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THE ECONOMIC IMPACT OF GREENHOUSE POLICY UPON THE AUSTRALIAN ELECTRICITY INDUSTRY: AN APPLIED GENERAL EQUILIBRIUM ANALYSIS

A Thesis Submitted to Monash University for the Degree of

DOCTOR OF PHILOSOPHY

by

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ABSTRACT

In 1997, the Australian Government became a signatory to the Kyoto Protocol and in doing so made a commitment to reduce its greenhouse gas emissions. The focus of the research is the electricity industry which is responsible for over 20 percent of Australia's total emissions and is consequently a target for policy makers. Particular attention is paid to analysing the economic impact of greenhouse policy upon the electricity supply industry of Victoria.

The research uses the MONASH-Electricity computable general equilibrium (CGE) model of the Australian economy to analyse the economic impact of greenhouse policy upon the Australian economy, with specific focus upon the electricity sector. Significant modifications have been made to the original MONASH model to include a detailed electricity sector which allows for intermediate substitution. Further modifications have been made to the regional economic component of the model, including the addition of a new statistical division to produce results for the electricity intensive La Trobe Valley region of Victoria.

STATEMENT OF AUTHORSHIP

Except where reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis presented by myself for another degree or diploma.

No other person's work has been used without due acknowledgment in the main text of the thesis.

This thesis has not been submitted for the award of any other degree or diploma in any other institution.

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Sharn Emma Enzinger

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GLOSSARY

$/MWh	Dollar per megawatt hour of electricity
%	Percent
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
AIJ	Activities Implemented Jointly
Alum	Aluminium
ANZSIC	Australian and New Zealand Standard Industrial Classification
APFBC	Advanced Pressurised Fluid Bed Combustion
AUD	Australian dollar
BT	Balance of Trade
CAS	Current Account Surplus
CDM	Clean development mechanism
CES	Constant elasticity of substitution
CGE	Computable General Equilibrium
CO_2	Carbon dioxide
COP	Conference of the Parties
CoPS	Centre of Policy Studies
CPI	Consumer Price Index
CRC Clean Power	Cooperative Research Centre for Clean Power from Lignite
CRESH	Constant ratio of elasticities of substitution homothetic production function
Ebrix	Energy Brix
Edis	Edison Mission Energy
EleBlk	Black coal electricity generator
EleBr	Brown coal electricity generator
ElectDis	Distribution arm of the electricity sector
ElectTrn	Transmission arm of the electricity sector
EleGas	Gas electricity generator
EleHyd	Hydro electricity generator
EleOth	Other (inc. renewables) electricity generator
EP	Emission permits
ES	Elasticities of substitution

ESAA	Electricity Supply Association of Australia
ESI	Electricity supply industry
EU	European Union
Flin	Flinders Power (NRG)
G-Cubed	Global General Equilibrium Growth Model
GDP	Gross Domestic Product
GenVic	Generation Victoria
GFT	Greenhouse Fuel Tax
GNE	Gross National Expenditure
GNP	Gross National Product
GRP	Gross Regional Product
GSP	Gross State Product
GTEM	Global Trade Environment Model
GWh	Gigawatt hour
Haz	Hazelwood Power
IIAM	Integrated Impact Assessment Model
I-O	Input-Output
LoyY	Loy Yang Power
MCA	Marginal cost of abatement
MMRF	Monash Multi-Regional Forecasting
MRES	MONASH regional equation system
Mt	Megatons
MW	Megawatt
MWh	Megawatt hour of electricity
NECA	National Electricity Code Administrator
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company
Nferrous	Non-ferrous metals
NGGI	National Greenhouse Gas Inventory
NSW	New South Wales
NT	Northern Territory
OECD	Organisation of Economic Co-operation and Development
Protocol	Kyoto Protocol
QLD	Queensland
SA	South Australia

SD	Statistical Division
SECV	State Electricity Commission of Victoria
SMHEA	Snowy Mountain Hydro Electricity Authority
TAIGEM	TAIwan General Equilibrium Model
TAS	Tasmania
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
VA	Voluntary agreement
VDP	Voluntary Departure Packages
VIC	Victoria
WA	Western Australia
Yall	Yallourn Energy

DEFINITIONS

Annex 1	Developed countries.
Annex B countries	Developed countries and economies in transition.
Australian Greenhouse Office	Australian Government advisory body on greenhouse issues.
Basecase	The basecase operates as an initial path from which deviations are measured in assessing the impact of the policy.
Carbon Sink	A natural occurring mechanism that removes CO_2 from the atmosphere.
Commitment period	The Kyoto Protocol commitment period between 2008–2012.
Commonwealth Government	Federal Australian Government.
Electricity pool	Flow of electricity from generators to centrally coordinated despatch.
GEMPACK	Software used in CGE modelling.
Government	Unless otherwise specified, refers to the Commonwealth Government of Australia.
Grandfathering	Available permits are issued on a pro-rata basis to those firms who are currently emitting CO_2
Greenhouse Challenge Agreement	A cooperative effort by industry and government to reduce greenhouse gas emissions through voluntary industry action.
Greenhouse gas emissions	Includes all equivalent greenhouse gases such as CO_2 CH_4 and N_2O.
Greenhouse Revenue	Revenue associated with the imposition of greenhouse policy upon sectors of the Australian economy.
Kyoto Protocol	The third Conference of the Parties held in Kyoto, Japan.
MONASH model	Dynamic CGE model of the Australian economy.
MONASH-Electricity	A CGE model of the Australian economy with detailed handling of the electricity sector.

No regrets	If at some time in the future the scientific community no longer perceives greenhouse emissions to be a serious issue there will be 'no regrets' for having taken action.
Parties to the Conference	A Party to the Kyoto Protocol.
Reference case	Grandfathered simulation described in Section 6.5.
Tablo Code	Provides a description of the model for computer generation.
tCO_2/MWh	Tonnes of CO_2 per MWh of electricity generated.

List of Industries in MONASH-Electricity

INDUSTRY

1 I1Pastoral
2 I2WheatSheep
3 I3HighRain
4 I4NthBeef
5 I5MilkCattle
6 I6OthExport
7 I7ImportComp
8 I8Poultry
9 I9AgServ
10 I10Forestry
11 I11Fishing
12 I12IronOre
13 I13NFerrous
14 I14BlkCoal
15 I15aOil
16 I15bGas
17 I15cBrCoal
18 I16OthMin
19 I17MinServ
20 I18Meat
21 I19Dairy
22 I20FrtVeg
23 I21OilFat
24 I22Flour
25 I23Bakery
26 I24Confect
27 I25Sea_Sugar
28 I26SoftDr
29 I27Beer
30 I28OthDrink
31 I29Tobacco
32 I30Ginning
33 I31Synthetic
34 I32CottonYa
35 I33WoolYarn
36 I34TextileF
37 I35Carpets
38 I36Canvas
39 I37Knitting
40 I38Clothing
41 I39Footwear
42 I40Sawmill
43 I41Panels
44 I42Fittings
45 I43Furniture
46 I44PulpPaper
47 I45BagsBoxes
48 I46Sanitary
49 I47NewsBooks
50 I48CommPrint
51 I49Fertilisr
52 I50BasicChem
53 I51Paints
54 I52Pharmacy
55 I53Soaps
56 I54Cosmetics
57 I55Explosive
58 I56Petrol
59 I57Glass
60 I58ClayProd
61 I59Cement
62 I60Readymix
63 I61Pipes
64 I62Plaster
65 I63IronSteel
66 I64aNFerrous
67 I64bAlum
68 I65Structurl
69 I66SheetMetl
70 I67Wire
71 I68MotorVeh
72 I69Ships
73 I70Trains
74 I71Aircraft
75 I72SciEquip
76 I73Electron
77 I74HousAppl
78 I75ElectEq
79 I76AgMach
80 I77ConMach
81 I78ManuMach
82 I79Leather
83 I80Rubber
84 I81Plastic
85 I82Signs
86 I83SportEq
87 I84aaaEleBr
88 I84aaaaEdis
89 I84aaabEBrix
90 I84aaacHaz
91 I84aaadLoyY
92 I84aaaeYall
93 I84aaafFlin
94 I84aabEleBlk
95 I84aacEleGas
96 I84aadEleHyd
97 I84aaeEleOth
98 I84bElectTrn
99 I84cElectDist
100 I85Gas
101 I86Water
102 I87Resident
103 I88OthBuild
104 I89Wholesale
105 I90RetailTrd
106 I91MechRep
107 I92OthRepair
108 I93RoadTrans
109 I94RailTrans
110 I95WaterTran
111 I96AirTransp
112 I97TransServ
113 I98Communic
114 I99Banking
115 I100NonBank
116 I101Investm
117 I102Insurnce
118 I103OthFinan
119 I104Dwelling
120 I105PubAdmin
121 I106Defence
122 I107Health
123 I108Educate
124 I109Welfare
125 I110Entrtain
126 I111Hotels
127 I112PerServ
128 I113Other

List of Commodities in MONASH-Electricity

	COMMODITY				
1	C1Wool	50	C48Sanitary	99	C86aaeEleOth
2	C2Sheep	51	C49NewsBooks	100	C86bElectTrn
3	C3Wheat	52	C50CommPrint	101	C86cElectDist
4	C4Barley	53	C51Fertilisr	102	C87Gas
5	C5OthGrains	54	C52BasicChem	103	C88Water
6	C6MeatCattle	55	C53Paints	104	C89Resident
7	C7MilkCattle	56	C54Pharmacy	105	C90OthBuild
8	C8OthExport	57	C55Soaps	106	C91Wholesale
9	C9ImportComp	58	C56Cosmetics	107	C92RetailTrd
10	C10Poultry	59	C57Explosive	108	C93MechRep
11	C11AgServ	60	C58Petrol	109	C94OthRepair
12	C12Forestry	61	C59Glass	110	C95RoadTrans
13	C13Fishing	62	C60ClayProd	111	C96RailTrans
14	C14IronOre	63	C61Cement	112	C97WaterTran
15	C15NFerrous	64	C62Readymix	113	C98AirTransp
16	C16BlkCoal	65	C63Pipes	114	C99TransServ
17	C17aOil	66	C64Plaster	115	C100Communic
18	C17bGas	67	C65IronSteel	116	C101Banking
19	C17cBrCoal	68	C66aNFerrous	117	C102NonBank
20	C18OthMin	69	C66bAlum	118	C103Investm
21	C19MinServ	70	C67Structurl	119	C104Insurnce
22	C20Meat	71	C68SheetMetl	120	C105OthFinan
23	C21Dairy	72	C69Wire	121	C106Dwelling
24	C22FrtVeg	73	C70MotorVeh	122	C107PubAdmin
25	C23OilFat	74	C71Ships	123	C108Defence
26	C24Flour	75	C72Trains	124	C109Health
27	C25Bakery	76	C73Aircraft	125	C110Educate
28	C26Confect	77	C74SciEquip	126	C111Welfare
29	C27Sea_Sugar	78	C75Electron	127	C112Entrtain
30	C28SoftDr	79	C76HousAppl	128	C113Hotels
31	C29Beer	80	C77ElectEq	129	C114PerServ
32	C30OthDrink	81	C78AgMach	130	C115Other
33	C31Tobacco	82	C79ConMach		
34	C32Ginning	83	C80ManuMach		
35	C33Synthetic	84	C81Leather		
36	C34CottonYa	85	C82Rubber		
37	C35WoolYarn	86	C83Plastic		
38	C36TextileF	87	C84Signs		
39	C37Carpets	88	C85SportEq		
40	C38Canvas	89	C86aaaEleBr		
41	C39Knitting	90	C86aaaaEdis		
42	C40Clothing	91	C86aaabEBrix		
43	C41Footwear	92	C86aaacHaz		
44	C42Sawmill	93	C86aaadLoyY		
45	C43Panels	94	C86aaaeYall		
46	C44Fittings	95	C86aaafFlin		
47	C45Furniture	96	C86aabEleBlk		
48	C46PulpPaper	97	C86aacEleGas		
49	C47BagsBoxes	98	C86aadEleHyd		

CHAPTER ONE

INTRODUCTION

Over the past decade there has arisen great interest in the debate on the impact of greenhouse gas emissions on the earth's atmosphere. Scientists have reached a general consensus that the world's changing climatic pattern is largely attributable to human induced increases in greenhouse gases since industrialization.[1] The phrase 'global warming' is used to describe the climate change and its associated consequences such as rising sea levels and the more frequent occurrence of natural disasters. The growth rate of greenhouse gas emissions is of such significant concern to the scientific community that the United Nations became involved in the search for a global solution to the problem.[2]

The United Nations Framework Convention on Climate Change (UNFCCC) was formulated in 1992. The UNFCCC recognises that a problem exists and aims to work with all nations to ensure that greenhouse gas concentrations in the atmosphere remain at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 2001). All nations have been invited by the UNFCCC to attend forums to discuss the problem of global greenhouse gas emissions. The objective of these forums is to encourage nations to recognise that the problem is global and must be addressed by a joint effort. It would be virtually impossible for one country to stand alone and make significant change.[3]

It was in late 1997 at the third Conference of the Parties (COP) to the UNFCCC in Kyoto, Japan that the first international commitment on reducing global greenhouse gas emissions was constituted. Parties to the Conference agreed to reduce their aggregate greenhouse gas emissions by 5.2 percent of 1990 levels by what is known as the commitment period of 2008-2012. The agreement reached was thereafter referred to as the Kyoto Protocol.

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[1] Not all scientists agree that humans are predominantly responsible for the recent observed changes in the earth's climate.

[2] The scientific consensus predicts a rise in the earth's average temperature of 1.5 to 4.5 degrees Centigrade over the next 100 years. This is in contrast to the temperature increase of half a degree Centigrade since the pre-industrial period before 1850. (UNFCCC website http://www.unfccc.de/)

[3] Even the United States (US) who is the largest emitter of CO_2 would rely on the cooperation of the large developing countries if future emission levels were to be decreased.

Developed countries are referred to as Annex 1 countries. Whilst developing countries were invited to attend the Kyoto conference, they are not required to participate in the Protocol agreement.

As a Party to the UNFCCC, Australia agreed to reduce its emissions. Australia faces an overall target of an 8 percent increase in its 1990 emission level.[4] Australia was successful in arguing for differentiated targets for each of the Annex 1 countries. It argued that without differentiated targets, it would be forced to comply with targets that were extremely damaging to its economy. The Australian Government was committed to reducing its greenhouse gas emissions but would not extend its position beyond 'no regrets'. Consequently Australia was granted less stringent targets relative to most other Parties to the Conference.

Before the Kyoto Protocol becomes legally binding upon the signatories, it must be ratified by at least 55 Parties to the UNFCCC. Those ratifying countries must account for at least 55 per cent of the total 1990 carbon dioxide emissions of the countries listed in Annex 1 of the UNFCCC (UNFCCC, 1997). With countries such as the United States accounting for 25 percent of 1990 emission levels, the success of the Kyoto Protocol is reliant upon the ratification of leading carbon dioxide (CO_2) emitting nations. In early 2001, the President of the United States announced that his Government would not ratify the Kyoto Protocol in its current format. Whilst the position of the United States certainly stalls the progress made in negotiating an internationally binding agreement on CO_2 emission reduction, it does not signify the end of the treaty process. A new Conference of the Parties has been scheduled for late 2001 and the UNFCCC is optimistic that it can reach a revised agreement which is more attractive to those countries who have been reluctant to ratify the Kyoto Protocol.[5]

The Australian Government has stated that it will not ratify the Kyoto Protocol before the United States ratifies. It has, however, considered carefully its international commitment to reduce its greenhouse emissions. The Australian Government is in the process of developing greenhouse policy. It is possible that the stance of the United States will delay

[4] The increase of 8 percent on 1990 levels represents a reduction on current emission levels.
[5] The seventh Conference of the Parties (COP7) is scheduled to be held in November 2001 in Marrakech, Morocco.

the introduction of greenhouse policy in Australia. If the Australian Government is unsure of its emission reduction commitment, it is likely to act in a conservative manner and postpone the introduction of greenhouse policy until further international agreements are firmed.

In the meantime, the Australian Government remains actively involved in encouraging all sectors of the economy to reduce emissions. The Greenhouse Challenge program has been established as a joint voluntary initiative between the Government and industry to abate greenhouse gas emissions (Australian Greenhouse Office, 1998b). Many companies responsible for a large percentage of Australia's emissions have become signatories to the Greenhouse Challenge. The Government has also committed over AUD$200 million to the establishment of a renewable energy program.

It is plausible that before the end of this decade the Australian Government will have entered into an international agreement to reduce its greenhouse gas emissions. The target is likely to be less stringent than that of the Kyoto Protocol but a significant reduction in aggregate CO_2 emissions will be required. Based on investigations by the Government's advisory body, the Australian Greenhouse Office, the type of greenhouse policy implemented will most probably be market based. The two most common types of market based instruments are taxes on emissions of greenhouse gases[6], or the establishment of an emission trading market.

Regardless of the market based policy mechanism introduced, the focus of the policy will be upon sectors of the Australian economy responsible for the majority of emissions. The electricity sector accounts for approximately 35 percent of the nation's total emissions. Based on this alone, the impact of a greenhouse policy aimed at reducing emissions will be felt heavily by this sector.

The most emission intensive electricity generators in the Australian market are the brown coal generators, located in the La Trobe Valley region in the State of Victoria. The La Trobe Valley is situated approximately 150 kilometres east of Melbourne, Victoria's

[6] For the purposes of discussion, unless otherwise stated the use of the term CO_2 will refer to all CO_2 equivalent greenhouse gases including CH_4 and N_2O.

capital. The power stations in the La Trobe Valley supply 90 percent of Victoria's electricity.

During the last decade, the Victorian electricity supply industry (ESI) underwent the transformation from state owned to privately owned and operated entities. The generators now compete against one another to supply electricity to retail distributors. The generators have recently been exposed to further competition with the emergence of a national electricity grid between the states on the eastern seaboard of Australia.

There is currently a lot of interest at the national, state and regional level in how the Australian Government's greenhouse policy will affect the La Trobe Valley's economy. A contribution of this research is to provide some of the answers to this question.

The remainder of this chapter is organised as follows. Section 1.1 provides a rationalisation of the use of Computable General Equilibrium (CGE) modelling to analyse the economic effect of greenhouse policy upon the electricity industry, and the La Trobe Valley region. The chapter concludes with section 1.2 which provides a reader's guide to the remaining chapters of the thesis.

1.1 METHODOLOGY

The analysis contained in this research centres around results from simulations of MONASH-Electricity. MONASH-Electricity is a CGE model of the Australian economy with detailed handling of the electricity sector. The model is an adaptation of the existing MONASH model of the Australian economy, developed by the Centre of Policy Studies (CoPS) at Monash University.[7]

The use of a CGE model when analysing the economic impact of greenhouse policy is particularly effective as it enables both the initial impact of the policy and subsequent feedback effects to be evaluated at the macroeconomic and industry levels. Within the structure of a typical CGE model demands for and supplies of commodities and factors are specified as functions of activity variables and relative prices (Adams and Parmenter, 1998). This assumption expands the interrelationship between the sectors of the economy beyond that used in alternative modelling techniques such as input-output analysis. According to Adams and Parmenter (1998), CGE models can incorporate all of the Input-Output (I-O) mechanisms as well as allowing for the imposition of economy-wide constraints on, for example, primary-factor supplies or the external account. Hence, the model incorporates mechanisms for potential crowding out of one activity by another as well as for I-O multiplier effects.

Another advantage of CGE modelling is that it takes into consideration changes in relative prices. If demand for an industry's output changes, the CGE model allows the price of the output to adjust. This in turn impacts upon another industry's demand for that good. For example, if an exogenous shock to the model causes the demand for industry *i*'s commodity to increase, its price will endogenously increase. Purchasers of industry *i*'s commodity will now be faced with higher costs as they have to pay more for each unit of commodity *i*. The equation system established in CGE models enables the economy to take into consideration such changes in relative prices (Parmenter, 1982).[8]

Labour and capital factors are also important in CGE modelling. Industries compete for scarce resources such as land, labour and capital. If the demand for output from a labour intensive industry increases, the cost of labour will subsequently rise. Other industries who use labour as a factor of production will be faced with the increasing cost of labour. The CGE model takes into consideration changes in the labour/capital ratio and how it will impact upon individual industries.

The MONASH model is a dynamic model which originates from the comparative static CGE model called ORANI[9]. Both of these models are well documented and have been used extensively by researchers and policy makers for a broad spectrum of applications.

A detailed technical review of the MONASH model will not be included in the thesis. Complete technical documentation is provided in Dixon and Rimmer (2000). The model is

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[7] For full documentation of the MONASH model refer to Dixon and Rimmer, 2000.

[8] "The model (input-output), however, has no mechanism which allows demand to change in response to the change in relative prices. Technological assumptions preclude substitution between commodities in industries input structures and the level and commodity composition of final demand is exogenous."

[9] For full documentation of the ORANI model refer to Dixon et al, 1982.

solved using the GEMPACK software reviewed in Harrison and Pearson (1986). Without recourse to the technical literature, the results identify the main theoretical mechanisms and elements of the database responsible for the conclusions drawn.

The methodology used in this thesis involved significant modifications to the MONASH model to create MONASH-Electricity. The main equation system of the original model remained but was complemented with the inclusion of equations calculating the level of greenhouse emissions from the industries in the Australian economy. To facilitate the accounting for greenhouse emissions, many of the existing energy industries in the model were modified. The most significant change came with the disaggregation of the original electricity industry. The single electricity industry was disaggregated into a detailed sector comprised of 13 industries responsible for the production of 13 commodities.

Further modifications involved a system of equations capable of facilitating intermediate substitution between the newly formed electricity generating industries. As greenhouse policy will cause different impacts upon the industries, it was essential to incorporate substitution at the industry level.

1.2 THESIS OUTLINE

The thesis is made up of a further six chapters. Chapter two provides a review of the current Australian and international CGE models that have been used in greenhouse analysis. Chapter three provides an overview of greenhouse gas emissions and their importance in the Australian and global context. The Australian electricity supply industry and its relationship to the La Trobe Valley region is explored in Chapter four. Chapter five concentrates on the modifications to the MONASH model database and theoretical mechanisms. Chapter six explores the model's simulation results. Concluding remarks and areas for further research are discussed in Chapter seven.

The objective of Chapter two is to provide an introduction for the reader to a selection of literature on using CGE modelling techniques for greenhouse policy analysis. The chapter begins with an overview of the models currently being used in an Australian context. Models used by economic researchers such as the Australian Bureau of Agricultural and

Resource Economics (ABARE) are contrasted with the MONASH model. Similar policy analysis is adopted by most of the Australian literature.

The second part of Chapter two identifies similar research conducted in other countries. In the majority of these cases the use of CGE models is the common theme. However the models used and the policy analysis adopted vary.

