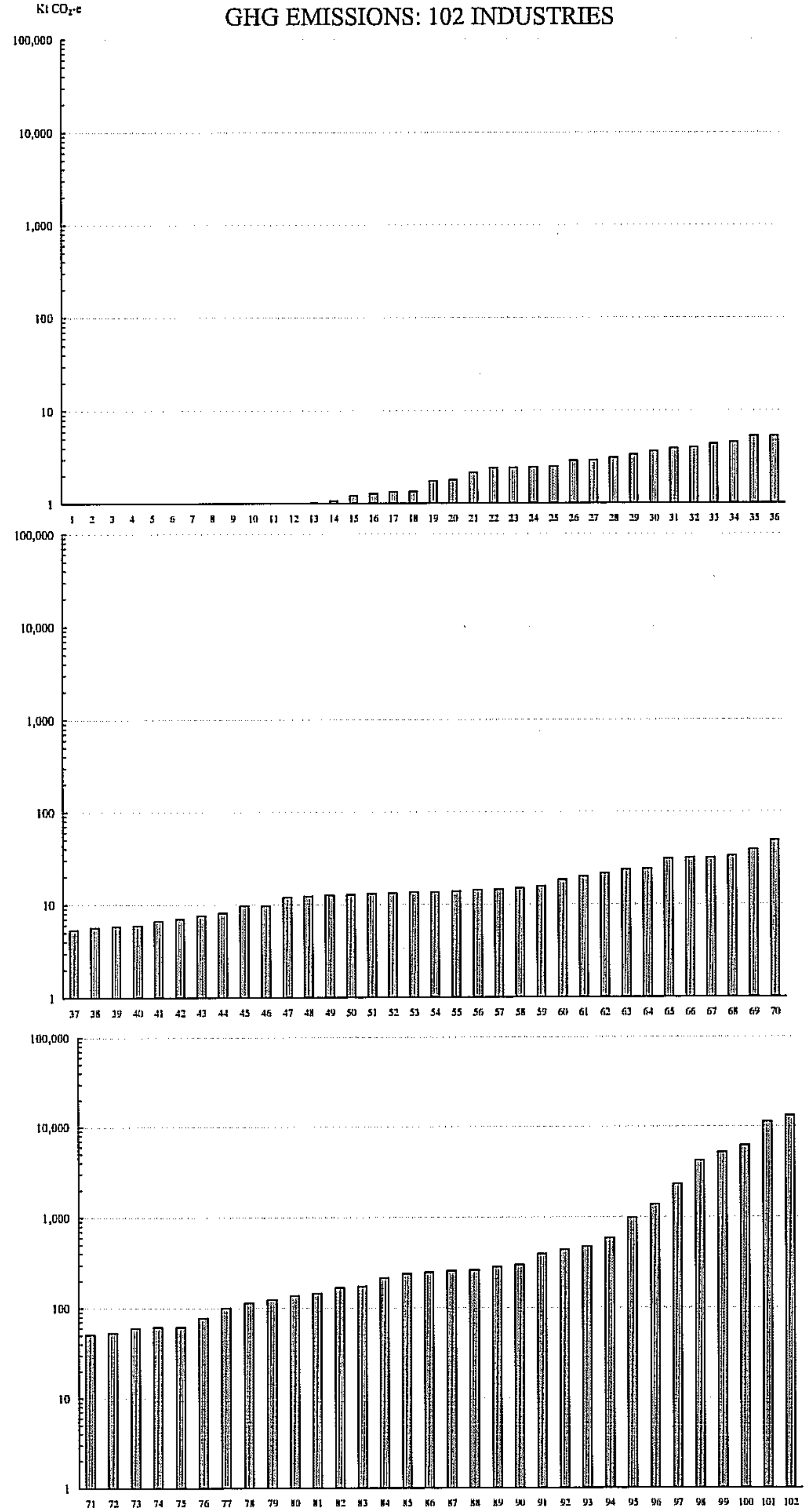
FIGURE A.3

STRUCTURE OF PRODUCTION IN WAE: ELECTRICITY INDUSTRY



CES:	Constant elasticity of substitution.
Leontief:	Inputs are used in fixed proportions to the level of gross output/output by technology t.