Included in Chapter three is an outline of the agreement entered into by developed nations at the Kyoto Climate Change Conference. A commentary on the nature of the Kyoto Protocol from an Australian and international perspective is provided. The current position of the Australian Government's greenhouse policy is also discussed in Chapter three.

Chapter four provides a detailed explanation of the structure of the Australian electricity industry. An integral part of the chapter is an account of how the industry has undergone significant structural reform over the last decade. Chapter four also includes an explanation of the Victorian electricity supply industry and its unique relationship with the La Trobe Valley region.

The methodology applied in the thesis is discussed in Chapter five. The results are derived using the MONASH-Electricity CGE model. MONASH-Electricity is an adaptation of the MONASH model. Chapter five is divided into two main sections. The first section reviews the MONASH model. The second section of the chapter describes the procedure involved in modifying the MONASH model's database. An explanation of how the electricity industry was disaggregated is included in this section. The regional component of the MONASH model has been modified to include an additional statistical division to produce results for the La Trobe Valley region of Victoria. New equations have been added to allow substitution between the electricity industries in response to greenhouse policy.

Simulation results from MONASH-Electricity are presented in Chapter six. This chapter begins with a discussion of the policy shocks applied and the treatment of the greenhouse revenue. The results from two separate simulations are explained. The first assumes that permits are provided free of charge to CO_2 emitters[10]. The second assumes that the CO_2 emission trading permits are auctioned and the government recycles the revenue via a reduction in household consumption taxes.

The final chapter of the thesis draws conclusions from the study and outlines areas for further research. Included in Chapter seven is a discussion of further model modifications that could be made to the existing MONASH-Electricity database and equation system.

[10] This is referred to as grandfathering the permits to emitters.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter explores the literature on greenhouse analysis using CGE modelling techniques. The chapter is divided into a review of the Australian literature and a broader review of the international literature.

There are currently four leading models in Australia which have been used for greenhouse policy analysis. Each of these models is outlined and a comparison between the main characteristics is provided in Section 2.2.

The review of the international literature in Section 2.3 includes research conducted by many modellers into the impact of greenhouse issues. The international literature review is broader in its scope as the policy issues considered differ. For instance, Edwards and Hutton (2001) focus on the economic impact upon the United Kingdom (UK) of meeting its Kyoto commitments. Other studies encompass a much wider focus, using CGE models to analyse the economic impact of a particular aspect of the Kyoto Protocol upon a group of regions. For instance, Edmonds et al (1999) found that the establishment of an international greenhouse gas emissions trading regime will significantly lower global mitigation costs.

Section 2.4 provides a comparison of the MMRF-Green model (discussed in Section 2.2) and MONASH-Electricity.

2.2 AUSTRALIAN LITERATURE ON CGE GREENHOUSE MODELLING

The main differences between the Australian models as described by Pezzey and Lambie (2001) in a study commissioned by the Australian Productivity Commission is whether the model is national or global. A national model will concentrate on the impact of greenhouse issues upon the Australian economy. Consideration will be given to global factors such as the market for international trade, but no other region is explicitly identified. A global model analyses the impact of greenhouse issues upon many different nations. Australia is often treated as one region in the global model[11].

There are advantages and disadvantages associated with both types of models. The advantage of a national model is that the sectoral and regional impact of greenhouse policy upon the Australian economy can be measured in much more detail. The disadvantage of a national model, and the advantage of global models, is that rising greenhouse gas levels is a global issue which requires a global response. If explicit assumptions are not made about the scope of greenhouse compliance, the economic impact upon a region such as Australia can either be over or under estimated.

Chapter three outlines the economics of greenhouse policy. One of the main issues raised in Chapter three is the fact that developing countries are not required to meet CO_2 emission targets under the Kyoto Protocol. This has ramifications for an analysis of the economic impact of greenhouse policy on Australia. If Australia trades mainly with developing countries, it is reasonable to assume that the relative cost of Australia's goods increases. However if Australia competes and trades predominantly with other developed countries the relative price of Australian goods may not increase at all. A global model should have the capacity to identify which regions are privy to the Kyoto Protocol and those who are not.

[11] In other instances Australia is treated as part of a more aggregated region such as the Asia-Pacific.

2.2.1 CENTRE OF POLICY STUDIES

ORANI-E

Some of the earliest CGE modelling research into the impact of greenhouse policy upon the Australian economy was performed by Robert McDougall who was then employed at the CoPS (McDougall, 1993a and 1993b).[12] The model used by McDougall was a version of the ORANI model (Dixon et al, 1982), known as ORANI-E.

ORANI-E is a comparative static CGE model of the Australian economy which incorporates a detailed representation of the Australian energy sector (McDougall, 1993b). The disaggregation of the electricity sector in ORANI-E, and of the existing Oil, Gas and Brown Coal industry in standard ORANI, is similar in principle to the disaggregation performed in this thesis (described in Chapter five). The electricity generation industry was also disaggregated but only down to the fuel technology level.[13]

ORANI-E facilitates a number of substitution possibilities. The model uses a flexible nesting facility to model energy-capital substitution, inter-fuel substitution, and substitution between different electricity generation technologies (McDougall, 1993b). Substitution exists between energy and capital, fuels used as intermediate inputs, and the different methods of electricity generation. A further model mechanism found in ORANI-E is the classification of the electricity generating technologies as belonging to the base, peak or remote area markets. There is no capacity for substitution between these markets, although generators within each market can be substituted.[14]

Figure 2.1 illustrates a flow diagram of the energy sector of the ORANI-E model and includes the elasticities of substitution (ES) employed. The substitution elasticity between different generators selling to the base and peak markets is 5.0. The substitution elasticity

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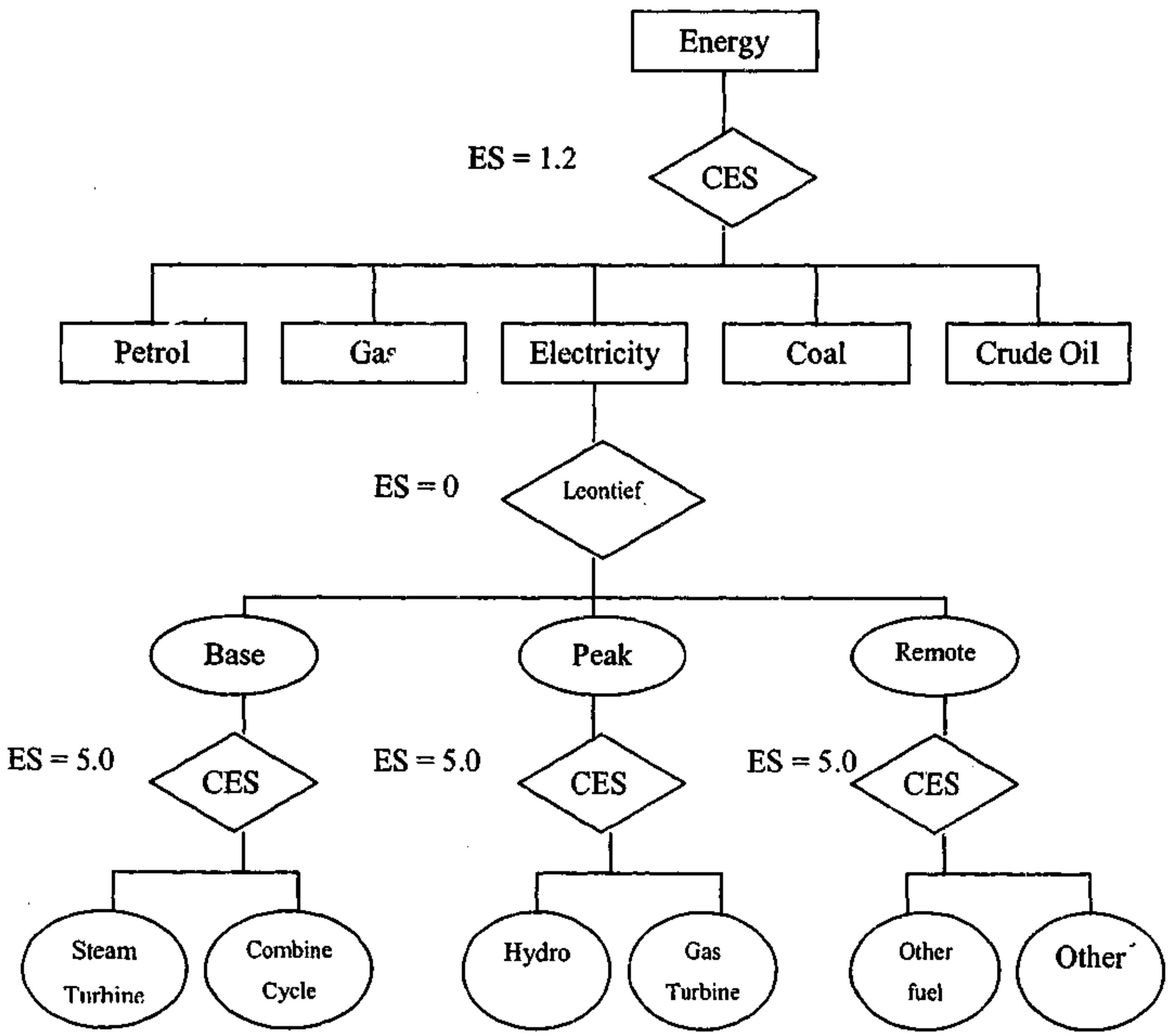
[12] An earlier project was conducted by the then Industry Commission using ORANI-greenhouse (Industry Commission, 1991).

[13] The electricity generation technologies used in ORANI-E are steam turbine, hydroelectricity, gas turbine, combined cycle, other fuel burning, and other non-fuel burning.

[14] The creation of the base and peak markets were not incorporated in MONASH-Electricity, although their inclusion is discussed in Chapter seven.

between energy sources (gas, electricity) is 1.2. As mentioned above, there is no substitution between the base and peak electricity markets.

Figure 2.1



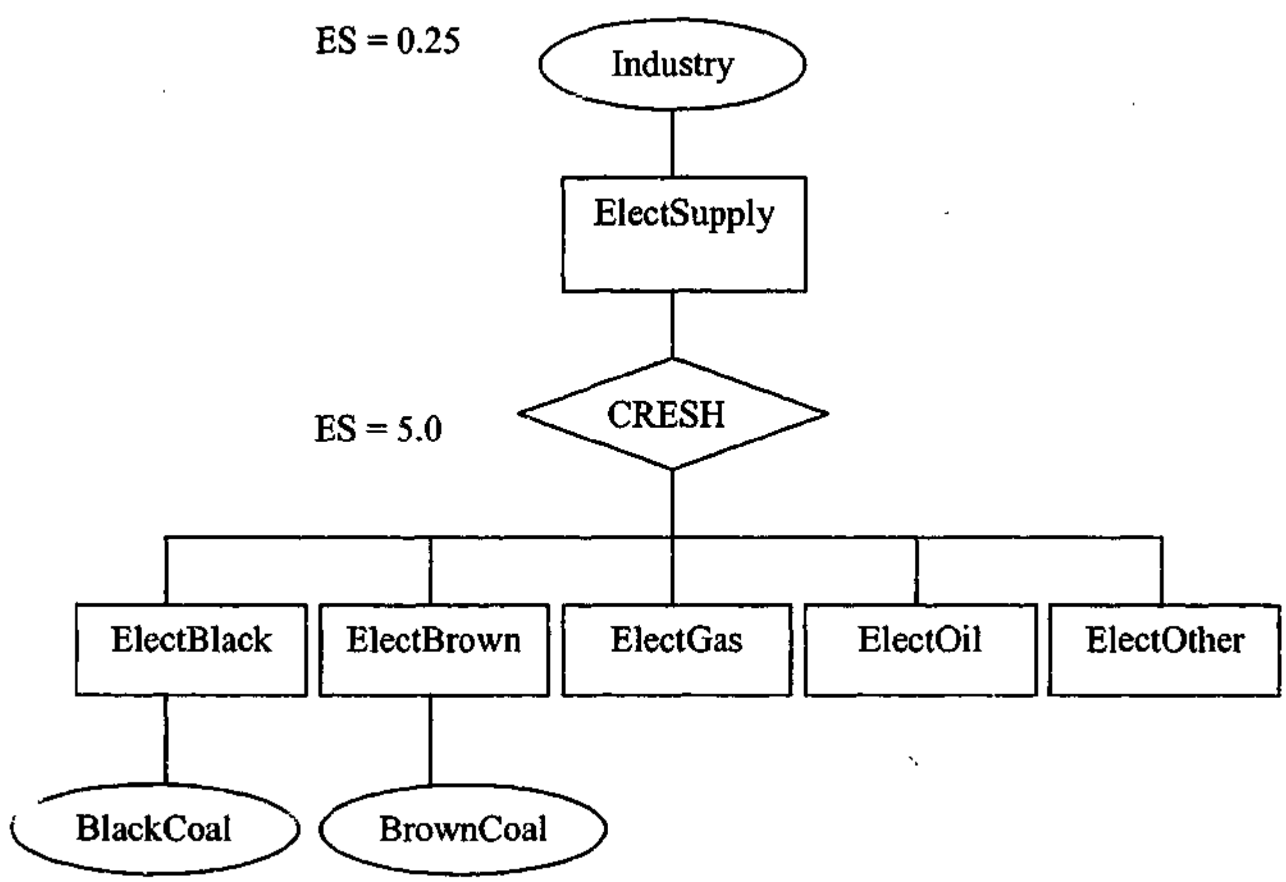
MMRF-Green

Monash Multi-Regional Forecasting-Green (MMRF-Green) is a dynamic CGE model of the Australian economy (Adams, Horridge and Parmenter, 2000a). The model is based on MMRF (Peter et al, 1996) which is a comparative static bottoms up regional model of the Australian economy. The dynamics of MMRF-Green were drawn from the MONASH model (Dixon and Rimmer, 2000).

MMRF-Green includes detailed data on the five main electricity generation techniques in the Australian electricity sector. The model allows for substitution between these fuel sources based on the relative price of each commodity output. As shown on Figure 2.2, the elasticity of substitution between the electricity generators in the MMRF-Green model is 5.0 (Adams et al, 2000) This implies that a 1 percent increase in the price of *ElectCoal* relative to that of *ElectGas* will generate a 5 per cent fall in the ratio of *ElectCoal/ElectGas* used by the *ElectSupply* industry.

For other energy-intensive commodities used by industry, MMRF-Green allows for abatement possibilities by including a similar, but weaker, form of input substitution. In most cases a substitution elasticity of 0.1 is imposed. For three important goods, petroleum products, electricity supply and urban gas, the substitution elasticity is 0.25. If the price of *ElectSupply* rises by 10 percent relative to other inputs to construction, the *Construction* industry will use 2.5 percent less electricity and compensate by using a little more labour, capital or other materials.

Figure 2.2



The model also allows for the endogenous adoption of abatement measures in response to greenhouse policy (Pezzey and Lambie, 2001). The MMRF-Green model gives particular focus to the regional economic impact of greenhouse policy.

A comparison between MMRF-Green and MONASH-Electricity is drawn in Section 2.4 of this chapter.

2.2.2 ECONTECH

MM600+

MM600+ is a comparative static CGE model of the Australian economy. MM600+ is a version of the Murphy Model, as developed by Econtech. MM600+ includes a detailed breakdown of industry sectors, products and product taxes in the Australian economy which enables it to distinguish between many different forms of energy and energy-using industries (Pezzey and Lambie, 2001).

The accounting of CO_2 emissions is over a wider range of sources relative to that used in the other national model, MMRF-Green. Emissions are captured from black coal, brown coal, liquid petroleum gas, natural gas, petrol, diesel fuel, aviation turbine fuel and aviation gasoline (Pezzey and Lambie, 2001). The firms that use these fuels as intermediate inputs are allowed to substitute between those fuels that are considered to be forms of primary energy[15]. In this sense, the substitution possibilities between the intermediate fuel inputs are very similar to those used in MMRF-Green.

A further substitution mechanism found in MM600+ is the ability to substitute between road and rail freight transport in response to changes in energy prices. The household sector of the economy is also able to substitute away from emission intensive goods. For instance, substitution at the household level exists between gas, electricity and fuel.

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[15] Including black coal, brown coal, liquid petroleum gas and natural gas.

The treatment of the electricity sector of the Australian economy is limited in MM600+. Detailed greenhouse emission possibilities are captured in the recognition of the different fuels used in energy production. However, it is assumed that there is only a single industry which represents the electricity generation sector of the Australian economy. Substitution possibilities between the different types of electricity generation in response to greenhouse policy are therefore ignored.

The modellers assume that the greenhouse policy is revenue neutral. Any revenue collected by the government by way of a CO_2 tax or auctioning permits is offset by an adjustment to the rate of labour income tax.

The database used in MM600+ is sourced from the Australian Bureau of Statistics (ABS). It is based on a series of input-output tables which contains data for 107 industries and 1000 products (Pezzey and Lambie, 2001). The database used is therefore significantly more detailed than that used in MMRF-Green.

The results for the Australian economy can be disaggregated using a tops-down technique to the regional level. There are 23 regions classified in MM600+.

2.2.3 ABARE

GTEM

The Global Trade Environment Model (GTEM) is a global CGE model developed by the ABARE. GTEM is based on ABARE's MEGABARE model which is discussed below (ABARE 1996). GTEM divides the world economy into a maximum of 45 regions which are either representative of an individual country (Australia), or a group of countries. The number of regions included in this model is greater than that found in most other global models.

The treatment of national components of an economy, such as the household sector, differs with global models such as GTEM. The household sector has the capacity to substitute between imports from different countries as well as between domestic and imported commodities.[16] A similar situation arises in the case of intermediate inputs. Producers have broader scope to substitute between imported intermediate inputs from different countries.

The treatment of production and technology in GTEM differs from that found in MMRF-Green. Whereas energy goods are treated no differently from other intermediate inputs in MMRF-Green, there exists a separate energy factor bundle in GTEM. The energy bundle allows producers to substitute between the use of primary factors and energy sources such as coal, gas, petroleum and electricity (Pezzey and Lambie, 2001).[17]

The production possibilities that apply to the electricity and iron and steel industries in GTEM differ again. A technology bundle replaces the energy bundles used by the other industries in the model. ABARE argues that "a deficiency of the nested production function approach (used by most other CGE models) is that it does not ensure that the implied pattern of input use is consistent with any feasible combination of activity levels for known technologies." [18] (ABARE, 1997). Industries are allowed to substitute between known technologies in response to changes in relative costs (Pezzey and Lambie, 2001).[19]

The assumption that the elasticity of substitution between the pairs of inputs are identical is removed. Instead, the range of technologies that comprise an industry's technology bundle are represented by a constant ratio of elasticities of substitution homothetic (CRESH) production function. This allows the elasticities of substitution between known

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[16] In national models the household sector can substitute between domestic and imported goods. It cannot however substitute between imported goods from different countries. For instance, the household sector in Australia could not substitute between imported cars from Europe and the US.

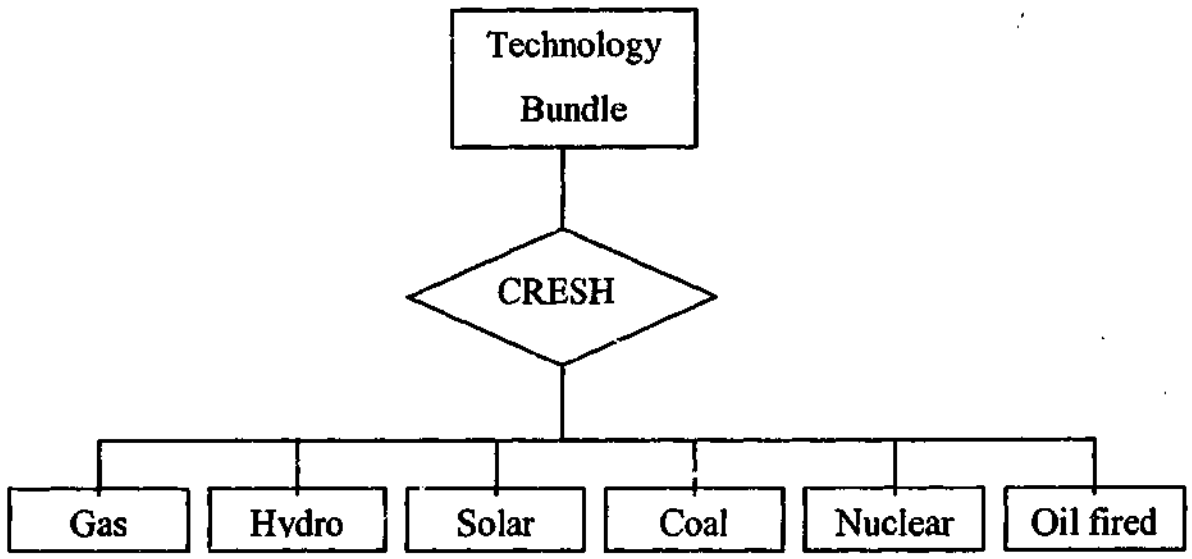
[17] CES substitution possibilities exist between the energy sources.

[18] In the technology bundle, it is assumed that output of a given industry is produced by only a finite number of technologies with distinct fixed (Leontief) input requirements. (ABARE, 1997)

[19] According to Pezzey and Lambie (2001), the differences between the technology bundle approach used by ABARE and the production approach adopted by the other modellers are; the technology bundle does not allow energy inputs to be directly substitutable for either one another or other production inputs; and this approach does not allow output to be produced from currently infeasible technologies.

technologies to differ. Figure 2.3 illustrates the technology bundle approach used in GTEM. The elasticity of substitution applied is 1.7 across all technologies[20].

Figure 2.3



The electricity generation sector of the economy is highly disaggregated in the GTEM model. Electricity generation techniques are identified as individual industries. The industry disaggregation includes nuclear electricity generation. Although Australia does not generate electricity using nuclear power, other countries modelled in GTEM rely on this source of generation. The data requirements to satisfy this level of disaggregation are substantial.

The treatment of trade variables is more pronounced in global models such as GTEM. In similar fashion to the structure of the GTAP model (Hertel, 1997) on which part of GTEM is based, equilibrium trade conditions exist in the model. Specifically, the quantity of each good exported by a country must equal the sum of imports of that same good by all other countries in the model. The model also includes Armington assumptions about traded goods so that commodities produced in different countries are not considered to be perfect substitutes.

[20] Based on personal communication with Stephen Brown, Modelling Coordinator, ABARE.

The treatment of emissions of CO_2 is similar between GTEM and MMRF-Green. GTEM does however include additional information on the measurement of sequestration from afforestation and reforestation activities.

Industries included in GTEM can reduce their emissions by either lowering their activity levels or substituting between energy commodities and/or by using different production practices or technologies (Pezzey and Lambie, 2001).

MEGABARE

ABARE has also engaged in greenhouse analysis using GTEM's predecessor, MEGABARE. Like GTEM, MEGABARE is a multicommodity, multiregion, dynamic, CGE model designed to conduct research on issues facing the global economy.

ABARE used the MEGABARE model to compare Australia's greenhouse policy welfare losses with other Organisation of Economic Co-operation and Development (OECD) countries (ABARE, 1997). To illustrate the economic consequences of uniform emission abatement strategies, two alternative international climate change policies were simulated using MEGABARE:

- less stringent scenario: OECD countries reduce their carbon dioxide emissions from fossil fuel combustion to 1990 levels by 2010 and further reduce emissions to 10 per cent below 1990 levels by 2020;
- more stringent scenario: OECD countries stabilise their carbon dioxide emissions from fossil fuel combustion at 15 per cent below 1990 levels by 2010 and hold emissions at those levels in the period to 2020. (ABARE, 1997)

According to ABARE, the assumed emission reductions are estimated to impose welfare losses (in real gross national expenditure relative to business-as-usual) in OECD countries. The first source of welfare loss is attributable to increases in industrial production costs and consumer prices. Assumed emission restrictions force producers and consumers in OECD countries to move away from carbon intensive fossil fuel use into more costly alternatives. The second source of welfare loss is the impact of the OECD emission abatement policies on the international trading system – in particular on trade in fossil fuels and fossil fuel intensive products. The welfare loss projected for an average Australian is over 22 times that experienced by an average European and just under 6 times that experienced by an American, under the less stringent scenario. (ABARE, 1997)

Whilst the MEGABARE model does not provide regional analysis for Australia, its capacity as a global model enables it to predict the impact of greenhouse issues upon the Australian economy in light of the response of other countries. According to the simulation results, Australia's coal output is projected to decline by around 24 per cent relative to business-as-usual. This is due to the decline in the demand for coal by the domestic electricity sector and a decline in demand from OECD importers such as Japan where emission abatement is estimated to impose a significant economic burden (ABARE, 1997).

2.2.4 AUSTRALIAN NATIONAL UNIVERSITY AND THE UNIVERSITY OF TEXAS

G-CUBED

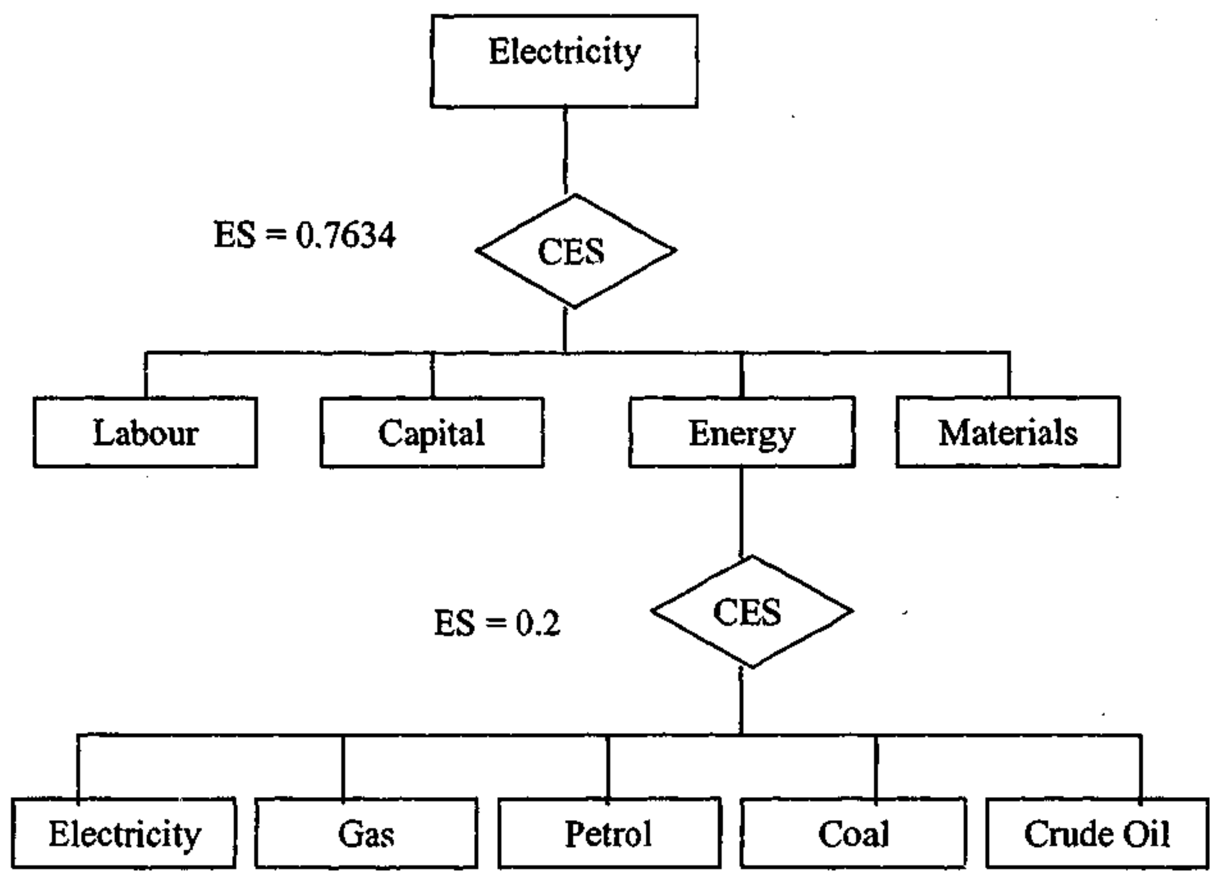
The Global General Equilibrium Growth Model (G-Cubed) is a dynamic global CGE model developed by Warwick McKibbin from the Australian National University and Peter Wilcoxen from the University of Texas.

G-Cubed consists of considerably less countries relative to the GTEM model. It divides the world into eight sectors, each with twelve industries.[21] The household sector of the economy can substitute between capital, labour, energy and materials. There are five goods included in the energy bundle and consumers can also substitute between these goods. The goods in the energy bundle are electricity, gas, petroleum and crude oil. The substitution possibilities available to the producer include the ability to source goods in the

[21] The eight sectors include the US, Japan, Australia, the rest of the OECD, Eastern Europe and the former Soviet Union, China, oil-exporting developing countries, and other developing countries.

energy bundle either domestically or from abroad.[22] Figure 2.4 illustrates a flow diagram of the energy sector of G-Cubed and includes reference to the elasticity of substitution used. According to McKibbin (1998) and McKibbin and Wilcoxen (1995, 1999 and 2000), output in the G-Cubed model can be represented by a constant elasticity of substitution (CES) function of inputs of capital, labour, energy and materials. Energy and materials, in turn, are CES aggregates of inputs of intermediate goods. Elasticities were estimated by constructing time-series data on prices, industry inputs, outputs and value-added for the United States.

Figure 2.4



Because of the relatively small number of industries identified in the G-Cubed model, the electricity sector of the economy accounts for one industry. Given that G-Cubed is a

[22] The substitution possibilities would have to be limited to those energy goods that are conducive to international trade such as crude oil. There could not exist the possibility of substitution between electricity produced in Australia and China for instance due to the fact that electricity cannot be transported without the existence of transmission lines.

global model, the level of data required to disaggregate the electricity sector for all of the countries modelled would be significant.

International trade between countries is determined by each country's demand for imports. G-Cubed requires any trade imbalance in a country to be offset by movements in financial capital between that country and other countries, thereby restoring the balance of payments (Pezzey and Lambie, 2001). The G-Cubed model further assumes that labour can move freely between the industries within a country but cannot flow between countries.

The CO_2 accounting in the G-Cubed model differs in that only emissions from fossil fuel combustion are modelled. G-Cubed includes five energy sectors and incorporates inter-fuel substitution. The energy sectors in the model are electricity utilities, gas utilities, petroleum refining, crude oil extraction, and gas extraction.

2.3 INTERNATIONAL LITERATURE ON CGE GREENHOUSE MODELLING

Section 2.3 provides an introduction to international literature on modelling greenhouse issues. Much of this literature has been developed over the latter part of the last decade due to the recent debate on climate change. The approach taken by the researchers differs greatly. Some models concentrate on the impact of domestic policy upon a single country, whilst others analyse the global impact of climate change. Given the diverse nature of the literature, it is difficult to draw detailed comparisons. The literature is categorised by those who concentrate on global issues and those who are interested in single country models. A brief overview of each research paper is provided. Comparisons are drawn when it is deemed appropriate.

A recent study by Weyant (2000) compared many of the leading CGE models that have been used to analyse the impact of greenhouse issues on the US. Weyant identified five key features that should be used to compare greenhouse CGE models. The features are substitution, innovation, the basecase projections, the policy regime considered, and the extent to which emissions reduction benefits are considered. Weyant argues that differences in these key factors explain the majority of result disparities in the CGE models used for greenhouse policy analysis.

Weyant acknowledges the difficulty of comparing CGE models. The structure of the model itself and the input assumptions made by the modeller all impact upon the results derived. For instance, in the models reviewed Weyant found that carbon price forecasts for meeting the US Kyoto target varied from less than US$20 per tonne to over US$400 per tonne. The impact of these taxes upon the US economy will obviously be very different.

The basecase assumptions made also impact upon the model results. In the case of greenhouse issues, the forecasts for global and regional greenhouse emissions fluctuate considerably. Weyant found evidence of emission forecasts ranging from 20 to 75 percent. Many of these factors depend on the assumptions made regarding the ability of the economy to substitute toward low emission technologies, many of which may not yet be developed.

An Energy Modeling Forum was run by Stanford University where different models were used to prepare the basecase projection of carbon emissions in each world region. Almost all of the models included the US as a world region. The carbon emission levels forecast by the models were made over a considerably wide range. Further studies (Weyant and Hill, 1999) presented four different greenhouse scenarios relating to the reductions in emissions that could be achieved with and without international permit trade. The scenarios were; no trading of international emissions rights; Full Annex I trading of emission rights; Separate trading blocks for the European Union (EU) and for the rest of the Annex I countries; and Full global trading of emissions rights.[23] The models included in the Energy Modeling Forum were used to analyse each of these scenarios.[24]

The general conclusions drawn from the modelling work were that moving from a no trade position to Annex I trade reduces the carbon price required by a factor of two (Weyant and Hill, 1999). Further reductions in the carbon price can be achieved if global emission

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[23] According to Weyant and Hill (1999) the modelling teams only ran the full global emissions trade scenario as a benchmark as they agreed that it is unlikely to be implemented by the Kyoto commitment period.

[24] Details of the models used in the analysis can be found in Box 1 of Weyant (2000).

permit trading is allowed. The models show a similar pattern for the aggregate relative costs of the alternative trading regimes. However there are significant differences in the models' projections of the economic costs to sectors under each regime. Some of this difference can be attributed to how much of the adjustment takes place through reductions in energy use as opposed to reductions in carbon intensity.

In comparing CGE greenhouse models Weyant (2000) concludes that there are two main factors causing variances in the results. The first is the basecase emissions projection against which emissions reductions are compared. The results indicate that the higher the basecase emissions, the greater the economic impacts of achieving a specific emissions target. The second factor is the policy regime considered. The elements of greenhouse policy such as the extent to which international permit trading is included, can have profound effects on the economic impacts of meeting greenhouse targets. Other factors contributing to differences in the modelling results are the substitution mechanisms in the model and the treatment of technical change. Weyant concludes with the statement that flexibility in substitution of less greenhouse gas intensive activities is not a policy choice, but a characteristic of the economy.

Another important factor in the results of CGE greenhouse modelling depends on whether the modeller allows for international trade in emission permits. As will become evident from the literature below, those who take into consideration the incorporation of trade in international emission permits find that the economic cost of greenhouse issues are generally lower. The broader the scope of the model, the lower the economic cost of the policy.

A gap in the literature relates to the treatment of carbon sinks as a policy mechanism for meeting Kyoto commitments. The research tends to focus on the implementation of market-based policy mechanisms such as carbon taxes and the auctioning of emission trading permits. The exclusion of carbon sinks from the literature reflects the uncertainty surrounding its international recognition and adoption.

2.3.1 INTERNATIONAL RESEARCH

Hutton and Edwards – Carbon Taxation in Europe

Edwards and Hutton (1999) developed a static CGE model to analyse the impact upon the EU of environmental taxation. The model is an adaptation of the CGE model created by Fehr, Rosenberg and Wiegard (1995) and includes a linkage to the International Institute for Applied Systems Analysis's integrated environmental assessment model RAINS.

The model encompasses four regions including the UK, Germany, the rest of the European Union, and the rest of the world. The EU accounts for just over 13 percent of global greenhouse gas emissions. The UK and Germany are paid particular attention in the modelling exercise as they account for 20 and 30 percent of EU emissions respectively. Both of these countries are relatively more dependent upon coal based energy than the other countries in the EU.

As outlined in Edwards and Hutton (1999) the basis of the model is a nested CES production function with goods in the same stage of nesting treated as closer substitutes for one another. There are three highly aggregated non-energy sectors and nine energy sectors identified in the model. The consumers in the economy are an aggregate of households, government and other non-profit organisations. The output can be either sold to the consumers or to other sectors as intermediate inputs. All sectors are assumed to be perfectly competitive. Labour is mobile between sectors but not between the regions. Capital is not tied down and can move freely around the world.

The research imposed a 30 ECU per tonne carbon tax on Germany, the UK and the rest of the EU. The carbon tax is applied to all primary fuels according to their carbon content, and to all imported secondary fossil fuels if the country of origin has not already applied a tax. It is assumed that the taxation revenue is recycled as a reduction in value added tax.

The results indicate that savings could be achieved in the order of a 20 percent reduction in CO_2 emissions, at relatively little economic cost to the EU countries. The cost of the carbon tax to the coal reliant countries is 0.12 percent of Gross National Product (GNP) for the UK and 0.04 percent of GNP for Germany.

In addition to their research into the impact of carbon taxation in Europe, Edwards and Hutton have recently authored a publication using the British section of the CGE model of the European energy sectors. The paper evaluates the economic implications of various methods of allocating permits within the UK (Edwards and Hutton, 2001). Different methods of allocating permits in a domestic trading regime are explored. The common methods of auctioning and grandfathering permits are contrasted with the benchmark allocation method. If benchmarking was applied, the permits would be allocated for a short period[25] based on a firm's output in the last period and the best practice pollution rates for that industry.

The UK is faced with a very stringent target of reducing its 1990 CO_2 emissions by 20 percent (UNFCCC, 2001). To achieve this, the researchers assumed that the price of permits was equal to £22-23 per tonne. This is equivalent to approximately AUD$65 per tonne.

The CGE model used in the analysis is considerably smaller than the MONASH model of the Australian economy. The UK CGE model consists of 12 sectors, with 9 of these relating to fuels. There are two factors, labour and capital. In compliance with Lord Marshall's report[26], the carbon emissions in the model are reduced by two methods. Large energy consumers are required to purchase permits whilst smaller consumers are faced with a carbon tax.

The methods used to allocate permits to those large firms operating in the emission permits market are very similar to those used in this thesis. In one instance the permits are auctioned and the revenue is recycled via a general reduction in consumption taxes. Grandfathering and benchmarking methods are also explored.

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[25] Less than five years.

[26] Lord Marshall's Report (1998) to the UK government on *Economic Instruments and the Business use of Energy* analyses many of the main arguments surrounding the implementation of an emission trading market. The report is extended to include a review of the establishment of an international market for trading permits. The report concludes that the high cost of participating in an international emission trading scheme will

The results indicate that welfare and GNP in the UK are lower when the permits are grandfathered. The authors attribute this to the efficiency gains achieved from using auction revenues to reduce other taxes rather than the revenue representing windfall profits to the energy companies, as is the case under grandfathering. A further result suggested that benchmarking the permits improves GNP and welfare relative to auctioning. The difference between the schemes, in terms of GNP, is around £1.25bn per annum. From this alone it can be concluded that the methods of permit allocation have varying impacts upon the UK's economy.

The elasticity of substitution between fuels used in the modelling is 2.0 for the UK and 1.25 for the rest of the EU. Elasticity of substitution between power generation is 4.0 for the UK and Germany and 2.5 for the rest of the EU.

Rutherford

Rutherford et al (1998) identify a number of international models developed by the Charles River Associates for use in climate change analysis. A brief outline of each model follows.

The Integrated Impact Assessment Model (IIAM) consists of eighty small open economies and a six region trade framework. The Multi-regional, Multi-sectoral Trade model (MRT) consists of twenty five regions, five energy goods and a range of one to seven other goods. The Carbon Emission and Trade Model (CETM) has eight regions and several energy intensive goods. Many of these models have been used by Rutherford and others to assess the economic impact of greenhouse issues. The work by Rutherford and various co-authors has been widely published. A selection of this research is outlined below.

Balistreri and Rutherford (2000) use a CGE model to analyse the impact of the Kyoto Protocol upon the State of Colorado in the US. Most of the international literature included in this chapter focuses upon the implications of the Kyoto Protocol upon a single country or globally. To date this is the only study found to focus upon a particular region

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exclude smaller companies. Large companies may participate in the scheme and smaller companies may have to pay a carbon tax.

within a country.[27] This study is important as it acknowledges that some regions are likely to incur a greater burden following the Kyoto Protocol relative to other regions in the same country.

The modellers assume that Colorado participates in a tradeable emissions market. The permits are allocated lump-sum to the household sector of the economy.[28] The estimated price of a carbon permit is US$231 if the US has to meet its Kyoto commitment in the absence of an international permit market. The existence of an efficient international permit market allows the permit price to fall to US$72[29].

The model used to assess the impact of greenhouse issues upon the Colorado economy relies on a number of linked models which predict the economic impact at the global level and for the US as a whole. A multi-regional trade model establishes international trade patterns for the US economy. A model of the US is then used to establish interstate trade patterns. The state level model links the changes in global trade markets, trade flows in the US, and emissions policy to derive results for the individual state economy.

The modellers do not attempt to compute a 50-region model of the US. Instead the US is divided into five regions and ten industries. The State of Colorado is not a precise replication of its host region, but state conclusions can be drawn from the results.

A carbon emission limit is imposed on Colorado. A number of scenarios are simulated to reflect the case where only Colorado is forced to meet its target; where the US introduces domestic measures to meet its Kyoto target; and finally where the world is forced to meet Kyoto targets with and without international trade in emission permits between Annex I countries and between the global economy. As identified above, the carbon price is at its highest when the US acts domestically to reduce its emissions, and at its lowest when full global trade occurs.

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[27] In some senses a single-country within the EU could be treated as a region.

[28] Reflecting grandfathering revenue techniques where the permits are allocated free of charge.

[29] This price is still considerably high relative to other assessments.

A CES nested production structure is used in the model. The electricity sector is highly aggregated relative to other models. At the lowest level of the production structure there exist substitution possibilities between coal and gas. A producer can then substitute between coal/gas and oil. At a higher level again substitution is allowed between the fossil-fuel composite and electricity. Finally capital and labour can be substituted with energy. A different nested structure is used for household consumption. Households can substitute between oil, gas, coal and electricity.

The results indicate that the Gross Product falls the furthest under the situation where the US Government attempts to meet its Kyoto target by relying solely on domestic policy. The greater the trade in international permits, the greater the improvement in the result for Gross Domestic Product (GDP). The scenario where emissions permits are traded internationally represents the lowest cost to the Colorado economy.[30] The results at the industry level show collapses in economic activity in most of the sectors. Those industries experiencing a high economic downturn include electricity and natural gas distribution.

The overriding conclusion drawn from the research is that regions may be in fundamentally different welfare positions following greenhouse policy, compared to the nation as a whole.

In addition to the above research, Thomas Rutherford has been involved in a number of other projects using CGE modelling techniques to assess the impact of greenhouse issues.

Böhringer, Rutherford and Vo (1999), model the economic impacts of greenhouse gas reduction. The authors identified three important elements included in their CGE model. Firstly, the regional disaggregation of the model should include all major trading partners of the unilaterally acting country. Secondly, the sectoral disaggregation of the model must cover those sectors which are emission and trade intensive. Thirdly, the representation of international trade needs careful analysis in terms of empirical evidence.

The model used is a static large-scale general equilibrium model for the EU. The model includes 23 production sectors and a detailed description of final demand in the most

[30] Remembering that the permit price under this scenario was significantly lower.

emission intensive countries within the EU: Germany, France, UK, Spain, Italy and Denmark.

Two policy simulations are implemented for unilateral action in Germany. In the first simulation Germany applies uniform carbon taxes sufficient to meet exogenous unilateral reduction targets. In the second simulation Germany issues tradeable emission permits on a grandfathered basis.

The main findings of the research are that the induced trade effects of unilateral action would make a policy of grandfathered permits pareto-superior compared to uniform taxes.

Rutherford et al (1998) use a different model to consider the impact of taxation policies which share the burden of abatement with future generations. The authors use an overlapping generations (OLG) model. The conclusions drawn are that an OLG model is an important tool for evaluating the prospects of a double-dividend. The authors further consider the intergenerational incidence of carbon taxes combined with alternative revenue-recycling strategies. A multisectoral CGE model for the German economy is used for this analysis.

Additional policy questions addressed by Rutherford and others (Babiker et al, 1997) within a CGE framework include whether lobbying by energy-intensive producers in the OECD could result in a decision to limit energy-intensive imports from non-OECD countries. Given the market power of the OECD it is possible that this stance could improve the welfare of the implementing nations by effectively passing some of the abatement costs onto the developing countries. The results of the study indicate that the trade interventions are in fact beneficial to the developed nations, but reduce global efficiency.

Böhringer – CGE Environmental Modelling of European Union

Böhringer, Jensen and Rutherford (1999) use a dynamic multi-sector, multi-region general equilibrium model for the EU to analyse the impact of meeting the Kyoto target upon six of the member states[31]. As mentioned previously, the outcome of the Kyoto Protocol for the EU is an overall target of an 8 percent reduction in its 1990 emission levels. Member states are not given individual targets. This allows the EU some flexibility in how it achieves its Kyoto commitment. It also raises a number of allocative issues, some of which are discussed in Böhringer et al (1999).

The modellers analyse the impact of greenhouse policy upon the six member states under the assumption that differentiated targets are applied to each. The importance of basecase projections is stressed by the modellers. The basecase is particularly significant for this type of research where the member states differ with respect to their CO_2 characteristics.[32]

In a separate project, Böhringer and Rutherford (1998) analyse the use of voluntary agreements (VA) between industry and government in meeting a country's environmental commitments. An example of a VA in the Australian context is the Greenhouse Challenge program run cooperatively between the government and industry groups. The popularity of VA's stems from the fact that they are generally more acceptable to industry and are perceived to be more cost-efficient than regulation.