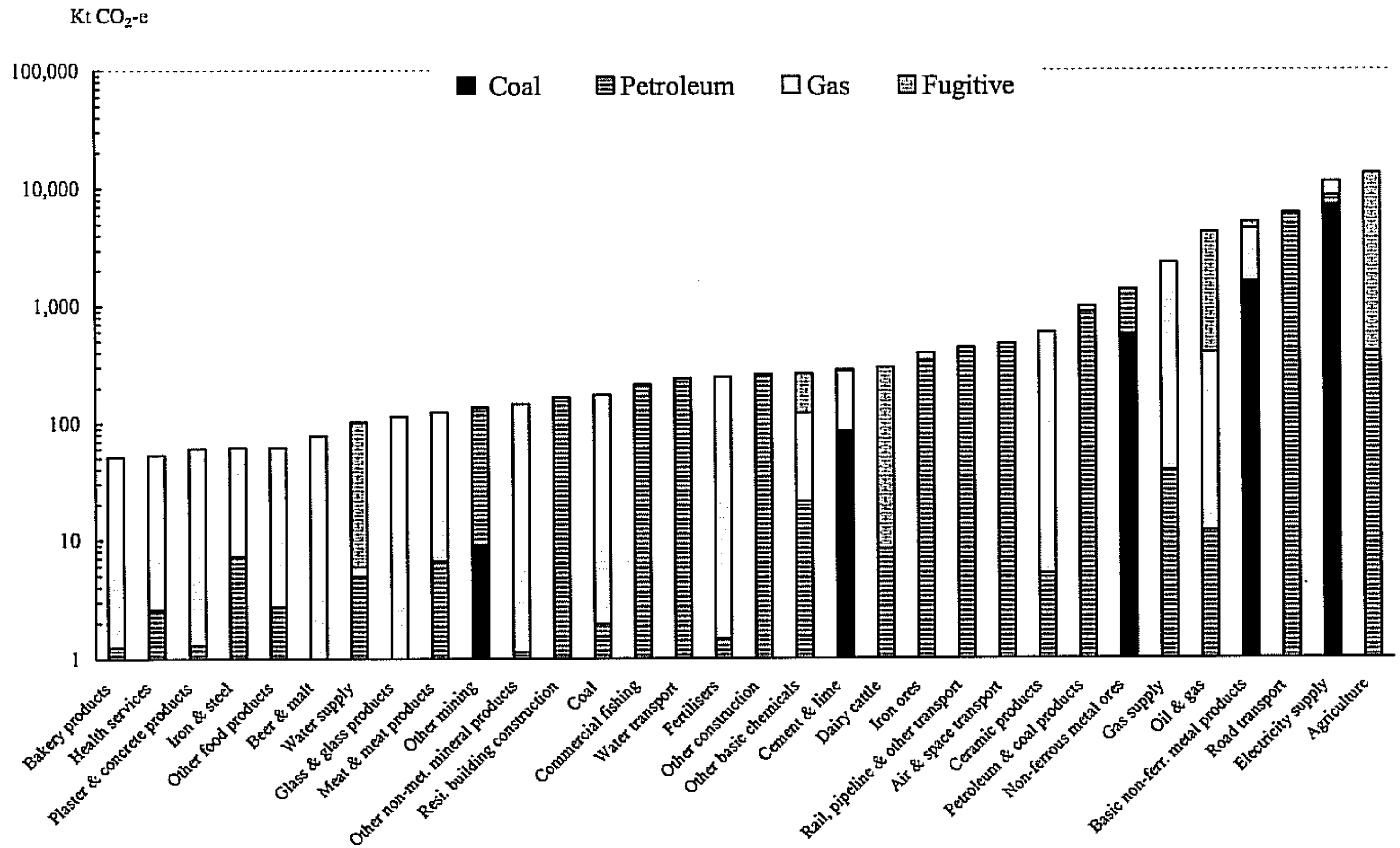
FIGURE A.4
GHG EMISSIONS: 102 INDUSTRIES