The approach by Böhringer and Rutherford (1998) uses a two-sector model with the VA represented as a system of tradeable grandfathered permits. The research finds that the VA can result in significant efficiency losses as compared to carbon taxes or auctioned permits. This outcome is due to the creation of scarcity rents by the VA which work as subsidies to the firms.

Another study by Böhringer and Rutherford (1995) predicts that for a 20 per cent cut in emissions in Germany, a carbon tax range of 1990 of £16 – £39 in 1992 prices is required.

McKibbin and Wilcoxen

McKibbin and Wilcoxen have been active participants in the debate over greenhouse issues and the Kyoto Protocol. The authors have jointly developed the McKibbin-Wilcoxen

[31] The model includes Denmark, France, Germany, Italy, Spain and the UK.

[32] The fuel mix used in electricity generation differs significantly between the EU.

Proposal to introduce a plausible solution to greenhouse issues prior to the full implementation of the Kyoto Protocol. As discussed in Section 2.2.4 above, the authors have additionally been involved in modelling the economic impacts of greenhouse scenarios using the global G-Cubed model.

McKibbin and Wilcoxen (2000) outline what they perceive to be the main limitations of the Kyoto Protocol and propose a method of overcoming some of these shortcomings. McKibbin and Wilcoxen believe that the success of an international agreement on reducing global emissions rests with the inclusion of permit trading. In a series of papers the authors argue that the economic pressures caused by the large transfers of wealth internationally (that underlie the claims over permits) could cause severe fluctuations in real exchange rates and international capital and trade flows (McKibbin and Wilcoxen 1997a and 1997b).

McKibbin (2001) puts forth the McKibbin-Wilcoxen Proposal as an early action policy to be implemented while countries continue to work through the mechanisms of the Kyoto Protocol. McKibbin (2001) argues that early action should be less complex than the suggestions surrounding the Protocol "while it would be nice to include alternative gases and sinks as part of a policy, it is an administrative nightmare to deal with them in the near term and adds enormous complexity to the task".

The McKibbin-Wilcoxen Proposal is based on the creation of two emissions-related assets and associated markets for each country (McKibbin, 2001). The assets are known respectively as an emission permit and an emission endowment. The emission permit is valid for a period of 12 months, whereas the endowment entitles the holder to an annual emission permit. The number of emission endowments initially allocated would reflect a country's CO_2 policy target. The price of endowments is variable and will move in response to the demand and supply of the asset. The emission endowment is a long term mechanism for ensuring that the economy meets its international climate change agreement.

On the other hand, the price of the emission permit would be fixed but the quantity of CO_2 released variable. The emission permit market relates to the short term costs of complying with greenhouse targets. McKibbin and Wilcoxen propose that the permit price is fixed for a period of 10 years at US$10 for all countries[33]. The price could be changed within this period by international negotiated agreement. According to the authors, a producer that wants to emit a unit of carbon for domestic use can obtain a permit in a given year by either having an existing emission endowment, purchasing an emission endowment in the endowment market (sold by another private holder of an endowment), or purchasing an emission permit in the permit market that is either supplied by a private owner or the government. Emitters of CO_2 do not have to purchase both a permit and endowment to emit the one tonne of CO_2.

The price of the emission permit is the marginal cost of abatement in a particular year, whilst the price of the endowment is the expected future marginal cost of abatement (McKibbin and Wilcoxen, 2000). The owner of the emission endowment has many options available. The first is to claim the emission permit and use it internally, the second is to sell the permit at the current market price (and abate), the third option is for the owner to sell the endowment on the open market. An endowment should only be sold if the owner believes that the current market price is higher than the price they expect to receive in the future.

The existence of the emission permit market would cease during the Kyoto Protocol's commitment period (2008-2012). Assuming that the level of emission endowments is equal to the CO_2 emissions target during the commitment period, firms should not be allowed to purchase additional permits from the market. If such a situation arose, the objective of reducing global emissions could not be achieved.

The McKibbin-Wilcoxen Proposal also incorporates developing countries who are not signatories to the Kyoto Protocol. An endowment market could be established in each of the developing countries, however the endowment would far exceed current requirements. With the number of endowments exceeding present emission levels, there would be no need for developing countries to purchase emission permits, and therefore no short-run cost. The price of endowments in developing countries would be positive as they reflect

[33] The domestic price of the permits remains unchanged as the government sells as many permits as necessary to maintain the market price at US$10 (McKibbin and Wilcoxen, 2000).

the expected future price of permits. This acts as a price signal that will affect the current investment plans without influencing short-run costs (McKibbin, 2001).

The McKibbin-Wilcoxen Proposal works on the principle of an international price which avoids the need for the development of an international emissions trading market and global monitoring of emissions. The authors predict that the McKibbin-Wilcoxen Proposal could be modified to reflect the elements of an international emission trading market when and if the Kyoto Protocol is ratified.

As mentioned above, the G-Cubed model has been used to analyse the impact of international permit trading. In McKibbin, Shackleton and Wilcoxen (1998), three policy scenarios are considered. The first is the unilateral stabilisation of US carbon emissions at 1990 levels, secondly the stabilisation of OECD emissions at 1990 levels without international permit trading, and thirdly joint stabilisation of OECD emissions with full international permit trading. Of particular interest is a comparison of the results for the second and third policies where international emissions trading is considered.

The results suggest that the existence of international emissions trading reduces the losses incurred by the OECD under the alternative scenarios. Given that the countries modelled were limited to those in the OECD, an unexpected result of the simulation arose. Contrary to expectations, the US became a net exporter of emission permits as it can reduce its emissions at a relatively low cost.

TAIGEM

A team of researchers in Taiwan have adopted some of the principles of the ORANI-E, MEGABARE, and GTEM models of the Australian economy to assist them in developing TAIGEM (TAIwan General Equilibrium Model). TAIGEM is a dynamic, multisectoral CGE model of Taiwan's economy. The model has been created to analyse the impact of greenhouse issues upon Taiwan.

TAIGEM uses the technology bundle approach developed by ABARE (1996). The electricity industry in the economy is made up of a number of different generation technologies.[34] The model allows the electricity industry to substitute between the technologies in response to changes in their relative costs. TAIGEM restricts substitution to known technologies, thereby preventing technically infeasible combinations of inputs being chosen as model solutions (Li et al, 2000).

Unlike many of the other CGE models reviewed in this chapter who use CES aggregations, TAIGEM uses CRESH. The output of the electricity sector is a CRESH aggregate of each electricity technology, and this technology requires fixed proportions of intermediate inputs, with the exception of energy inputs and primary factors (Li et al, 2000).

Jensen – CGE Model MOBIDK of the Danish Economy

Research by Jensen (1998) uses a dynamic CGE model of the Danish economy to analyse the economic impact of Denmark meeting its Kyoto target. Denmark faces a reduction in its CO_2 emissions of 20 percent relative to its 1990 emission levels.

The model includes seven production sectors, seven energy goods, and three non-energy goods. These sectors capture inter-industry relations and differences in carbon intensities across fuels and sectors. Price wedges represent existing indirect taxes.

The electricity sector in the Danish economy is similar to that of Australia in that it relies on coal-fired generators. The elasticity of substitution between energy and non-energy used in the model is less than one.

The research uses the CGE model to compare the impact of Denmark meeting its Kyoto commitment in a short time period (2005) with a long-run approach (2015).[35] The results indicate the short-run impact of implementing this policy target on the Danish economy is equivalent to a welfare loss of 20 percent of GDP. The long run analysis results in a lower welfare loss of 13 percent of GDP.

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[34] Electricity generation technologies include; hydro, steam turbine-oil, steam turbine-coal, steam turbine-gas, combined cycle-oil, combined cycle-gas, gas turbine-oil, gas turbine-gas, diesel, and nuclear.

[35] The reason the Kyoto commitment period of 2008-2012 was not chosen as one of the simulation years is unknown.

Conrad and Henseler-Unger – GE for Long Term Energy Policy in Germany

Conrad and Henseler-Unger (1986) use a general equilibrium model to compare the long-term economic performance of an energy policy based on nuclear power versus an energy policy based on coal-fired power plants. The research concentrates on the German economy which is export orientated and relies on low cost energy.

The energy sector of the model is relatively detailed as it includes ten industries. According to the authors, the methodological novelty of the model is an integration of the price-dependent input coefficients with input coefficients of the latest vintage. This concept considers the aspect of price substitution as well as changes in the input structure due to advances in technology in the latest investment projects. The elasticity of substitution was assumed to be 0.5 in each sector of the model, including electricity.

Pench – Ecotaxes in Italy

Pench (1999) uses a multi-country CGE model of the EU to analyse the economic impact of greenhouse issues upon the Italian economy. The tax reform simulated in the model represents an additional 20 percent ad valorem tax on total output of the energy sector. The tax is offset by an increase in transfers to consumers to ensure that public expenditure remains unchanged.

The model used in the analysis is based on eight countries, two primary factors (labour and capital) and fourteen commodities.[36] The tax reform results in a welfare gain for Italian consumers as Italy is an energy importing country. Imposing a carbon tax results in a reduction in Italy's import bill and a consequent rise in its exchange rate. This outweighs the negative effects of a carbon tax on energy and actually causes a rise in real incomes. Similar results are found in Edwards (1998) for Germany.

[36] The countries included in the model are France, Belgium, The Netherlands, Germany, Italy, United Kingdom, Denmark and a country representing the Rest of the World.

Proost and Van Regemorter – General Equilibrium Modelling for Belgium

Proost and Van Regemorter (1993) survey the economic modelling needs for energy related environmental problems in the European Community. Whilst the survey was completed in 1993, many of the modelling techniques adopted are applicable today.

According to Proost and Van Regemorter (1991) a general equilibrium approach is necessary to analyse the full effects of greenhouse policy upon income distribution. This is particularly the case if environmental taxes are employed as the revenue can be reinjected outside the energy sector under consideration. The authors argue that a GE approach is important so that deeper substitution possibilities and trade effects for non-energy commodities can be measured.

Proost and Van Regemorter were involved in the development of the GEM-E3 general equilibrium model. GEM-E3 stands for General Equilibrium Modelling Project for Energy-Economy-Environment.

Breuss and Steininger – CGE for Austria

Breuss and Steininger (1998) use a CGE model to explore the hypothesis that for a given CO_2 target, any reduction in non-neutral CO_2 emissions brought about by increased biomass energy use, reduces the stringency level of the CO_2 policy. The CGE model used is based on Bergman (1990, 1991). Modifications to the model include further development of the sectoral structure, foreign trade modelling, revenue recycling options, and energy supply features.

The option of increased biomass energy use is evaluated within the framework of, and compared to, greenhouse policy by means of a tax and/or permit scheme and different modes of revenue recycling. For the purposes of the research, biomass is treated as an alternative source of energy supply that is CO_2 neutral in origin. In other words, an energy source that does not increase atmospheric concentration levels. Biomass decreases the necessary CO_2 tax level, and therefore the opportunity cost of biomass energy use itself. For example, without the use of biomass Australia is likely to require a carbon tax in excess of $50 to achieve its Kyoto commitment. However substituting toward this fuel source may allow the tax to decrease to $45. This is based on the assumption that the calculation to derive the $50 tax did not allow for energy substitution.

Other CGE Models used for Greenhouse Analysis

There are a number of other CGE models used as a tool to analyse the economic impact of greenhouse policy on a region or on a global scale. Amongst the models reviewed are:

- Dellink (2000) – dynamic CGE Model with pollution and abatement for the Netherlands;
- Uri and Boyd (1999) – CGE Model for Mexico used to predict the economic impact of price increases in gasoline and electricity[37];
- Xie and Saltzman (2000) - CGE analysis to measure the economic impact of China complying with greenhouse targets[38];
- Manne and Richels (1992) - ETA-MACRO model;
- Gottinger (1998) [39].

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[37] The model consists of 13 producing sectors, 14 consuming sectors, 4 household categories and a single government.

[38] The CGE model used is an adaptation of the Cameroon models (Condon et al, 1986, and Devarajan et al, 1991) but has specific links between pollution control and economic activities. Particular environmental consideration adapted in the model include: pollution abatement activities and pollution abatement costs of production sectors; pollution taxes; pollution control subsidies; environmental compensation; separately accounted environmental investment; and, various pollution indicators (Xie et al, 2000).

[39] The paper is an excellent reference for those interested in developing a CGE model to analyse greenhouse economic issues. However the absence of details relating to a country's energy sector does not allow the model to be compared to other CGE models used to analyse the impact of greenhouse issues upon a particular economy.

2.4 SIMILARITIES AND DIFFERENCES BETWEEN MMRF-GREEN AND MONASH-ELECTRICITY

The equation structure and greenhouse accounting mechanisms used in MONASH-Electricity are drawn heavily from MMRF-Green (Adams et al, 2000b). Section 2.4 compares the two models, highlighting the similarities and the distinctions for the reader.

2.4.1 SIMILARITIES

MONASH-Electricity is based predominantly on the MONASH model of the Australian economy as developed by the CoPS. The greenhouse equations incorporated in the model are however based on those in MMRF-Green. Whilst these models approach the policy analysis from a different viewpoint, they are based on the same inter-relationships. Both models are dynamic CGE models of the Australian economy. The MMRF-Green model provides a more regional focus to policy analysis whilst the MONASH model concentrates on the macroeconomic impacts. Both models can generate results for the macroeconomic, state and statistical division level of the Australian economy[40].

The main similarity between MMRF-Green and MONASH-Electricity in the context of greenhouse modelling, is the accounting of greenhouse gases and the mechanisms for implementing greenhouse policy. The Tablo code[41] used in both models allows greenhouse policy to be implemented via an increase in the tax on the intermediate usage of CO_2 emission intensive fuels. In both models the revenue is redistributed via a reduction in household consumption tax or as a reduction in household disposable income. Many of the variables defined in MMRF-Green are found in MONASH-Electricity.

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[40] Due to its reliance on the above mentioned CGE models, MONASH-Electricity holds similarities with both models. MONASH-Electricity is a modification of the existing MONASH model. The discussion on the differences between the models can therefore be limited to MONASH-Electricity and MMRF-Green.

[41] The Tablo code provides a description of the model for computer generation (see Harrison and Pearson, 2000).

The original database used in both of the models is based on a national input-output table published by the ABS. Regional input-output data was initially sourced from the ABS but some modifications associated with the disaggregation of the energy sector were deemed necessary.

2.4.2 DIFFERENCES

There are two distinct areas of difference between the MONASH-Electricity and MMRF-Green models. The first group of differences relate to the physical structure of the model. These differences can also be drawn between the MONASH and MMRF-Green models. The second distinction relates to particular model modifications made to improve the economic CGE analysis of greenhouse issues. These differences would also be apparent if a comparison was made between MONASH and MONASH-Electricity.

A main structural distinction between the MONASH-Electricity model and MMRF-Green is that the former provides results at the macroeconomic level which are subsequently disaggregated to the state and statistical division level using a tops-down methodology. MMRF-Green is a regional model which derives macroeconomic results by aggregating state regional results. Another notable difference between the models is the number of sectors included in each. Disaggregations to the standard MONASH[42] model derive a MONASH-Electricity database with 128 industries, 130 commodities and 8 occupation groups.[43] The MMRF-Green model is divided into eight regions representing the states and territories of Australia. Each region includes 40 industries and 42 commodities (Adams et al, 2000).

Most of the distinction between the two models can be drawn between the modifications made to improve the analysis of greenhouse policy. Arguably the greatest difference is in the disaggregation of the original electricity industry. Both models involve a more detailed electricity sector relative to the MONASH model and the ABS input-output database. The

[42] The standard MONASH model includes 113 industries, 115 commodities and 8 occupation groups (Dixon and Rimmer, 2000).

[43] Full details of the disaggregation are found in Chapter five.

degree of industry detail and the methodology used to disaggregate the electricity industry is however dissimilar.

MMRF-Green disaggregates the original electricity industry into five new industries which sell their output to a single electricity supply industry. MONASH-Electricity also disaggregates to this industry level but the classification of the new industries is slightly different. Both models include electricity generation from brown coal, black coal and gas. MMRF-Green also includes oil generation and hydro. MONASH-Electricity includes hydro electricity only.

A significant improvement incorporated in the MONASH-Electricity disaggregation is the acknowledgment that the Australian electricity industry consists of three distinct sectors. To improve the accuracy of greenhouse modelling, MONASH-Electricity disaggregates the original electricity industry into the three arms – generation, transmission and retail. The economic cost of greenhouse policy falls unequally upon these sectors and should be reflected in the industry results. The benefit of this disaggregation is highlighted in the statistical division results (discussed in Chapter six) where the burden of greenhouse policy rests with those regions who support the generation sector of the electricity industry.[44]

MONASH-Electricity includes more extensive disaggregation of the electricity industry with the brown coal generators recognised as separate industries. The regional focus of the thesis encouraged the disaggregation of the brown coal electricity industry into the individual generators. This level of detail allowed the impact of greenhouse policy upon the generators to be assessed, and the associated regional implications explored.

Another difference between the models stems from the disaggregation method adopted. In MMRF-Green the electricity supply industry does not use primary factors or other materials and services. The only intermediate input purchased is electricity from the generators. All of this electricity is then sold to end users such as households. Due to the way in which the original electricity industry was disaggregated in MONASH-Electricity,

[44] Without this level of disaggregation at the statistical division level, the burden of greenhouse policy may incorrectly appear to fall on populated areas such as Sydney due to the active retail arm of the industry in the city.

it was assumed that the electricity supply industry uses intermediate inputs. The electricity supply industry is representative of the retail arm of Australia's national electricity market (NEM). It would therefore be expected to use other inputs in its supply of electricity to the end consumer.

The additional industry breakdown facilitates greater levels of substitution between the electricity generators than is incorporated in MMRF-Green.

An attribute of the MMRF-Green is that it includes emissions from agriculture and the recognition of carbon sinks. Emissions from agriculture and sequestration from carbon sinks are treated differently from the treatment of CO_2 emitting fuels. Although beyond the scope of this thesis, it is acknowledged that the exclusion of these emissions is a limitation of the MONASH-Electricity model. Methods of addressing this limitation are outlined in Chapter seven.

MMRF-Green imposes a tax on the use of CO_2 emitting fuels such as brown coal. The tax indirectly impacts upon the electricity generators via their use of fuel as an intermediate input. Those generators who rely on more emission intensive fuels will find that they carry a higher tax burden. This leads to unequal changes in price which in turn stimulates generator substitution by the electricity supply industry.

MONASH-Electricity also imposes a tax on the use of CO_2 emitting fuels. It however recognises that the different methods of electricity generation produce different levels of CO_2 per megawatt hour (MWh). The treatment of emissions for the electricity industry is therefore based on tonnes of CO_2 per MWh generated. This differential treatment allows three separate shocks to be applied to capture the impact of greenhouse policy.[45] Similarly to MMRF-Green, a tax is placed on intermediate usage of the energy fuels. Additional taxes are placed on the electricity generators in the economy, including a specific tax on the brown coal electricity generators.

[45] A single shock representative of greenhouse policy is used in MMRF-Green.

A final difference worth noting is the tax shock itself. Whereas MMRF-Green treats the CO_2 tax as an increase in a specific tax rated per tonne of CO_2, MONASH-Electricity simulates an increase in the power of the tax.

2.5 CONCLUSION

This chapter has explored the Australian and international literature on using CGE modelling techniques for greenhouse policy analysis. Section 2.2 provided an overview of the main models used in the Australian context and clearly outlined their main differences. A comparison of international literature was provided in Section 2.3.

The chapter concluded by drawing on important comparisons between the MONASH-Electricity model and its predecessors MONASH and MMRF-Green. A discussion of both model similarities and differences was included in Section 2.4.

CHAPTER THREE

GREENHOUSE POLICY

3.1 INTRODUCTION

At the Kyoto Climate Change Conference held in December 1997, an agreement was reached between industrialised nations to reduce their collective greenhouse gas emissions by a total of 5.2 percent below 1990 levels in the commitment period 2008 to 2012 (UNFCCC, 1997). The commitment period is a five year time period during which the Parties to the Kyoto Protocol must meet their agreed targets[46]. It is unknown whether future commitment periods will run concurrently (2013-2017) or after a specified time (for example, 2015-2020).

Kyoto was the third conference of the parties of the United Nations Framework Convention on Climate Change (UNFCCC). Australia's commitment to the agreement involves an allowance to increase its emissions by 8 percent on the 1990 base year level (Department of Foreign Affairs and Trade, 1998). Australia's original projection of emissions growth was 43 percent above 1990 levels by the Kyoto commitment period (Department of Foreign Affairs and Trade, 1998). According to Australia's second national communication to the UNFCCC, its 'business-as-usual' emissions in 1990 were 380Mt (Sturgiss, 1998). Australia has agreed to reduce its emissions by 22.8 megatons (Mt) by 2012 to meet its Kyoto target.

Australia, who is the 16th largest emitter by volume of CO_2 and the second largest emitter when ranked on a per capita basis, argued at Kyoto that uniform reductions should not be enforced (U.S. Dept. of Energy, 1994). The Australian Government put forth the argument that a uniform target would disadvantage Australia relative to other developed nations such as those in the European Union.

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[46] A Party to the Kyoto Protocol is a country who participated in negotiations.

As the world's largest coal exporter, the third largest aluminium exporter, and one of the largest energy exporters amongst OECD countries, the Australian Government argued that it would incur a higher cost than other developed nations as these areas of export strength are CO_2 emission intensive.

Other industrialised nations such as Japan and the US face more stringent commitments under the Kyoto Protocol of 6 and 7 percent reductions respectively. Section 3.2.3 explains the current position adopted by the US on the Kyoto Protocol.

Subsequent meetings of the UNFCCC have attempted to strengthen the commitment of the Parties and to eradicate issues that were left unresolved at Kyoto.[47] Such issues included the recognition of carbon sinks, the debate surrounding land clearing, and perhaps most importantly, the participation of developing countries via the clean development mechanism (CDM). Whilst it is important to recognise the progress that has been achieved post Kyoto, the Protocol remains the key international agreement to which Parties are negotiating. The discussion throughout this chapter will therefore refer to the Kyoto Protocol with the inherent assumption that it includes all subsequent international negotiation that has taken place.

The Parties to the Kyoto Protocol have had difficulty in reaching agreement on many of the issues mentioned above. There are two main factions, which have different views on the scope and development of international emissions trading and some of the other key issues, such as the recognition of carbon sinks. An Umbrella Group incorporating the United States, Australia, New Zealand, Japan, Canada, Russia, Norway, Iceland and the Ukraine believes that the participation of the developing countries via an international emissions trading arrangement and the CDM is essential for global emission reductions. The Umbrella Group also supports the inclusion of carbon sinks as a method of sequestration used to offset emissions. The opposing view is held by many members of the European Union who believe that the recognition of carbon sinks should be excluded from the Protocol. This group believes that carbon sinks provide only a short term solution which allows the Umbrella Group to avoid meeting their targets through abatement.