Industries

1. Non-bank finance
2. Footwear
3. Financial asset investors
4. Libraries, museums, etc.
5. Railway equipment
6. Services to finance, etc.
7. Wool scouring
8. Knitting mill products
9. Motion picture, radio, etc.
10. Paints
11. Prefabricated buildings
12. Banking
13. Confectionery
14. Concrete slurry
15. Defence
16. Other wood products
17. Photo. & scientific equipment
18. Insurance
19. Sport & recreation services
20. Leather & leather products
21. Soap & other detergents
22. Agricultural machinery
23. Wine & spirits
24. Electronic equipment
25. Services to mining
26. Aircraft
27. Education
28. Other business services
29. Ownership of dwellings
30. Clothing
31. Ships & boats
32. Mining & construction machinery
33. Sawmill products
34. Rubber products
35. Community services
36. Other services
37. Other machinery & equipment
38. Other electrical equipment
39. Recorded media & publishing
40. Furniture
41. Household appliances
42. Oils & fats
43. Structural metal products
44. Printing & services to printing
45. Other manufacturing
46. Personal services
47. Retail trade
48. Soft drinks, etc.
49. Textile products
50. Pulp, paper & paperboard
51. Textile fibres, etc.
52. Government administration
53. Communication services
54. Legal, accounting, etc.
55. Other property services
56. Services to transport;storage
57. Sheet metal products
58. Research, tech. & comp. services
59. Plastic products
60. Medicinal & pharm products
61. Paperboard containers
62. Flour mill products, etc.
63. Fruit & vegetable products
64. Services to agriculture
65. Wholesale trade
66. Dairy products
67. Accommodation,etc.
68. Motor vehicles & parts
69. Fabricated metal products
70. Plywood & fabricated wood
71. Bakery products
72. Health services
73. Plaster & concrete products
74. Iron & steel
75. Other food products
76. Beer & malt
77. Water supply
78. Glass & glass products
79. Meat & meat products
80. Other mining
81. Other non-met. mineral products
82. Resi. building construction
83. Coal
84. Commercial fishing
85. Water transport
86. Fertilisers
87. Other construction
88. Other basic chemicals
89. Cement & lime
90. Dairy cattle
91. Iron ores
92. Rail, pipeline & other transport
93. Air & space transport
94. Ceramic products
95. Petroleum & coal products
96. Non-ferrous metal ores
97. Gas supply
98. Oil & gas
99. Basic non-ferr. metal products
100. Road transport
101. Electricity supply
102. Agriculture

FIGURE A.4
GHG EMISSIONS: THE LARGEST EMITTERS



Appendix 2: Detailed Results

This appendix presents the projected changes due to the introduction of permits allocation scheme in the outputs of the 105 WAE industries (see Table A.1). The results are also aggregated for 10 broad industries. The projected changes for the WA energy sector, which have been given in Table 1, can be read from the industries numbered 6, 7, 36, 69 and 70 in Table A.1. The results for Transport sector in Table 1 correspond to those of industries numbered 73 through 76 in Table A.1.

TABLE A.1
EFFECTS OF PERMITS ALLOCATION SCHEMES ON SECTORAL OUTPUT

		Simulation 1 (1)	Simulation 2 (2)	Simulation 3 (3)	Simulation 4 (4)
Agriculture, forestry & fishing					
1	Agriculture	-.05	-.05	-.07	-.02
2	Dairy cattle	-5.29	-5.29	-5.35	-1.87
3	Services to agriculture	-1.41	-1.48	-1.88	-.66
4	Forestry & logging	296.85	296.82	-2.82	-.99
5	Commercial fishing	-3.97	-3.89	-3.59	-1.26
	Total	4.50	4.50	-.84	-.29
Energy mining					
6	Coal	-5.85	-5.84	-6.50	-2.27
7	Oil & gas	-.26	-.26	-.28	-.10
	Total	-.67	-.67	-.73	-.26
Non-energy mining					
8	Iron ores	-.42	-.40	-.34	-.12
9	Non-ferrous metal ores	-1.86	-1.77	-1.72	-.60
10	Other mining	-.34	-.32	-.27	-.09
	Total	-1.17	-1.11	-1.06	-.37
Food processing					
11	Meat & meat products	-3.28	-3.15	-2.78	-.97
12	Dairy products	-3.57	-3.61	-3.89	-1.36
13	Fruit & vegetable products	-2.99	-3.07	-3.57	-1.25
14	Oils & fats	-2.74	-2.67	-2.39	-.84
15	Flour mill products & cereal foods	-1.81	-1.85	-2.15	-.75
16	Bakery products	-3.20	-3.51	-3.91	-1.37
17	Confectionery	-1.73	-1.85	-1.96	-.69
18	Other food products	-2.76	-2.70	-2.67	-.94
19	Soft drinks, cordials, etc.	-2.18	-2.31	-2.39	-.84
20	Beer & malt	-1.81	-1.89	-1.94	-.68
21	Wine & spirits	-.86	-.87	-1.23	-.43
	Total	-2.88	-2.87	-2.85	-1.00

(continued on next page)

TABLE A.1 (contd.)
EFFECTS OF PERMITS ALLOCATION SCHEMES ON SECTORAL OUTPUT

		Simulation 1 (1)	Simulation 2 (2)	Simulation 3 (3)	Simulation 4 (4)
Other manufacturing					
22	Wool scouring	-3.50	-3.91	-4.46	-1.56
23	Textile fibres, yarns, etc.	-3.42	-3.77	-4.33	-1.52
24	Textile products	-3.83	-4.31	-5.40	-1.89
25	Knitting mill products	-3.50	-3.91	-4.46	-1.56
26	Clothing	-3.79	-4.28	-4.88	-1.71
27	Footwear	-3.39	-3.84	-4.60	-1.61
28	Leather & leather products	3.57	3.85	-2.66	-.93
29	Sawmill products	69.97	70.07	-1.09	-.38
30	Plywood, veneer, etc.	29.28	29.48	-8.71	-3.05
31	Other wood products	-.33	-.45	-1.84	-.64
32	Pulp, paper & paperboard	48.32	48.26	-3.18	-1.11
33	Paperboard containers, etc.	-1.52	-1.69	-3.58	-1.25
34	Printing & services to printing	-.85	-1.10	-3.38	-1.18
35	Publish.;recorded media, etc.	-2.55	-2.89	-3.84	-1.34
36	Petroleum & coal products	-8.75	-8.94	-9.76	-3.41
37	Fertilisers	-14.78	-14.71	-14.47	-5.07
38	Other basic chemicals	-7.85	-7.77	-8.01	-2.80
39	Paints	-.85	-.88	-1.54	-.54
40	Soap & other detergents	-3.13	-3.47	-4.02	-1.41
41	Medicinal, pesticides, etc. products	-1.56	-1.59	-2.03	-.71
42	Rubber products	-3.01	-3.29	-4.27	-1.49
43	Plastic products	-2.28	-2.46	-3.53	-1.24
44	Glass & glass products	-8.24	-8.32	-8.91	-3.12
45	Ceramic products	-25.50	-25.40	-26.29	-9.20
46	Cement & lime	-4.35	-4.38	-8.04	-2.81
47	Concrete slurry	-1.42	-1.56	-2.51	-.88
48	Plaster & other concrete products	12.67	12.62	-2.39	-.84
49	Other non-metallic mineral prod.	-13.32	-13.18	-13.05	-4.57
50	Iron & steel	-2.81	-2.76	-3.29	-1.15
51	Basic non-ferrous metal & prod.	-20.36	-20.21	-20.80	-7.28
52	Structural metal products	-.98	-.96	-1.34	-.47
53	Sheet metal products	-2.58	-2.75	-3.48	-1.22
54	Fabricated metal products	-2.53	-2.61	-3.30	-1.15
55	Motor vehicles & parts, etc.	-2.99	-3.33	-4.97	-1.74
56	Ships & boats	-.09	.06	-.14	-.05
57	Railway equipment	-5.09	-5.42	-6.28	-2.20
58	Aircraft	-5.21	-5.26	-5.34	-1.87
59	Photographic & scientific equip.	-1.00	-1.03	-1.16	-.40
60	Electronic equipment	-.76	-.81	-1.00	-.35
61	Household appliances	-3.87	-4.32	-5.06	-1.77
62	Other electrical equipment	-2.25	-2.38	-3.16	-1.11
63	Agricultural machinery	.17	-.01	-2.42	-.85
64	Mining & const. Machinery, etc.	1.64	1.58	-2.98	-1.04
65	Other machinery & equipment	-1.32	-1.35	-2.72	-.95
66	Prefabricated buildings	-.09	.07	-2.67	-.93
67	Furniture	-4.22	-4.84	-6.42	-2.25
68	Other manufacturing	-2.13	-2.20	-2.61	-.91
	Total	-5.85	-5.92	-9.00	-3.15