[47] COP4 in Buenos Aires, November 1998; COP5 in Bonn Germany, November 1999; and COP6 in The Hague, November 2000.

Section 3.2 of this chapter provides an overview of the Kyoto Protocol. Section 3.3 provides an international perspective on greenhouse emission trading. This is followed by a summary of Australian greenhouse policy in Section 3.4. The chapter is concluded in Section 3.5.

3.2 THE KYOTO PROTOCOL

The science of global warming and climate change is not new but it has received more attention in the last decade as the global community has begun to recognise the environmental and economical significance of the greenhouse effect. The greenhouse issue is a global problem. Some scientific studies have concluded that regardless of the source of the emission, it will have the same long run global environmental impact.[48]

Like any science, the validity of the environmental impact of greenhouse gases has been widely debated. Many scientists argue that the greenhouse issue is likely to have detrimental impacts upon the world via global warming. There are however a number of scientists who argue that the effects of greenhouse gases are overestimated. In recent years, these two groups of thought have come to some form of consensus by agreeing that the increase of CO_2 in the atmosphere, as a direct result of human industrialisation, has contributed to global warming. Although the relativity of the cause and effect is still the subject of discussion, both parties agree that this is an issue that needs to be addressed today to avoid the negative repercussions of global warming in the future.

The science of greenhouse gases has been acknowledged by the Parties to the UNFCCC since 1994. Arguably the most important Conference to date was held in Kyoto in December 1997. As mentioned in the introduction to this chapter, the outcome of the Kyoto Protocol is that the developed nations have agreed to reduce their emissions of greenhouse gases in aggregate by 5.2 percent below 1990 levels in the commitment period (UNFCCC, 1997). Further to this, the Protocol allows countries to have differentiated

[48] According to scientists, the environmental impact of one thousand tonnes of CO_2 released into the atmosphere is the same regardless whether the emitting country is Australia or Canada.

targets and supports the inclusion of carbon sinks and the establishment of a tradeable emissions market. Two notable exclusions from the Kyoto Protocol are the incorporation of developing nations and the absence of a formal policy definition to assist countries in meeting their targets.

The rest of this section outlines three of the main issues which have raised interest in light of the Kyoto Protocol and more recent Conference of Parties (COP) negotiations. The first is the exclusion of developing nations from the agreement. The second issue is the uncertainty surrounding the mechanisms of the Protocol itself. The remainder of the section provides an account of the international stance of the Kyoto Parties.

3.2.1 A GLOBAL PROBLEM

The main criticism of the UNFCCC, and in particular the Kyoto Protocol, is that it is trying to solve a global problem without the participation of the global community. Greenhouse gas emission control is a global problem, the solution to which involves a diverse group of disciplines, with arguably the greatest role being played by politics and economics.

The overall aim of the UNFCCC is clearly defined as the reduction in the volume of greenhouse gases in the earth's atmosphere (UNFCCC, 2001). However, there are strong political forces surrounding the greenhouse issue. Each country is willing to concede that globally there is a need to reduce CO_2 emissions, but no one country is prepared to take positive action if they have to incur greater economic costs relative to other countries. Such political pressure has resulted in differentiated targets for developed countries and the exclusion of developing countries from the agreement altogether.

The reason developing nations are not included as Parties to the Kyoto Protocol stems from the UNFCCC's recognition that placing restrictions on the amount of CO_2 they emit may limit their capacity for growth, and consequently, for an improvement in their standard of living. On a per capita basis, developed countries emit more CO_2 than the developing nations. It is argued that those countries who have traditionally been the largest emitters should bear the burden of abatement.

The exclusion of developing countries as signatories to the Kyoto Protocol however limits the effectiveness of the agreement. The developing nations are estimated to become the largest greenhouse gas emitters in the first half of this century as their economies rapidly expand. "In the past decade world energy demand has risen by more than a fifth. The main drivers of energy demand growth are the pressures of population increase and population shift from rural to urban areas, together with industrial and economic development. The world's population is forecast to grow by more than 50 per cent from 5.2 billion to 7.8 billion by 2020" (PowerGen, 2000). The vast majority of this growth is predicted to occur in the developing world, particularly in China and India.

According to scientists, even if the developed world meets its Kyoto commitments, long run aggregate reductions in global emissions will be negligible without the participation of the developing nations. Projections by the US Energy Information Administration indicate that by 2020 total greenhouse gas emissions by developing countries will exceed those of the developed countries and economies in transition (known as Annex B countries). This raises substantial questions about the effectiveness of emission reductions in the medium term and the evolution of a sustainable trading system (Hagan, 1998).

The developed world has clearly indicated that it is not willing to be disadvantaged by the Kyoto Protocol, especially with trading partners and competitors in the developing nations. In many instances industrialised nations are not prepared to undertake abatement measures beyond 'no regrets'. A 'no regrets' response to climate change means that if at some time in the future the scientific community no longer perceives greenhouse emissions to be a serious issue there will be 'no regrets' for having taken action (Gray and Rivkin, 1991). A country such as Australia is willing to undertake abatement activities only if they also have more immediate positive environmental impacts. However, evidence suggests that 'no regrets' measures will be insufficient for countries such as Australia to meet their abatement target. To satisfy greenhouse gas emission abatement commitments, additional measures will be necessary.

A further issue stemming from the exclusion of developing nations from the Kyoto Protocol is whether organisations traditionally located in Annex B countries will relocate to developing nations instead of incurring the costs of abatement. For instance, if the cost of abatement for an Australian manufacturer of pulp and paper is significant, the company may decide to relocate its operations to Indonesia. If this situation arises and the organisation continues to emit the same amount of CO_2 as previously, global emissions will remain unchanged. Recalling that it does not matter where CO_2 is emitted in terms of the global environmental impact, the exemption of developing nations to the Protocol may in fact annul the achievements made by the Annex B countries.

The Kyoto Protocol does recognise methods by which the developed countries can work cooperatively with developing nations to reduce global emissions. Whilst the developing countries do not have commitments of their own, projects such as the CDM will act to reduce emissions from these countries.

The concept of the CDM allows an Annex B country to invest in projects that reduce greenhouse gas emissions in developing countries. Article 12.3 of the Kyoto Protocol states that countries that fund projects through the CDM obtain credit from these projects, provided 'benefits' accrue to the host country. Article 12.10 of the Protocol specifies that credits obtained under CDM during the period 2000-2008 can be banked for later use in meeting Annex B commitments during the first commitment period 2008-2012. This banking clause provides the incentive for private firms in Annex B countries to invest in emissions reduction programs in developing countries prior to the beginning of the first commitment period.

The attractiveness of the CDM is that it has the potential to reduce net global emissions. The CDM works on the principle of least cost abatement. Rather than the developed country reducing its own emissions, it can invest in projects which reduce emissions in another country. If it is cheaper for a developed country such as the US to invest in abatement projects in China than domestically, it will use the CDM. The CDM acts as a method of indirectly including the developing nations in the Protocol. The costs of abatement will still be borne by the developed nations, however the developing countries are introduced to new technology, which should reduce global emissions. An example of the CDM in operation is the installation of a new electricity power plant in China. Pacific Power is an Australian electricity company involved in a CDM project with an electricity generator in China. Pacific Power has introduced efficiency improvements to the coal fired electricity plant to achieve a reduction in CO_2 emissions of 112000t/year. There are a further 100 electricity plants in China that could potentially benefit from the same technology. According to estimates, similar programs to improve the technology of the electricity industry in India could save between 76Mt and 110Mt of CO_2 by the year 2010 (Gunasekera and Mwesigye, 1998).

The measurement of the CDM in terms of emissions credited is yet to be determined. The success of the CDM relies on the development of the international emissions trading market. Assuming an international permit trading market exists, a decision must be made regarding the measurement and conversion of the permit. If a permit is worth one tonne of CO_2 emitted, one tonne of CO_2 abated in the developing country could allow the developed country to emit one tonne of CO_2 on its own shores. The benefits of the CDM for the developing country are that advances in technology will potentially increase the standard of living for its residents.

It should be made clear that whilst programs such as the CDM allow developing countries to indirectly participate in international greenhouse abatement, the benefits in terms of global CO_2 emission reduction are likely to be much lower than what could be achieved if developing countries were Party to the Kyoto Protocol. The CDM facilitates a low cost method of abatement for Annex B countries but does not directly force developing countries to reduce (or at least not increase the growth rate of) their greenhouse gas emission levels. Whilst developing countries remain outside the realm of the Kyoto Protocol, the problem of trying to eradicate a global problem without global action remains.

3.2.2 CRITICISMS OF THE KYOTO PROTOCOL

The Kyoto Protocol advanced the international agreement on reducing global greenhouse emissions but it left many issues unresolved.

As outlined above, the main criticism of the Kyoto Protocol is that the developed countries are expected to reduce global greenhouse emissions with a likelihood of high economic cost, whilst developing countries are permitted to continue emitting at strong growth levels.

Further criticism relates to the Kyoto Protocol's commitment period. Under the existing arrangements there are no restrictions on emissions prior to or following 2008-2012. This means that leading up to the commitment period a nation could emit as much CO_2 into the atmosphere as it desired, provided that it met its internationally agreed targets during 2008-2012. Organisations should be encouraged to achieve a reduction in greenhouse gas emissions prior to, during and after the commitment period. The overriding uncertainty surrounding the Kyoto Protocol and its predecessors equates to significant risks for businesses that engage in early action. Without the existence of a domestic or international emissions trading market in operation prior to the commitment period, business risks include the fact that property rights are not well defined, and the risk that the business may be disadvantaged by future government policy if their baselines are not preserved.

The Kyoto Protocol's commitment period has also come under criticism because it allows insufficient time for technological change. In Australia and many other Annex B countries, the greenhouse gas emission intensive sectors of the economy are also those sectors where there is considerable long-run investment in capital. Private organisations who have invested in existing infrastructure are resistant to change. These organisations are sceptical about the Kyoto Protocol because it forces them to greatly accelerate technological change at a very high cost. Some sectors of the economy will face extreme pressure as they try to reduce their CO_2 levels by introducing technology that would otherwise be implemented over a much longer time frame.

A further issue to be addressed in the future is a decision on the accurate and unbiased monitoring of a country's emissions. At present, responsibility for the measurement of a nation's emissions rests with the country itself. Alternatively, an independent sub-committee of the UNFCCC could be dispatched to provide unbiased monitoring on each nation's CO_2 emissions. This option would assure the global community that all nations are meeting their commitments. It also avoids many of the unattractive aspects of self-regulation.

3.2.3 RATIFICATION OF THE KYOTO PROTOCOL

The Kyoto Protocol will enter into force 90 days after it has been ratified by at least 55 Parties to the UNFCCC, and as long as those countries ratifying it account for at least 55 per cent of the total 1990 CO_2 emissions of the countries listed in Annex B of the UNFCCC.

As discussed, the main criticism of the Kyoto Protocol stems from that fact that it does not offer a global solution to a global problem. This criticism, coupled with the potentially damaging impact of stringent greenhouse targets on energy intensive economies, has led the President of the US to announce that his government will not ratify the Protocol.

With the US accounting for 25 percent of the world's total CO_2 emissions it was thought by many that the stance taken by the US meant that ratification was unlikely. This is particularly the case when countries such as Australia had previously stated that they would not ratify the Kyoto Protocol ahead of the US. Australia accounts for 2 percent of the world's total CO_2 emissions.

As outlined in *The Economist* (December 1998) the US has traditionally been reluctant to ratify international treaties such as the Kyoto Protocol. The previous Clinton administration appeared committed to forging the US toward meeting its greenhouse commitments. However with the change of government new policies have been developed. The non-ratification of the US has been interpreted throughout the world as a rejection of the United Nations (UN) treaty on greenhouse. Countries such as those within the European Union have not reacted positively to the announcement.

Whilst the nonconformity of the US may set back the drive for international greenhouse agreement, it is unlikely to mean the end of the agenda altogether. Future negotiations will involve compromise to encourage large CO_2 emitters such as the US to ratify the agreement. In the meantime, CO_2 intensive countries and industry groups may slow down their greenhouse abatement strategies. However, with greenhouse awareness aroused and with consumers in developed countries genuinely concerned about the environment, greenhouse abatement will continue to be on the top of the international treaty agenda. Individual countries such as Australia are likely to continue on the path of implementing greenhouse policy measures. The influence of the US's stance on Australia may be the implementation of a less stringent policy measure.

On the positive side, in April 2001 the Australian Government passed the *Renewable Energy (Electricity) 2000 Act*. Under the Act, Australia must source an additional 2 percent of its electricity from renewable energy sources by 2010. The Act was passed after the US announced that it would not ratify the Kyoto Protocol. It can therefore be assumed that Australia is taking its own measures to address its high greenhouse gas emission levels without waiting for international leadership.

In summary, the future of the Kyoto Protocol, as it currently stands, remains in doubt. The world's largest CO_2 emitting countries are unlikely to ratify the international agreement in its existing format. The main hurdle for ratification is the exclusion of the developing countries. In the majority of instances, complying with the Kyoto Protocol requires developed countries to decrease their economic growth prospects. Such a high cost would only be borne if the objective of reducing global CO_2 emissions is likely to be achieved. It is predicted that during the next two decades, emissions from developing countries will greatly exceed those of the developed world. Developed countries are resistant to incur the high cost of abatement if the developing countries continue to emit CO_2 at increasing rates and therefore jeopardise the gains made.

International negotiations held by the UNFCCC are scheduled to restart towards the beginning of 2002. Further concessions regarding some of the Kyoto Protocol's stipulations will be made. Provided that one of the concessions includes the embodiment of the developing countries, it remains possible that an international treaty on greenhouse gas reduction could be ratified in the very near future.

3.3 INTERNATIONAL TRADE IN EMISSION CREDITS

One of the most popular methods proposed for reducing global CO_2 emissions is the establishment of an international emissions trading market. Each tonne of CO_2 released into the atmosphere would require an emission permit to be held by the emitter. The emission of CO_2 without accompanying permits will attract a financial penalty. Organisations without sufficient permits to cover their emission levels can purchase permits at the international market price. The supply of permits on the market will come from those organisations whose marginal cost of abatement is lower than the market price.

Firms in this position will gain from reducing their own emissions and selling the excess permits on the market.

The scope of the international market could vary depending on those countries who choose to participate. For example, it might encompass both developed and developing countries, or be limited to developed countries. The number of global permits would be limited to ensure that the environmental target was achieved. For instance, in light of the Kyoto Protocol the number of permits available on the market in 2008-2012 would equate to 5.2 percent above 1990 emission levels. The benefit of an international emissions market is that the costs of abatement are likely to be lower. Research by Balistreri and Rutherford (2000) and others support this. For instance, if the cost of abatement is lower in New Zealand relative to Australia, Australia will be likely to purchase permits from New Zealand.

There is still a lot of debate as to whether an emissions trading market in CO_2 should be set up domestically in the first instance. Many governments are of the opinion that a domestic emission trading market will provide the foundation for a successful international market. If countries can establish domestic markets using similar principles, the transition to an international scheme should be smoother. The possibility of a domestic emissions trading market in Australia is discussed in Section 3.4 below.

A number of issues need to be resolved before an international tradeable emissions market is established. As the market will be dealing with tradeable emissions which represent a financial asset, it must be carefully regulated. The market must have sufficient capacity to deal with the trade of permits on an international scale. To overcome this the trade in permits could be attached in the first instance to the main stockbroking houses in the world such as the New York Stock Exchange. Regulation could be initially provided by the UNFCCC.

A separate issue in the market for international tradeable permits arises in the case of multinational corporations. The UNFCCC needs to decide if multinational companies should be permitted to transfer permits internally. For instance, clarification is needed on whether a subsidiary which reduces its emissions in Australia can transfer those credits directly to its parent company in the US. This would have implications for individual countries meeting their targets under the Kyoto Protocol.

A final issue which needs to be addressed is how the permits are to be priced. The permits could be offered on the market at a pre-established price or they could be auctioned. The auctioning of permits would allow the market to determine the price.

As discussed in Chapter two, the McKibbin-Wilcoxen Proposal advocates a fixed price international approach to issuing permits. The advantage of setting a fixed price for the permit is that the firms know the cost of the permit ahead of time and can therefore decide whether to reduce their own emissions or to purchase the credits from the government. The market will be more informed but the trade-off is that the fixed permit price may not reflect market conditions. To avoid this situation, the authors recommend that the world price of the additional permits be reviewed regularly.

Regardless of the pricing methodology employed, the size of the market is likely to cause complexity. If the permits are auctioned, substantial revenue will be collected from their sale. The issue of who collects the revenue and how it is redistributed adds further scope for debate at the international level. It has been suggested that the revenue collected could be used to reduce greenhouse gas emissions in developing countries. There are however very large wealth transfers from the developed countries to the developing countries associated with this option. If the permits are alternatively grandfathered to current CO_2 emitters free of charge, there remains the potential for disagreement and the problem of associated administration costs.

3.4 AUSTRALIAN GREENHOUSE POLICY

The exemption of the developing nations as signatories to the Kyoto Protocol does not only raise difficulties in meeting global targets, it also creates particular problems for Australia. As raised earlier, the development of an international greenhouse agreement covering only some of Australia's competitors raises serious trade competitiveness concerns. The main industry competitors for Australia are based in developing countries where there are unlikely to be emission commitments (McDonald, 1997). Almost half of Australia's trade is with non-OECD countries and over 60 percent of its exports go to Asia (O'Sullivan, 1997).

Australia does not only face the threat of losing market share to cheaper competitors in developing countries, it may also be disadvantaged in attracting foreign investment. Multinational corporations may think twice about investing in Australian industry if developing countries have no emission abatement commitments (O'Sullivan, 1997).

The Australian Government is yet to formulate its greenhouse policy. There are however two main schools of thought on the type of policy which could be implemented to enable Australia to meet its commitment under the Kyoto Protocol. The first is the use of command-and-control measures whereby the Government regulates the level of emissions from different sectors of the economy. The second option involves the use of market-based instruments such as environmental taxes and tradeable emission permits. Market-based mechanisms are generally considered to be the more cost-effective policy option (Cornwell, Travis and Gunasekera, 1997).

Taxing greenhouse gas emissions remains the most popularly proposed mechanism with some sectors of the Australian economy. A tax on emissions per tonne of CO_2 could be used to discourage emissions. The initial impact of the tax would be borne by emission intensive industries, such as those found in the energy sector.

A second market-based policy option is the establishment of a domestic emission trading market. The Government could issue emitting organisations with a certain number of tradeable permits, each entitling the holder to release one tonne of CO_2. Under this scheme, organisations would be allowed to openly trade certificates. Those organisations who emit more CO_2 than they hold permits for, will be liable for large fines imposed by the Government.[49] This policy is deemed to be attractive as it encourages organisations to seek the most cost efficient method of production.

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[49] In a similar market for tradeable emissions in the US for sulphur dioxide, the fine is $2000 US per excess tonne, adjusted for inflation annually. The fine is usually equivalent to 20-30 times the market price of permits. The severity of such a fine acts to deter companies from emitting excess sulphur dioxide.

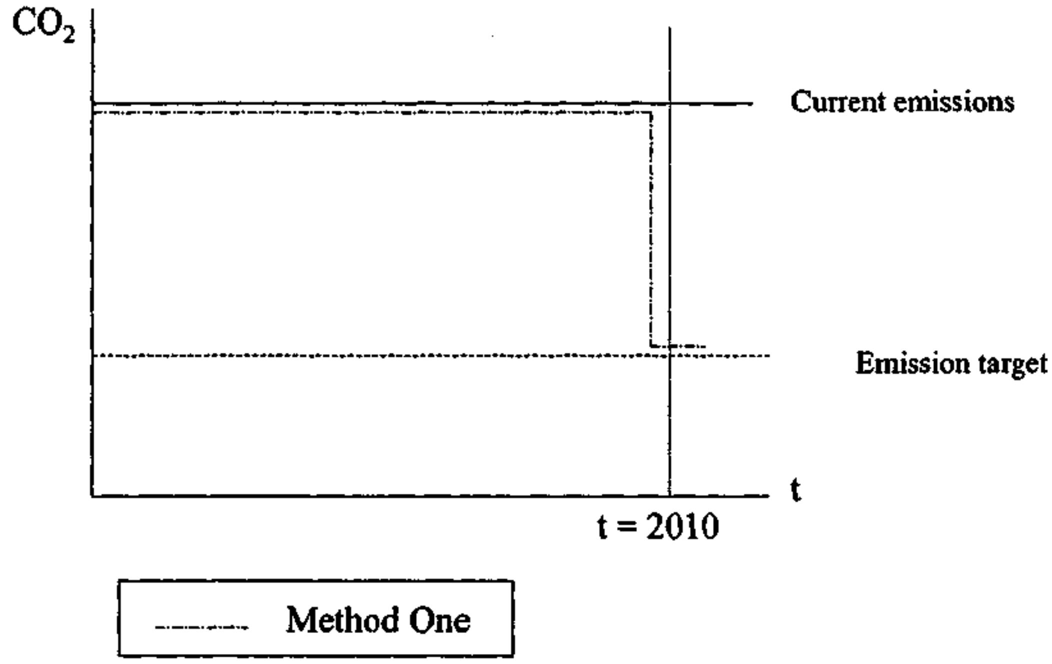
The outcome for the Australian economy will be essentially the same regardless of the market-based greenhouse policy tool chosen by the Government. If we assume that there are no transaction costs, there is no economic difference between the introduction of a domestic emission permit trading market and a tax on CO_2 emissions.[50]

As mentioned above, one way for the Australian Government to meet its target under the Kyoto Protocol is to set up a domestic emissions trading market. The Government could introduce this market in a number of different ways. One alternative (*method one*) is to establish the market with the exact number of permits to cover the nation's target emission level just prior to the commitment period (see Figure 3.1). Under this scheme organisations who emit CO_2 could bid between themselves to ensure that they have sufficient permits to cover their operations. To ensure that the government meets its own target, the penalty for noncompliance must be severe.

[50] Based on the CO_2 tax being levied at the same rate as the equilibrium permit price under the emission trading market.