(continued on next page)

TABLE A.1 (contd.)

EFFECTS OF PERMITS ALLOCATION SCHEMES ON SECTORAL OUTPUT

		Simulation 1 (1)	Simulation 2 (2)	Simulation 3 (3)	Simulation 4 (4)
69 Electricity		-5.67	-5.69	-5.75	-2.01
70 Gas supply		-18.41	-18.55	-19.25	-6.74
Trade & transport					
71	Wholesale trade	-2.25	-2.53	-4.18	-1.46
72	Retail trade	-4.49	-5.14	-6.07	-2.12
73	Road transport	-4.19	-4.47	-6.07	-2.12
74	Rail, pipeline & other transport	-5.57	-5.97	-6.90	-2.41
75	Water transport	-3.29	-3.27	-3.19	-1.12
76	Air & space transport	-5.13	-5.25	-5.43	-1.90
	Total	-3.68	-4.07	-5.27	-1.84
Financial & business services					
77	Banking	-1.98	-2.19	-2.82	-.99
78	Non-bank finance	-1.15	-1.28	-1.83	-.64
79	Financial asset investors	-.07	-.06	-.05	-.02
80	Insurance	-2.95	-3.35	-4.27	-1.50
81	Services to finance, investment, etc.	-1.42	-1.59	-2.06	-.72
	Total	-1.88	-2.10	-2.71	-.95
Other services					
82	Ownership of dwellings	-.03	.00	.00	-.01
83	Other property services	-2.12	-2.28	-2.80	-.98
84	Scientific research, etc. services	-.20	-.15	-.07	-.03
85	Legal, accounting, etc.	-2.67	-2.94	-3.62	-1.27
86	Other business services	-1.98	-2.19	-2.87	-1.00
87	Government administration	-2.01	-2.23	-3.26	-1.14
88	Defence	-1.87	-2.07	-3.10	-1.08
89	Education	-2.70	-3.04	-3.99	-1.40
90	Health services	-3.98	-4.51	-5.47	-1.91
91	Community services	-4.19	-4.75	-5.73	-2.00
92	Motion picture, radio & TV services	-1.93	-2.13	-2.62	-.92
93	Libraries, museums & the arts	-3.17	-3.58	-4.49	-1.57
94	Sport, gambling & recreat. services	-4.22	-4.81	-5.56	-1.95
95	Personal services	-4.66	-5.30	-6.11	-2.14
96	Other services	-2.61	-2.93	-4.04	-1.42
97	Sales by final buyers	-3.22	-3.36	-3.34	-1.17
98	Complementary imports cif	.00	.00	.00	.00
99	Services to mining	-.09	.12	.77	.27
100	Water supply;sewerage services	-1.44	-1.53	-1.83	-.64
101	Residential building construction	-.04	-.05	-.05	-.02
102	Other construction	-2.34	-2.56	-3.80	-1.33
103	Accommodation & restaurants	-4.71	-5.34	-6.23	-2.18
104	Services to transport;storage	-.24	-.18	-.04	-.01
105	Communication services	-2.39	-2.67	-3.30	-1.16
	Total	-1.89	-2.09	-2.64	-.92

References

ABARE (1996). The MEGABARE Model: Interim Documentation. Canberra: Australian Bureau of Agricultural and Resource Economics.