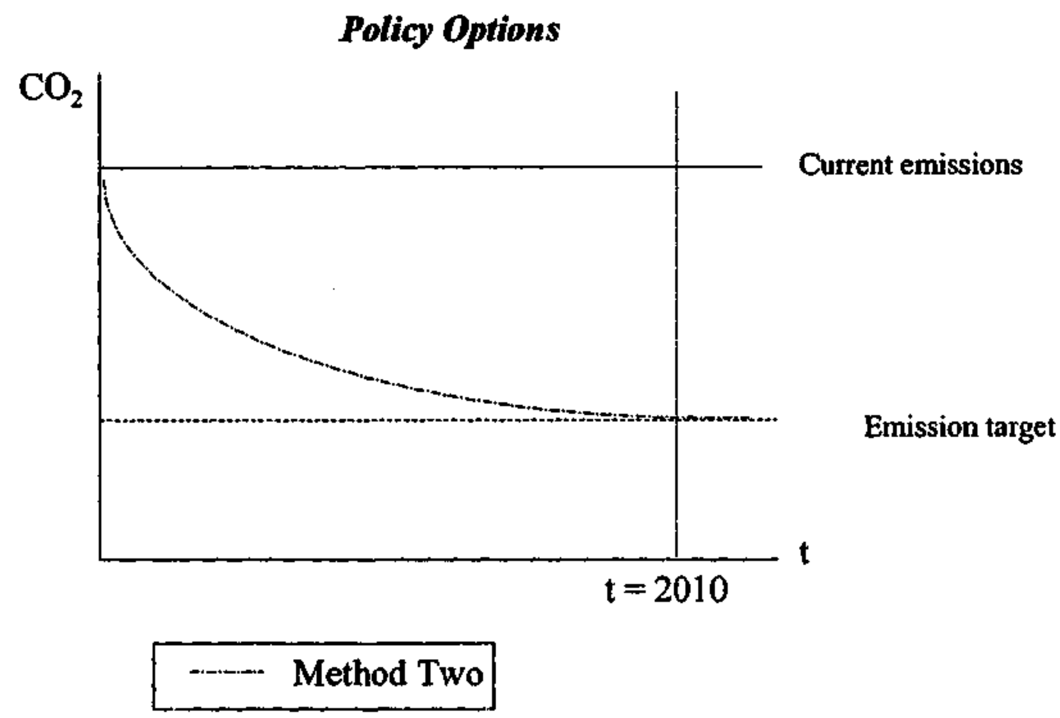
Figure 3.1

Policy Options



The Government may take an alternative approach to the tradeable emission market and decide to reduce emissions gradually (*method two*). This phased-in approach may provide the Government with a greater assurance that it will meet its own target as firms adjust their emissions over a longer period of time. In the first instance, the Government could issue all existing CO_2 emitters with enough permits to cover their current levels. Each year thereafter the Government could remove some of the permits from the market. Those organisations who continue to emit at the same rate would then have to purchase additional permits from the market (see Figure 3.2).

Figure 3.2



The main difference between the options available to the Government is that under the first alternative, organisations will be allowed to continue to emit as much CO_2 as they desire until the target year. This reiterates one of the main problems of the Kyoto Protocol in that countries can continue to emit as much CO_2 as they want, provided that they meet their target during the commitment period. It also highlights the fact that the UNFCCC provide no guidance on how the targets could best be achieved.

If the Australian Government decides to establish a market for emissions trading, it needs to address the issue of how domestic permits are to be allocated. Although the way in which the Australian Government issues its permits will not alter the level of global emissions, it does have important ramifications for the domestic economy.

One way the permits could be distributed is known as the 'grandfathering' method. Under the grandfathering method the available permits are issued on a pro-rata basis to those firms who are currently emitting CO_2. The Government could allocate less permits than current emission levels to encourage a reduction in aggregate emissions.

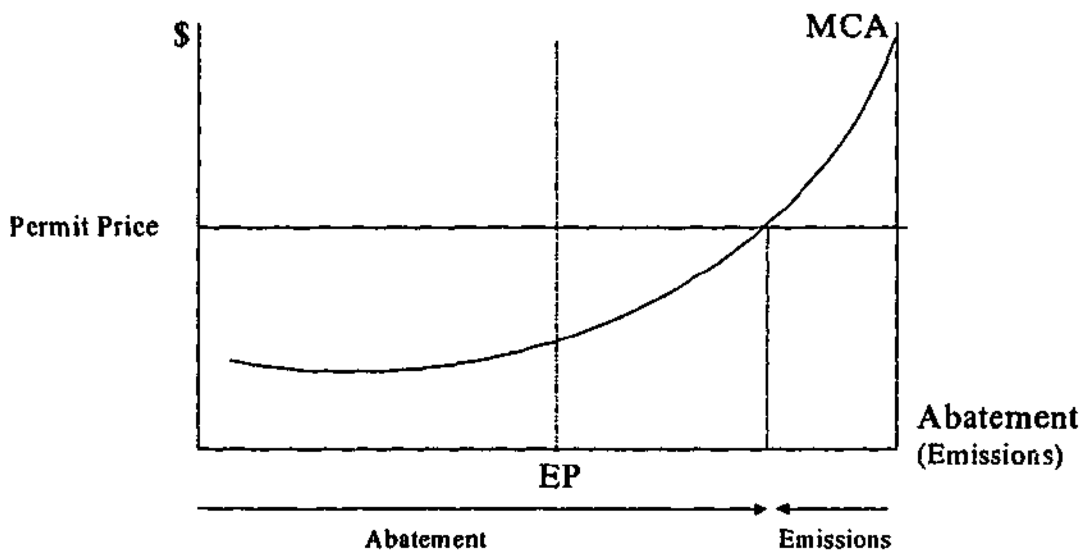
Under this method the permits could be allocated by the Government initially free of charge. Once the emission quota is filled, the market could adjust itself to determine the market price. How the grandfathered emission trading permits are distributed amongst the economy is important. Pressure has been placed on the Australian Government by the electricity industry to base the grandfathering on emission levels in 1990 as emissions by the sector at this time were relatively high. Other interest groups believe that the data on emissions in 1990 is inaccurate and that 2000 should be used as the benchmark. By the year 2000 individual CO_2 emitters were predominantly part of the Government's Greenhouse Challenge program and were consequently providing accurate measurements of emission levels.[51]

An organisation issued with permits under the grandfathered approach will need to decide whether to reduce its current emissions and sell the excess permits on the market or to maintain its present emission levels. The opportunity cost of holding onto permits for internal use is that they cannot be sold externally for financial gain.

Figure 3.3 illustrates the decision making process of an industry issued with emission permits (EP). At EP the marginal cost of abatement (MCA) is lower than the permit price. Hence it is more cost effective for this industry to abate and sell the permits on the market than it is to maintain its existing level of CO_2 emissions.

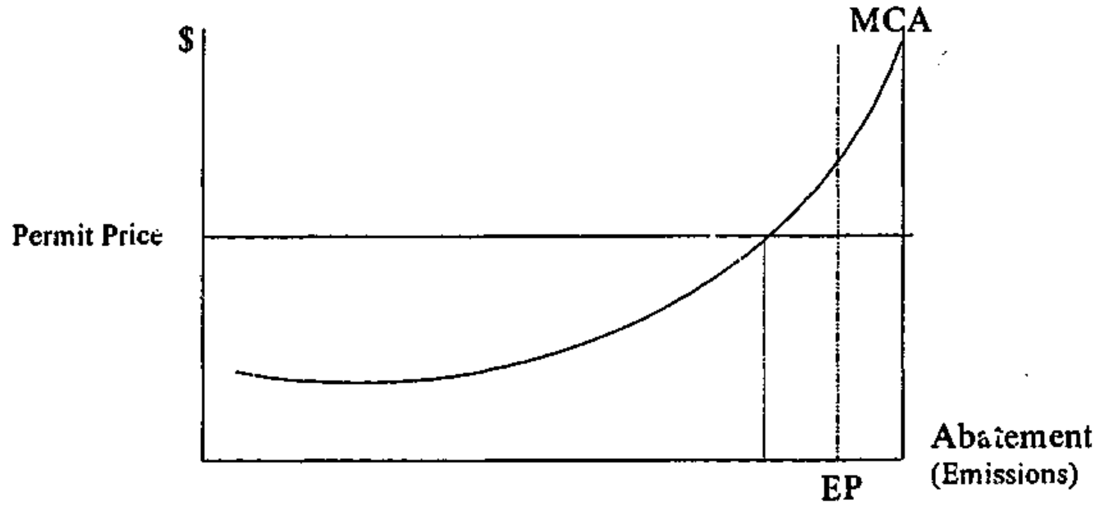
[51] The Australian Government has committed an additional $27 million to extend the Australian Greenhouse Challenge Program to embrace over 1000 companies by 2005.

Figure 3.3



An alternative scenario is shown on Figure 3.4. If the MCA is higher than the market price for the permit, it is more cost effective for the industry to purchase permits from the market than it is to abate. An example of this scenario is in the case of the newest electricity generators in Victoria, where increased abatement is expensive due to their use of the most efficient technology.

Figure 3.4



A separate policy option available to the Government is to auction the available permits. Organisations will have to decide whether to purchase emission credits via auction or whether to abate. A firm will abate until it reaches a position where the MCA is equal to the price of the permit. After that point, the firm will purchase emission credits. The market will determine the equilibrium price for the permits.

The advantage of this method is that the sale of the permits represents greenhouse revenue to the Government.[52] The Government could then use this money to stimulate other areas of the economy, "it may be not only more efficient, but politically acceptable, for government to auction allowances and then use the funds to assist adjustment elsewhere in the economy" (Hagan, 1998).

The varying methods of permit allocation hold very different ramifications for the economy. If the permits are auctioned, the additional revenue can be used by the Government for revenue recycling. On the other hand, if the permits are allocated free of

[52] Greenhouse revenue is the revenue received by the Government following the imposition of greenhouse policy upon sectors of the Australian economy. For example, the revenue collected by the government from the sale of emission permits.

charge the Government does not receive any revenue but the costs to the industrial sector are effectively reduced.

Before auctioning the permits, the Australian Government should decide whether it wants to restrict the number of permits available to certain industries. This may seem contradictory to the overall aim of reducing greenhouse emissions, but the Government may wish to protect individual sectors from the negative consequences associated with the introduction of greenhouse policy. By forcing one sector of the economy to carry the burden of abatement, another sector can be partially protected. As mentioned above, the way in which the Australian Government reduces its emissions is left entirely to its own discretion.

A number of issues relating to the tradeable permit market are the duration of permits, the emission load, the emission cap, and the coverage of greenhouse gases (Cornwell and Gunasekera, 1998).

Another important issue arises if the tradeable emissions market is set up in a similar fashion to that of a financial market where people hold stocks. In some situations the permits may simply be held as trading stock (Hagan, 1998). If a company who does not emit any greenhouse gas enters the market as a pure speculator, it may hold onto the permits past the initial commitment date of 2008-2012. In this situation some firms will have paid an inflated market price or alternatively incurred large fines as they were unable to purchase the necessary permits from the market. Consideration will need to be given to the existence and role of speculators in the market place.

To avoid the cost of abatement, private organisations are hedging their risk by becoming involved in sequestration activities such as 'Activities Implemented Jointly'.[53] Activities Implemented Jointly (AIJ) is based on the concept of joint implementation whereby countries with high emission abatement costs can undertake activities in other countries with lower marginal abatement costs (Cornwell et al, 1997)

[53] The process of absorbing emissions is called sequestration. (Cornwell et al, 1997)

International AIJ may create problems for the Australian Government if it does not meet its own targets domestically. As part of its domestic policy the Australian Government is considering preventing organisations from participating in international AIJ schemes if Australia has not met its own targets. For example, an Australian company who holds surplus tradeable emissions will not be permitted to sell them to a foreign company unless Australia has met its own target. It would instead be encouraged to sell the excess permits domestically.

3.4.1 AUSTRALIAN GREENHOUSE POLICY AND THE USE OF CARBON SINKS

A carbon sink is a natural occurring mechanism that removes CO_2 from the atmosphere (Kahn, 1997). The two most common forms of carbon sinks are oceans and forests. The main natural carbon sink is the dissolution of CO_2 in the world's oceans (Kahn, 1997). Trees and other vegetation that use CO_2 through photosynthesis to produce wood and other forms of biomass, are an additional, albeit poorly quantified sink (Kahn, 1997). Ocean and forestry sinks are however treated differently under the Kyoto Protocol and therefore have different ramifications for the Annex B countries.

The main difference in terms of the Kyoto Protocol is that governments and private organisations have limited capacity to create oceanic carbon sinks[54], whereas they can develop a forestry sink by planting trees. For this reason the remaining discussion on carbon sinks will relate specifically to forestry.

The formation of carbon sinks through new forest plantations reduces the amount of CO_2 stored in the air. While a forest is growing, CO_2 is absorbed into the trees (Gunasekera and Cornwell, 1998). The rate of tree growth is the main determinant of the extent of carbon sequestration. A mature forest has a zero net effect on the level of CO_2 in the atmosphere. This is due to the combined impact of a slow growth rate and degeneration which results in the gradual re-release of CO_2.

[54] Fleetma has been trialing programs to inject carbon dioxide into an acquifier in the North Sea.

In addition, different types of trees have different storage values of carbon and sequest CO_2 at different rates over time (Kahn, 1997). When trees are harvested, all of the carbon is eventually released as CO_2 into the atmosphere (Kahn, 1997). The rate of re-emission depends upon how the timber is used. Carbon preserved in wood products such as construction materials, furniture and books have different rates of decay. Forests therefore act both as a source and a sink of CO_2 depending on the forest life-cycle and timber uses[55]. The issue, then, is when in the life-cycle of the plantation to recognise the sequestration benefits and issue permits.

The question is raised as to whether it is environmentally or economically valid to recognise carbon sink sequestration as equivalent to abatement. In the long run, abatement activity by an electricity generating company to reduce its emissions by 100 tonnes of CO_2, will result in a greater total reduction of emissions than if the same company plants enough trees to sequester 100 tonnes from the atmosphere. A short-run analysis might provide the same environmental impact, but in the long-run some of the trees will either burn or decay. This is part of the difficulty of the measurement process. For example, if the forest is harvested and that wood is in turn used to build houses, the CO_2 will not be released into the atmosphere until the house begins to decay.[56]

One method of addressing the above issues would be to encourage long-run commitments. In the event of a natural disaster, the owner of the carbon sink could agree to replant the equivalent number of trees as were lost. This would ensure that there would be fewer net change in stocks when the trees are harvested, burnt or they decay.

Unless the risk that carbon sinks may not be maintained in the future is taken into consideration, significant compliance and enforcement costs may be incurred by either growers or regulators in meeting international commitments (Kahn, 1997).[57] To avoid

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[55] "In a typical plantation or naturally regenerating forest, biomass accumulation usually occurs relatively slowly in the early stages following planting or regeneration. The process accelerates as the trees increase in size and maturity, potentially reaching a steady or declining state as mature trees begin to decay. Harvesting, disturbance by fire, storm or pests, or clearing will result in re-emission of sequestered carbon." (Australian Greenhouse Office, 1998)

[56] The measurement of the emissions from individual houses over time is virtually impossible.

[57] An further issue arises as to the collapse of a company who has invested in a carbon sink. If the company

some of these problems carbon credits could be allocated over a staggered time frame. For instance, the credits could be recognised after 10 years. This however, may act as a deterrent to companies as they would not be able to recognise the returns on their investment for a long period of time.

Two important issues have been raised in the above discussion. Firstly, consideration must be given as to when carbon sequestration in a forestry sink should be recognised. Secondly, a decision should be made as to whether sequestration and abatement should be given equal value. Both of these issues tie us back to the main economic problem of reducing global greenhouse gas emissions.

The recognition and acceptance of carbon sinks is encompassed by a number of regulatory rules outlined by the UNFCCC. The Kyoto Protocol says that emissions and removals of greenhouse gases by certain land clearing and forest activities commenced since 1990 can be counted in meeting a country's commitments. For Kyoto Protocol accounting purposes, trees planted today will only have their carbon absorption counted during the period 2008-2012. (Greenhouse Response Branch, 1998) This has important ramifications for forest plantations as CO_2 absorbed by the trees between now and 2008 will not be counted. The accurate scheduling of plantations so that maximum CO_2 absorption occurs between 2008-2012 is essential to all Parties trying to reduce overall emissions during the commitment period.

Once again the mechanisms of the Kyoto Protocol potentially restrict the global goal of reducing CO_2 emissions. If Parties to the UNFCCC plant trees that absorb the maximum CO_2 during 2008-2012 and refrain from harvest during this period, it represents a short term solution to the problem. Post 2012 these trees will be harvested and the CO_2 will be predominantly re-released back into the atmosphere. One way to avoid this situation is to introduce concurrent commitment periods. Eventually however the trees will be harvested or will decay during a commitment period.

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has already received the carbon credit for the sink, the recovery of the 'asset' is of concern.

The following discussion provides an overview of how Australia can potentially benefit from the inclusion of carbon sinks as part of the Government's greenhouse policy response.

In the Australian context, carbon sinks would most easily be incorporated into a domestic emission trading regime. For every tonne of CO_2 sequestered by the forestry sink, an emission permit could be allocated. The permit could be used to offset the carbon sink owner's emissions or sold to another party at the market price. Each year the forest owner would receive an emission permit equivalent to the sequestration of the forest. At the time of harvest the forest owner would be liable for the re-emission of the carbon into the atmosphere. The forest manager would then have to hold permits equal to the annual permits received.

Australia is in favour of the inclusion of carbon sinks as it acknowledges the contribution they could make toward the attainment of its target. Australia is abundantly rich in the scarce resource of cleared land relative to other countries such as many in the EU. There is potential for Australia to exploit this position and make significant land use changes.

If carbon sinks are to make a contribution to solving the problem of global greenhouse emissions, much work needs to be done on the establishment of universal guidelines for accurate measurement. Factors such as the type of trees, the density of the stand, the age of the trees, and the natural environment all impact upon how much carbon is sequestered by any one forest. In Australia alone, the difficulty of carbon sink measurement is evident as sequestration levels vary between regions. According to research on the nature of carbon sinks, "sequestrations from sources and sinks vary significantly on an inter-annual an decadal time-scale due to climatic changes (precipitation and temperature) as well as location and seasonal factors." (Australian Greenhouse Office, 2000).

Land owners and entrepreneurs in Australia are already responding to the recognition of carbon sinks, as evidenced by the recent establishment of many individual and syndicated plantation investments.

The extent to which government policy will assist with the overall achievement of emission reduction targets will depend upon the incentives created by specific policy details, such as how carbon value is measured and transferred to the owner.

The difficulty with any specific policy to target Kyoto Protocol requirements is the uncertainty attached to both future international agreements and market prices. As mentioned above, the timing and frequency of future commitment periods is uncertain. An over-reliance on specific policies targeting the first commitment period could be thwarted by a decision to make the commitment periods consecutive. For example, a Government ban on harvesting during the first period may result in a large amount of harvesting in a subsequent consecutive period. Even if commitment periods are scheduled five years apart this may alter the optimal rotation period as it leaves a small window of opportunity to harvest before the next commitment period arrives.

It is likely that all Parties to the Kyoto protocol will act in a similar way, discouraging harvest during the first commitment period and perhaps encouraging planting times to sequester the most CO_2 during 2008-2012. This could have significant ramifications for carbon prices, but more importantly in the case of forestry, timber prices. A five-year period without harvesting could lead to a world shortage of timber, driving timber prices up relative to carbon prices and shortening optimal rotation periods. Governments could then find themselves in a compromising situation if it becomes optimal for forest managers to harvest during the commitment period. This scenario points to the importance of having a range of policy measures in place to prevent a potential spiralling of carbon and timber prices during the commitment period.

Whilst it is recognised that carbon sinks are not single handedly going to solve Australia's greenhouse problem, they are likely to be an effective instrument in lowering the cost of abatement. There lies a challenge for Australian greenhouse policy to take advantage of Australia's potential to make land use changes, by clearly specifying mechanisms to measure and transfer carbon value.

The adaptation of carbon sinks into a CGE modelling framework remains an area for further research (addressed in Chapter seven).

3.5 CONCLUSION

This chapter provides an outline of greenhouse policy in the Australian context. The Kyoto Protocol and the international greenhouse position were covered in Sections 3.2 and 3.3. A summary of the Australian greenhouse policy position was explored in Section 3.4. Whilst no firm policy commitment has been developed to date, it is most likely that a market-based mechanism will be used. The impact of such mechanisms are analysed in Chapter six.

CHAPTER FOUR

THE AUSTRALIAN ELECTRICITY INDUSTRY AND THE LA TROBE VALLEY REGION

4.1 INTRODUCTION

Chapter four provides important background information and informs the modelling analysis in chapters five and six. The La Trobe Valley region of Victoria was chosen as a focus for this research because the electricity industry makes up a large proportion of economic activity in the region. The region's economy has only recently begun to stabilise after experiencing the full force of national and state industry reform. Any further change to Government policy which impacts on the electricity industry (such as greenhouse policy) is likely to have a significant effect on the La Trobe Valley. The region is therefore a suitable case in point to examine the linkages between Australian greenhouse policy and a regional economy.

This chapter begins with an overview of the Australian electricity industry post and pre reform. Section 4.2.1 describes the nature of the electricity sector. The base and peak components of the market are discussed in Section 4.2.2. Industry trends are raised in Section 4.2.3 whilst the physical structure of the industry is outlined in Section 4.2.4.

Following Section 4.2, the focus of the chapter becomes the Victorian Electricity Supply Industry (ESI) which is almost entirely located in the La Trobe Valley region. The La Trobe Valley electricity generators produce the equivalent of 90 percent of the State of Victoria's energy needs, and are responsible for 8 percent of Australia's total greenhouse gas emissions (Danoher, 1997).

As will be demonstrated in Section 4.4, the impact of greenhouse policy upon the Victorian ESI will have direct economic implications for the La Trobe Valley region. The objective of this section is to clearly explain the relationship between the Victorian ESI and its host region. The current economic climate in the La Trobe Valley is also explored.

The chapter is concluded in Section 4.5.

4.2 AUSTRALIAN ELECTRICITY INDUSTRY PRE AND POST REFORM

4.2.1 AUSTRALIA'S ELECTRICITY INDUSTRY – THE MARKET

The Australian electricity industry is recognised as one of the nation's most valuable sectors, contributing 1.4 percent to GDP and supplying electricity to export orientated industries at internationally competitive prices (ABARE, 2000).

Throughout the last decade the ESI in Australia has undergone fundamental reform. Prior to 1990, each state or territory owned and operated a single vertically integrated electricity industry. Each entity was responsible for the generation, transmission and distribution of electricity within the state boundary. In most instances the state had more than one electricity generation plant. There was however no competition in the market as each generator worked toward the common goal of supplying the state with electricity. Investment in the industry was driven mainly by State Government agenda. Prices for electricity were regulated and were set at a level which covered the industry's costs and provided a satisfactory return to the Government, who was the sole shareholder (SECV, 1985-).

Traditionally the electricity supply industry in each state was divided into three separate operating units, with one overseeing management team. The generation side of the organisation tended to be located at the physical site of the plant, which in most cases were in regional areas due to the availability of natural fuel resources. The generation arm of the industry was renowned for being technologically advanced, and was given the relative freedom to expand its infrastructure and asset base. The industry was Government funded and was considered to be very lucrative.

The absence of competition in the electricity industry enabled market inefficiencies to arise. Arguably the greatest inefficiency was the unwarranted high levels of employment.

The industry was renowned for strong labour unions who encouraged working practices which at times lead to gross overstaffing (Foster et al, 1997).

In the late 1980's an inquiry was conducted by the then Industry Commission[58] into the potential efficiency gains from the deregulation of the electricity industry in each state. The findings of the Commission were released in 1991. The main recommendations were:

- 'restructuring the electricity supp'y industry into the separate elements of generation, transmission and distribution, and retail supply;
- the introduction of competition into generation and retail supply; and
- the enhancement and extension of the three state interconnected power systems'.

The Victorian Labour Government had already started to implement microeconomic reform into the State Electricity Commission of Victoria (SECV) before the Industry Commission's findings were released. SECV management identified that the reform needed to include a reduction in employee numbers. Employees were offered Voluntary Departure Packages (VDP). During the restructure 4,820 direct electricity generation jobs were shed (Foster et al, 1997). As will be discussed in Section 4.4, the majority of these positions were located in the La Trobe Valley region.

The next stage in the reform process was the deregulation of the SECV into individual state-owned organisations. The generation arm was known as Generation Victoria (GenVic) and consisted of the separate generating business units (GenVic, 1994). For instance, the Hazelwood Power Station and Mine was referred to as one business unit. A description of each of the electricity generators operating in the La Trobe Valley will be provided in Section 4.3.

Following the deregulation of the industry, the State Government of Victoria privatised each of the brown coal generators. The collective revenue received by the State for the sale of the ESI totalled almost $11 billion, with one of the generators alone selling for $4.7 billion. The retail arm of the newly deregulated Victorian electricity industry was also privatised.

[58] The Australian Industry Commission is now known as the Productivity Commission.

Whilst similar industry deregulation occurred in the remaining States of Australia, they observed with interest the economic impact of privatisation upon the Victorian economy and particularly the La Trobe Valley region. To date no other state has followed the lead of Victoria in fully privatising its electricity industry. As will be discussed later, this has significant ramifications upon the ability of the Victorian generators to compete in the National Electricity Market (NEM).

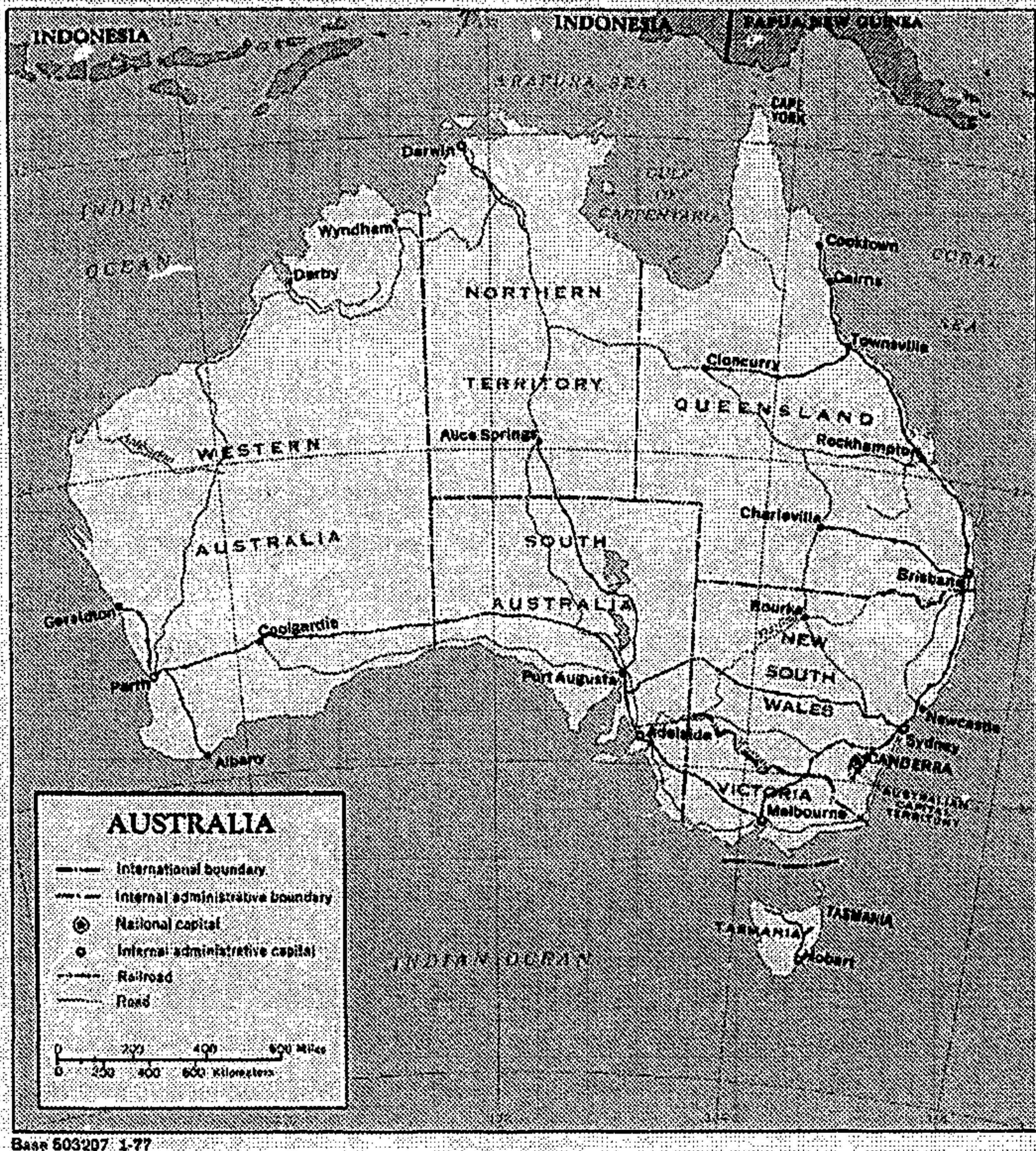
The final recommendation of the Industry Commission, to promote the State's interconnected power systems, was enacted soon after the report's release. In 1994, corresponding with the establishment of GenVic, the Victorian Electricity market (VicPool) was created. This was followed by the establishment of the New South Wales State Electricity Market (SEM) in 1996. These markets were linked in 1997 and limited interstate trade of electricity began. The NEM was formally developed in 1998.

The NEM is a wholesale market for the supply and purchase of electricity, combined with an open access regime for use of the transmission and distribution networks in the participating jurisdictions of the Australian Capital Territory (ACT), New South Wales (NSW), Queensland (QLD), South Australia (SA) and Victoria (VIC) (see Map 4.1 for a map of the Australian States). Two independent bodies were created to manage and administer the NEM. The National Electricity Market Management Company (NEMMCO) is responsible for the management of the wholesale electricity market and the security of the power system. The second company is the National Electricity Code Administrator (NECA) which is responsible for administering the code (NEMMCO, 1998).

The main roles of NEMMCO are to centrally coordinate the dispatch process and the spot market. All of the electricity generated flows into a central 'pool'. The market for electricity is quite different from most other goods as electricity cannot be stored. Once the electricity flows into the pool it is impossible to identify the source. The electricity any one retailer or contestable customer draws from the pool could come from any electricity generator.

The day before dispatch, the generators all bid for half hour time slots to supply electricity into the pool. NEMMCO receives all of these confidential bids and decides how much electricity each generator supplies, based on the bid price. The generator with the lowest

Map 4.1


INDONESIA
INDONESIA
PAPUA NEW GUINEA
ARAFURA SEA
CAPE YORK
Darwin
GULF OF CARPENTARIA
INDIAN OCEAN
Wyndham
Derby
Cooktown
Cairns
CORAL SEA
NORTHERN TERRITORY
Townsville
Cloncurry
QUEENSLAND
Alice Springs
WESTERN AUSTRALIA
Rockhampton
Charleville
SOUTH AUSTRALIA
Brisbane
Geraldton
Bourke
Coolgardie
NEW SOUTH WALES
Perth
Port Augusta
Newcastle
Sydney
Adelaide
CANBERRA
Albany
VICTORIA
Melbourne
AUSTRALIAN CAPITAL TERRITORY
TASMANIA
Hobart
INDIAN OCEAN
AUSTRALIA
International boundary
Internal administrative boundary
National capital
Internal administrative capital
Railroad
Road
0 200 400 600 Miles
0 200 400 600 Kilometers
Base 503207 1-77

bid gets contracted first and so on until electricity demand is satisfied by supply. Regardless of their own bid, all generators who supply electricity to the pool during that half hour receive the highest bid price of suppliers operating in that time period. The generators are informed 24 hours prior to dispatch how much electricity they should generate and send to the pool.

The demand side of the market comes from electricity retailers and other end use customers who submit dispatch bids to NEMMCO. The demand and supply of electricity is known as the spot market. NEMMCO calculates a spot price that is the equilibrium price between demand and supply.

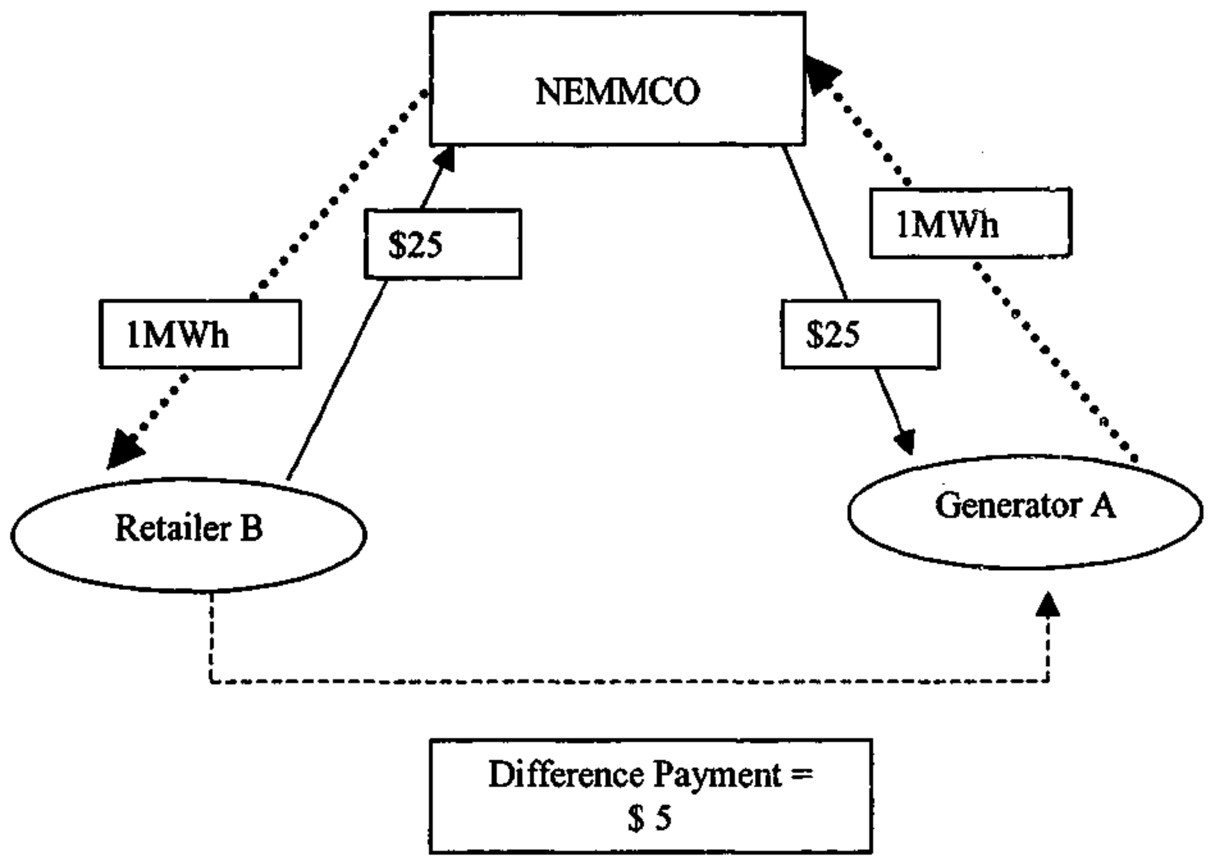
In addition to the wholesale trade of the physical electricity via the spot market, the generators and retailers also trade in the financial markets to limit the risk associated with a volatile spot price. The generators and retailers are reluctant to expose their businesses to large fluctuations in the spot price. Although the average spot price is relatively stable, it has been prone to large fluctuations when the supply of electricity is reduced due to generation outages or industrial disputes (ESAA, 1999). The generators want to reduce the risk of being paid low pool prices, whilst the retailers do not want to be exposed to high pool prices.

More often than not the published pool price is not the actual price received by the generators (or paid by the retailers) for the majority of their electricity. The brown coal generators produce electricity at a cost of approximately $4/MWh. Black coal generators have a higher short run cost than this due to the fact that their mines are often not located physically next to the power station, as is the case in Victoria. The long run average cost of the Victorian generators, including their associated debt, is closer to $35/MWh. With a pool price averaging $22/MWh, electricity generators enter into contracts to ensure they receive revenue to at least cover their long run average cost.

The financial nature of the electricity contract is best explained with the use of an example (see Figure 4.1). Generator A offers to sell Retailer B electricity at $30/MWh which is accepted and the financial contract is drawn up. Generator A is paid the pool price from NEMMCO for the quantity of electricity it generates. Retailer B still has to pay NEMMCO the pool price for the quantity of electricity it consumes. If the pool price was

$25, NEMMCO pays Generator A $25 and Retailer B has to pay NEMMCO $25. Retailer B also has to make a 'difference' payment to Generator A for the balance ($5).

Figure 4.1



The retailer or contestable customer is not bound to purchase the amount of electricity from the pool that is specified in the contract. It is, however, still required to pay the difference between the contract and the spot price. If the retailer wants more electricity than the contract specifies it has to pay the spot price (which may actually be lower than the contract price negotiated).

The true financial magnitude of the electricity contract was recently exemplified when one of the Victorian generators ceased electricity generation. Although the generator was not producing electricity, its contracted customers were still drawing electricity from the pool. As the consumer does not receive electricity directly from the generator, supply is uninterrupted. A very different scenario would occur if the contract was not purely financial, and the electricity flowed directly from the generator to the customer.

There are many operators in this financial market including stockbrokers. These organisations have established themselves to deal in electricity futures contracts via the Sydney Futures Exchange.

4.2.2 BASE AND PEAK MARKETS

The spot market creates two separate electricity industries, the base and peak markets. Base generators are inclined to use natural resources such as brown or black coal to fuel their generation. These generators tend to be the main suppliers in each state in terms of capacity. The power stations used by base generators take a long time to start and shut-down. Base generators do not switch the plant on and off in response to fluctuating prices in the spot market. For this reason the prices bid to NEMMCO for electricity from these sources tend to be lower than from other 'fast-start' generators. In the short-run it is better for base generators to submit low bids, rather than cease electricity production.[59]

Generators in the peak market are those which take relatively little time to stop or start generation. Because these plants are not running all of the time, they are not subject to the same economies of scale as the larger base generators. Remembering that all generators who supply to the market in a given half hour are paid the highest bid, base generators are generally pleased when the peak generators are despatched. Peak generators are usually despatched in times of electricity supply shortage and tend to bid into the market at much higher prices. There currently exists a limit on the spot price of electricity per MWh of $5000 (ESAA, 2001).

Whether a base or peak generator supplies to the pool depends in part on the demand and supply of electricity at the national and state level. Supply of electricity can flow between the States of QLD, NSW, VIC and SA but it is restricted by the interconnector capacity of the transmission lines. There are also discussions taking place to construct a transmission line between VIC and Tasmania (TAS), to be known as Basslink.

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[59] The Victorian brown coal generators need to be running all of the time as they cannot be easily switched on and off. This is in contrast to the 'fast start' generators such as the Jeeralang gas plant which can start up within a couple of minutes.

Transmission lines currently exist between QLD and NSW, NSW and VIC, and between VIC and SA. Electricity generators in SA can only export electricity into NSW if VIC is not using all of the available transmission capacity. When the interconnector limit is reached, NEMMCO will dispatch the next cheapest electricity from within that region. According to NEMMCO it may need to schedule a more expensive generator to meet electricity demand in a state notwithstanding the availability of a lower priced generator in another state (NEMMCO, 1998). This tends to be the fast-start plants who operate in the peak electricity market. If the transmission lines are open, electricity flowing into the pool will come from base generators who bid lower dispatch prices.[60]

In addition to the promotion of interstate trade, the electricity market will soon become more competitive as consumers are able to choose who supplies their electricity. In the future[61] all consumers will be able to enter into contracts with retailers who are not geographically located in their region.[62] The market of contestable customers will further promote competition as these consumers can negotiate to purchase electricity directly from the wholesale NEM.[63] Yallourn Energy is the only Victorian generator selling directly to contestable customers.

4.2.3 INDUSTRY TRENDS

According to ABARE, electricity consumption in Australia increased almost threefold over the last three decades. Accounting for 34 percent of total electricity consumption is the manufacturing sector, which includes the non-ferrous metals industry. The activity levels of this industry have risen greatly over the latter part of the last century. The iron and steel sector has traditionally been a high consumer of electricity. Growth in this industry has stabilised over the past decade. ABARE predicts that the share of electricity in the fuel mix for the manufacturing sector is likely to be slowly replaced with natural gas (ABARE, 2000).

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[60] For instance to satisfy demand in Victoria, electricity could be sourced from the brown coal generators in the La Trobe Valley and the black coal generators of the Hunter in NSW.

[61] January 2002 for Victorian consumers.

[62] At present customers can only purchase electricity from the retailer supplying their geographical region.

[63] Contestable customers are consumers who hold a licence to directly purchase electricity from the wholesale pool.

Electricity consumption by the household sector of the economy more than doubled over the last three decades of the last century (ABARE, 2000). The growth in consumption outweighed the rise in the average population over the same period. Consumption of electricity per residential customer also increased by 36 percent over this period (ABARE, 2000). Part of this increase can be attributed to the increase in electronic appliances in the household. Since the 1980's it has been common for households to own a computer and associated equipment such as printers. The advent of the Internet and its wide acceptance into the lives of consumers has resulted in the average resident now spending much more time using a computer. In addition to the use of the computer for work, academic and leisure, computers are now the major information source for many households. Many residents are now able to work entirely from home on the Internet.

There is the potential for consumers to reduce their demand for electricity, or at least slow its growth, with the advent of energy saving appliances and energy efficient building designs. It is still predicted by ABARE however that electricity will continue to play an important role in supplying energy to the household sector for many years to come.

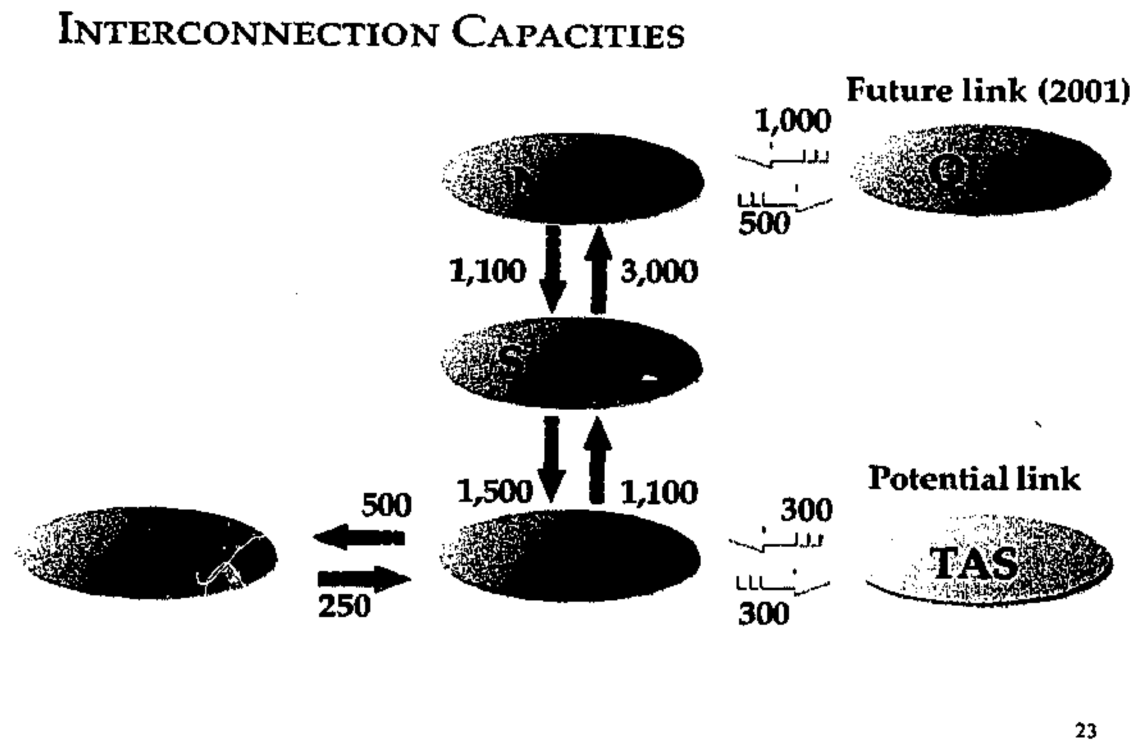
Similarly to the case for the household sector, the commercial sector of the economy also responded positively to the computerisation of the workplace. A sharp rise in electricity consumption followed as businesses used more electricity in their workplace. The demand for electricity solely for heating and lighting was overtaken by many forms of electronic equipment including computers and fax machines. The deregulation of the business operation hours also allowed retailers to trade on weekends. The new extended hours of trading meant an increase in the demand for electricity.

4.2.4 PHYSICAL ASPECTS OF THE AUSTRALIAN ELECTRICITY INDUSTRY

The Australian electricity industry has traditionally consisted of the fossil fuel generators in each of the states. Coal accounts for over 90 percent of electricity generation capacity in each of the States of NSW, QLD and VIC (ESAA, 1999).

As mentioned above, electricity can now flow between the States of SA, VIC, NSW and QLD via transmission lines established through the NEM (see Map 4.2 on the following page). The electricity is traded between these states through a series of interconnected networks. Figure 4.2 illustrates the interconnector capacities that presently exist. All values are reported in MW.