ABARE (1997). The Economic Impact of International Climate Change Policy. Research Report 97.4. Canberra: Australian Bureau of Agricultural and Resource Economics.

Ahammad, H. (2000). "WAG: A Computable General Equilibrium Model of the Western Australian Economy." Discussion Paper No. 00.11. Perth: Department of Economics, The University of Western Australia.

Ahammad, H. and N. Islam (1999). "Estimating the WA Agricultural Production System: A Profit Function Approach." Discussion Paper No. 99.11. Nedlands: Department of Economics, The University of Western Australia.

Allen Consulting Group (2000). Meeting the Kyoto Target: Impact on Regional Australia. Allen Consulting: Canberra/Melbourne/Sydney.

Australian Greenhouse Office (2000). National Greenhouse Gas Inventory: Analysis of Trends and Greenhouse Indicators, 1990-1998. Commonwealth of Australia: Canberra.

Environmental Futures (2000). Determining the Impact of Various Emission Trading Allocation Scenarios on the Woodside Energy Business Environment. Perth.

Brown, S., D. Kennedy, C. Polidano, K. Woffenden, G. Jakeman, B. Graham, F. Jotzo and B.S. Fisher (1999). Economic Impacts of the Kyoto Protocol: Accounting for the Three Major Greenhouse Gases. Research Report 99.6. Canberra: Australian Bureau of Agricultural and Resource Economics.

Burniaux, J.M., G. Nicoletti and J. Oliveira-Martins (1992). "GREEN: A Global Model for Quantifying the Costs of Policies to Curb CO_2 Emissions." OECD Economic Studies No. 19, Winter, 49-92.

Campbell White and Associates (2000). In Environmental Futures (ed.) Determining the Impact of Various Emission Trading Allocation Scenarios on the Woodside Energy Business Environment. Perth.

Dixon, P.B., B.R. Parmenter, J. Sutton and D.P. Vincent (1982) ORANI: A Multisectoral Model of the Australian Economy. Amsterdam/New York/Oxford: North-Holland.

Gregory, R.G. (1976). "Some Implications of the Growth of the Minerals Sector." Australian Journal of Agricultural Economics 20: 71-91.

Houghton, J.T., L.G. Meira Filho, B.A. Callander, N. Harris, K. Maskell and A. Kattenburg (eds.) (1996). Climate Change 1995: The Science of Climate Change. Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Islam, N. and P. Johnson (1997). Agriculture and the Western Australian Economy: An Input-Output Analysis. South Perth: Agriculture Western Australia.

McDougall, R.A. (1993). "Energy Taxes and Greenhouse Gas Emissions in Australia." General Paper No. G-104. Clayton: Centre of Policy Studies and the Impact Project.

McKibbin, W. (1999). "An Early Action Proposal with Known Costs: A Sensible and Realistic Option for Emission Trading in Australia." Paper presented at the 2nd annual AIC Emission Trading Workshop held in Sydney, August 30-31,1999 and at the ICM Emissions Trading Conference held in Sydney, July 12 and 13, 1999.

NGGIC (1998). Australia's State and Territory Greenhouse Gas Inventory, 1990 and 1995. Canberra: National Greenhouse Gas Inventory Committee, Australian Greenhouse Office.

Truong, T. P. (1999). "GTAP-E: Incorporating Energy Substitution into the GTAP Model." GTAP Technical Paper No. 16. West Lafayette: Centre for Global Trade Analysis, Purdue University.

Ye, Q. (1998). The Economic Significance of the New Minerals Projects in Western Australia. PhD Thesis, Economic Research Centre, Department of Economics, The University of Western Australia.

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