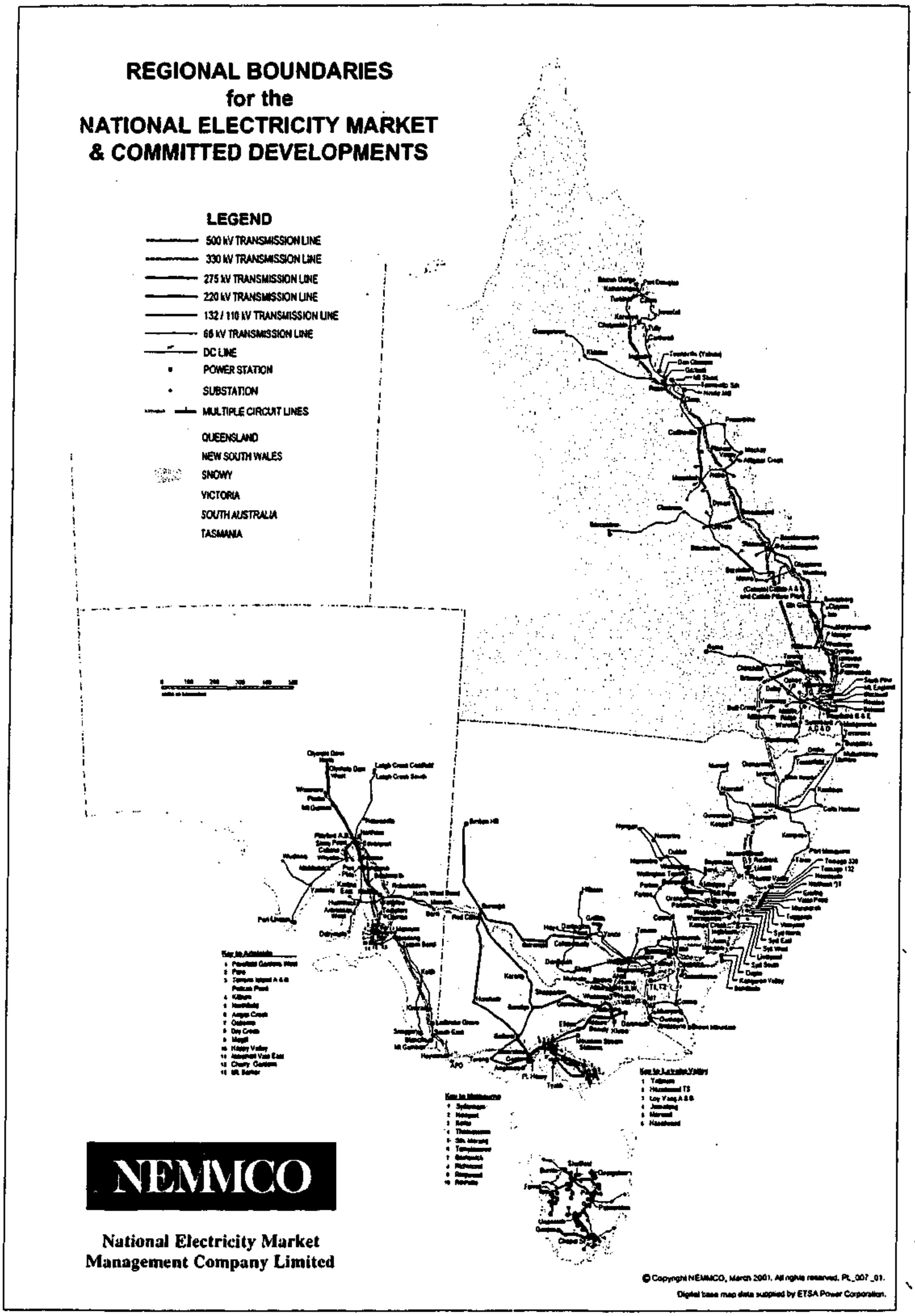
Figure 4.2



Source: NEMMCO, 1998

As shown on Figure 4.2, the flow of electricity between the states is uneven. For instance, 500MW can be exported by VIC into SA but only 250MW can flow in the reverse direction. The reason for this imbalance is the physical capacity of the transmission lines

Map 4.2


REGIONAL BOUNDARIES
for the
NATIONAL ELECTRICITY MARKET
& COMMITTED DEVELOPMENTS
LEGEND
500 kV TRANSMISSION LINE
330 kV TRANSMISSION LINE
275 kV TRANSMISSION LINE
220 kV TRANSMISSION LINE
132 / 110 kV TRANSMISSION LINE
66 kV TRANSMISSION LINE
DC LINE
POWER STATION
SUBSTATION
MULTIPLE CIRCUIT LINES
QUEENSLAND
NEW SOUTH WALES
SNOWY
VICTORIA
SOUTH AUSTRALIA
TASMANIA
NEMMCO
National Electricity Market
Management Company Limited
© Copyright NEMMCO, March 2001. All rights reserved. PL_007_01.
Digital base map data supplied by ETSA Power Corporation.

that have been constructed. Separate transmission lines are required for the flow of electricity in each direction.

At the time of the diagram's publication, the interconnection link between NSW and QLD was not finalised. The flow of electricity between these states can now take place with the transmission lines operative. The potential link between VIC and TAS (Basslink) has been granted approval by the Tasmanian government. However, the development of the transmission lines between VIC and TAS involves major capital infrastructure. The body of ocean between the states adds a difficult dimension to construction. Large cables need to be laid in a tunnel under the seabed. The ESAA expects that the employment of National Grid International to build, own and operate the Basslink interconnection will result in the flow of electricity between the states occurring in 2003.

A trend since the establishment of the NEM is the strong growth in the use of brown coal electricity generation (ABARE, 2000). This growth is attributable to the fact that brown coal electricity generation is presently the cheapest source of electricity in the Australian market. The Victorian generators compete vigorously against one another and have maintained consistently low electricity prices.

In the future Australia's electricity generation is likely to see a move away from these traditional fuel sources. Renewable energy sources are at the forefront of technological development. Some of the renewable energy sources to be explored include:

- Photovoltaics;
- Solar water heating;
- Hydro electric;
- Biomass to electricity;
- Wind power; and
- High temperature solar thermal electric.

Neither integrated gasification with combined cycle technology (IGCC) or pressurised fluidised bed combustion (PFBC), poses any serious threat to the fossil fuel generators in the short-run. However the potential undoubtedly exists for this new technology to replace the current methods if the right economic incentives arise (ABARE, 2000).

Australia has already established electricity generation capacity for some of the above mentioned methods. In particular, the use of wind power has been developed along the coastal regions of TAS and VIC. The generation capacity of wind power is very small at this stage but the potential for significant growth exists. Victoria, which is perhaps the best location in Australia in terms of quality of the wind resource and proximity to electricity demand, has an economic capacity in the short to medium term of not much more than 1,000 MW even on the most optimistic technological projections (ESAA, 2000).

Australia already has an established hydro generation industry in the Snowy region of NSW and VIC, and throughout TAS. A large percentage of hydro electricity generation is sourced from the Snowy Mountains Hydro-Electric Authority. "The Scheme's main operations are the collection, storage, diversion and release of water for irrigation purposes and the generation and transmission of environmentally friendly renewable electricity for NSW, VIC, and the ACT. At the same time the Snowy is positioning itself to be a profitable efficient producer of renewable energy and regulated water through existing and new business opportunities. The Scheme has been designed primarily with peak load generators with low utilisation factors. It provides important support services to the South-East Australian interconnected electricity grid and provides the key electricity transmission link between NSW and VIC." (Steering Committee on National Performance Monitoring of Government Trading Enterprises, 1998)

Due to the political unpopularity of hydro electricity development, it is unlikely that new hydro dams will be constructed in the future. The hydro electricity generators are unacceptable due to the environmental damage caused to the rivers from which they source the water. However a contradiction exists as in terms of greenhouse policy, these generators are considered to be the most greenhouse friendly of the existing electricity generators in Australia.

The development of renewable energy technology such as wind power could represent future export markets for Australia. Regional areas in Australia and in other remote areas of the world could benefit immensely from low emission generation from sources who do not need to be connected to an electricity grid. The sale of renewable energy technology to countries such as Indonesia could provide export opportunities for Australia.

According to industry sources, Australia has at least 400 years supply of brown coal at present usage levels (ESAA, 1999). Black coal reserves at are similar levels. The supply of natural gas is estimated to be considerably lower at 70 years. This could be significantly reduced if greenhouse policy encourages the use of substantially more gas in generating electricity.

In the Australian Prime Minister's statement entitled *Safeguarding the Future: Australia's Response to Climate Change*, it was proposed that the Government set a mandatory target for electricity retailers to source an additional two percent of their electricity from renewable energy sources by 2010.[64] This Government commitment means that renewable energy sources will be in greater demand and will compete with the brown coal generators in supplying to the electricity grid.

As mentioned previously, brown coal is the cheapest method of producing energy given the existing technology. If however the Government imposes large greenhouse taxes on the brown coal generators, whilst at the same time encouraging the renewable forms of energy production, renewable energy may in effect become a cheaper electricity source. In addition to the mandatory target of two percent from renewable energy sources, the Government has stated that it will commit $21 million in the Renewable Energy Innovation Investment Fund and a further $29.6 million to a loans and grants scheme in Renewable Energy.[65] With large monetary incentives in renewable energy research and development, a number of organisations are likely to enter this market. It will be of interest to observe if the brown coal generators themselves decide to enter.

[64] Legislation has recently been passed to enact this Government commitment.
[65] The states and territories of Australia have also committed substantial funds.

4.3 VICTORIAN ELECTRICITY INDUSTRY

A focus of this thesis is the Victorian electricity supply industry. Greenhouse policy will impact heavily upon the Victorian ESI due to its reliance on brown coal electricity generation. The brown coal electricity generators are the highest CO_2 emitters per MWh of electricity produced. It is this emission intensity that is likely to see the Victorian ESI more severely effected relative to other generators in the Australian NEM.

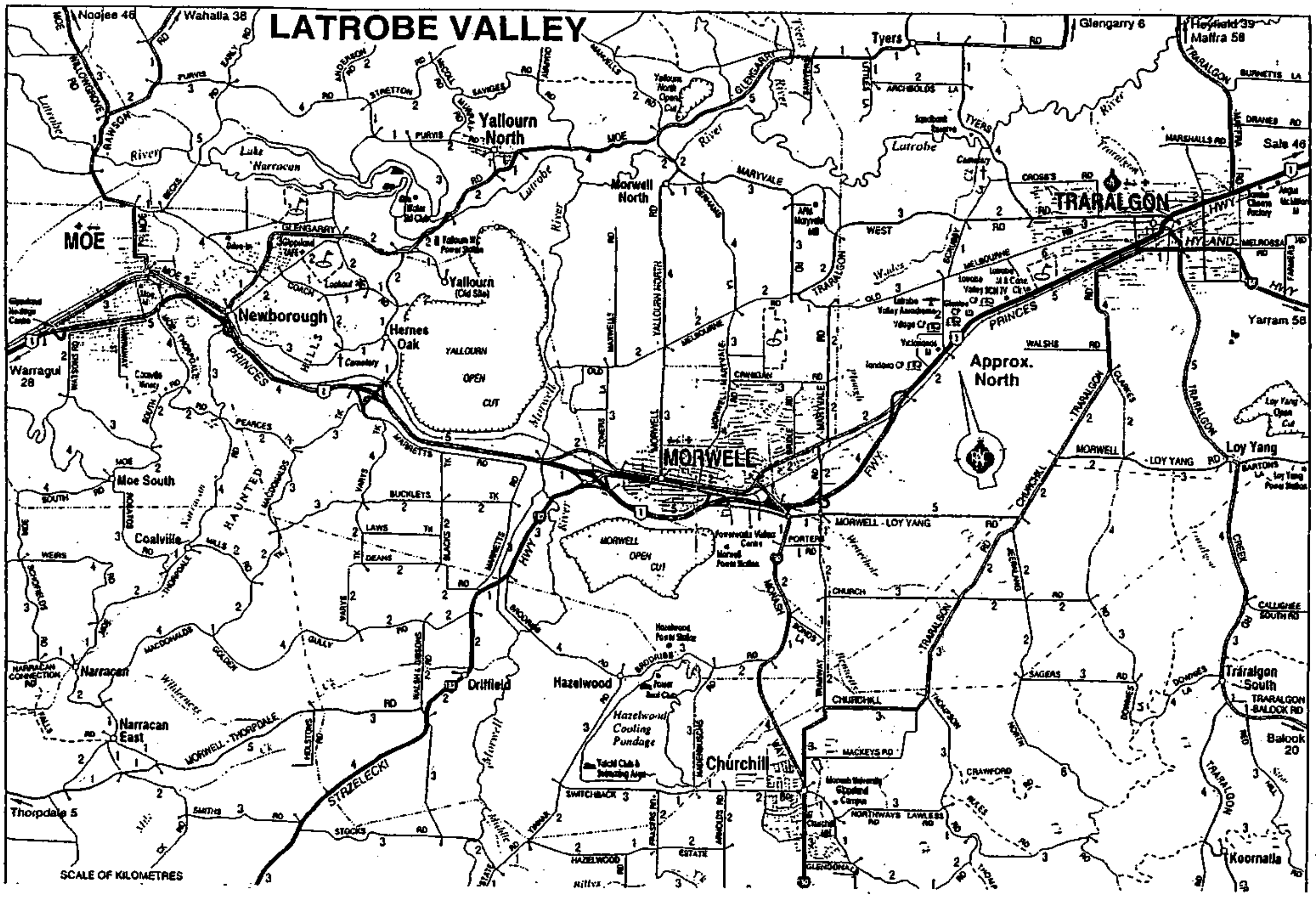
As mentioned in Section 4.2.1, in 1989, following a series of investigations by government authorities, the SECV announced its decision to restructure the ESI in an attempt to make it more efficient by introducing competition. With the ultimate motive of privatisation, the State Government of Victoria deregulated the ESI by establishing a company made up of the generating business units.

Almost all of Victoria's energy supply comes from the La Trobe Valley brown coal generators. The five generators in the region are Loy Yang Power, Hazelwood Power, Edison Mission Energy, Yallourn Energy and Energy Brix Australia. Collectively the generators supply the equivalent of 90 per cent of Victoria's total power needs and are responsible for 8 percent of Australia's total greenhouse gas emissions (La Trobe Valley Task Force, 1996). The following discussion provides a brief outline of each generator (see Map 4.3 on the following page for a map of the La Trobe Valley).

Yallourn Energy

Yallourn Energy operates an 1450 MW thermal power station and an adjacent brown coal mine. Like most of the mines in the La Trobe Valley region, the coal has a high moisture content (65-68 percent). The mine operates 24 hours a day, 365 days per year to supply brown coal to the power station for electricity generation. The Yallourn power station and mine are located next to the small town of Yallourn North and within close proximity to the regional centre of Moe.

Yallourn Energy is operating on a business plan of 30 years. In the near future the brown coal will be mined from the new Maryvale Coal Field which is under construction.


LATROBE VALLEY
Noojee 46
Wahalla 38
Glengarry 6
Heyfield 39
Maffra 58
Tyers
Sale 46
Yallourn North
MOE
Newborough
Yallourn (Old Site)
Hernes Oak
YALLOURN OPEN CUT
Morwell North
TRARALGON
MORWELL
Warragul 28
Moe South
Coalville
Yarram 58
Approx. North
Loy Yang
MORWELL OPEN CUT
Hazelwood
Driffield
Narracan
Narracan East
Hazelwood Cooling Pondage
Churchill
Traralgon South
Balook 20
Thorpdale 5
Koornalla
PRINCES HWY
STRZELECKI HWY
SCALE OF KILOMETRES

Map 4.3

Yallourn Energy was the first of the power generators to be privatised when it was sold in April 1996. Whilst not as large as some of the other generators, Yallourn Energy supplies the equivalent of 25 percent of Victoria's electricity. Yallourn Energy currently employs just under 600 people.

Yallourn Energy's greenhouse gas emission levels are currently 1.384 tonnes of CO_2 per megawatt hour. The likely impact of greenhouse policy on the company was well expressed by its previous owners in the following statement. This sentiment is also held by the other brown coal electricity generators operating in the La Trobe Valley.

"The owners of the company have made a major financial investment by purchasing the plant in its current form. New technologies for achieving significant improvements in thermal efficiency through repowering are neither technically nor economically justifiable at this point in time.

Consideration of repowering is not likely to be seriously undertaken before 2010. Commensurate with these studies will be the options of:

1. *repowering the existing station, or*
2. *building or a new high efficiency station on a different site, or*
3. *ceasing business."*

Edison Mission Energy

Edison Mission Energy owns and operates the 1000 MW Loy Yang B power station which currently employs 126 people. The power station is located 10 kilometres south of Traralgon in the La Trobe Valley. Edison Emission Energy does not own a brown coal mine, but sources its fuel from the Loy Yang Power mine.

Edison Mission did not experience the full impact of industry deregulation due to the fact that it was built just prior to the deregulation and was privatised soon after. The power station emits 1.23 tonnes of CO_2 per megawatt hour which equates to approximately 4.5 million tonnes of CO_2 equivalent gas per annum.

The power station is striving to reduce its emissions however as it is currently operating at the maximum peak efficiency of brown coal technology, it is facing a difficult challenge. The business activity in the power station is predicted to increase from 3,638 GWh per annum in 1995/96 to 7,758 in 2000/2001. The organisation's emission levels are predicted to double over the same period.

Hazelwood Power

Hazelwood Power owns and operates a 1600 MW power station and adjacent open cut brown coal mine. Hazelwood Power is located on the fringe of Morwell, in the heart of the La Trobe Valley.

Hazelwood Power is the oldest of the existing generators and therefore has possibly the largest scope to improve its practices and greatly reduce its emissions of CO_2 without the enormous capital outlays that would have to be borne by efficient operators such as Edison Mission Energy. Hazelwood Power currently employs 580 people and was sold in 1996 to a predominantly international consortium. Hazelwood Power emits 9.45 million tonnes of CO_2 per annum.

The ESI privatisation extended the corporate life of Hazelwood Power which was earmarked for closure by the SECV toward the end of 1997 (SECV, 1991). The asset life of the Hazelwood Power station has now been extended for an additional 30 years due to investment expenditure which has been undertaken on the plant by its new owners.

Hazelwood Power has recently increased its business activity from 5,786 GWh per annum in 1995/96 to 9,699 in 2000/2001, which has coincidently led to increases in the company's CO_2 emissions.

Loy Yang Power

With a 2000 MW power station Loy Yang Power is the largest electricity generator in Victoria. Loy Yang Power also owns and operates Australia's largest open cut coal mine.

The location of the power station and mine are adjacent to the Edison Mission power station, south of Traralgon. The organisation currently employs 550 people.

During the baseline year Loy Yang Power emitted 17.4 million tonnes of CO_2. Reducing these levels is a difficult challenge facing Loy Yang Power as it is a relatively new power station and is presently the lowest cost producer in the NEM. Loy Yang Power has committed almost $60 million to reducing its CO_2 emissions. Management at Loy Yang Power estimate that with a series of environmental improvements put in place they can reduce their annual emission levels to almost 17 million tonnes of CO_2.

Energy Brix

Although not solely a brown coal generator, Energy Brix also forms part of the La Trobe Valley electricity industry. Energy Brix specialises in the production of brown coal briquettes. Briquettes are low moisture, high energy fuel made from dried and compressed brown coal and are primarily used for industrial boiler fuel with a small local domestic heating market (Latrobe Valley Task Force, 1998) A significant percentage of the briquettes produced by Energy Brix are exported. In the baseline year over 95,000 tonnes of briquettes were exported, with Germany representing the largest export market.

Energy Brix is Australia's largest co-generation plant, producing both electricity and briquettes. The coal used in the power station and adjoining briquetting complex is sourced either from the Yallourn Energy open cut mine or the Hazelwood Power mine. Both of these mines are linked to Energy Brix by rail. The briquettes are transported from the La Trobe Valley to other regions by road transport.

Energy Brix believes that it is currently doing all it can within the 'no regrets' framework to meet the Greenhouse Challenge. Energy Brix began its operations in 1959 and is therefore not as efficient as newer plants. To improve the efficiency of the plant and simultaneously reduce CO_2 emissions, large capital investment would have to be undertaken. According to Energy Brix such investment would go beyond the Government's 'no regrets' stance.

Energy Brix's CO_2 emissions per annum are 1729 kilotonnes. Even with a large number of efficiency improvements, the emissions at the site are likely to increase, although this still represents a reduction from where they would otherwise have been. If a tax is placed on Energy Brix and it passes this tax onto the consumer, Australia's export market in briquettes may dramatically decline as the price of the product rises. If an international company who also produces briquettes is not subject to the same level of tax, Energy Brix may lose its price advantage in the German market. Australia may in effect lose its competitive advantage.

Research commissioned by the La Trobe Valley generators found that the generating sector of the electricity industry contributes more than AUD$400 million to the La Trobe Valley's economy per annum, providing 4,000 jobs directly and a further 160,000 jobs in Victorian industry (La Trobe Valley Task Force, 1996). The 4,000 direct jobs are mainly located in the La Trobe Valley region as people are either employed to work with the generators or one of the contractors who provide support services (Foster et al, 1997). A further discussion of the relationship between the Victorian ESI and the La Trobe Valley is found in Section 4.4.

The projected 160,000 indirect jobs created by the ESI within the Victorian economy is based on the notion that electricity is used as a major input in the production of many goods such as aluminium. Without low cost electricity it is argued that these industries would not continue to operate in Victoria. The accuracy of the injected sum of AUD$400 million into the regional economy annually may be questioned, however what cannot be argued is the importance of this industry to the region within which it resides.

Prior to the deregulation of the Victorian ESI almost all of the support services were provided inhouse. One of the main changes which arose from deregulation is the outsourcing of services such as maintenance to private contractors. The generators themselves no longer provide their own maintenance services, but employ contractors to perform these roles for them. In many cases staff who had been previously employed by the SECV were transferred to the private organisation.

At present the electricity supply market is fiercely competitive due to the lower than expected electricity pool prices. As discussed above, the Victorian generators are in competition not only between themselves but also with interstate generators. This competition recently intensified with the option for business customers and some domestic customers to choose their electricity supplier (ESAA, 2000).

Amid this market based competition is the proposed greenhouse policy aimed at reducing the level of CO_2 emissions released by the generators. It is the nature of the policy that is important to the generators, as the cost of emission abatement threatens to reduce their return on investment. In an attempt to be proactive in the push for lower emissions, the Victorian generators have formed a joint action group called the La Trobe Valley Task Force. The objective of the Task Force is to identify the ways in which the Victorian ESI can reduce its emissions with as little damage to the generators' financial position and the regional economy as possible.

The La Trobe Valley Task Force has signed onto the Government's Greenhouse Challenge program. The Greenhouse Challenge was introduced in 1995 as a cooperative effort by industry and government to reduce greenhouse gas emissions through voluntary industry action (ESAA, 1997). Towards the end of 1997 the Australian Government committed an additional AUD$27 million to extend the program with the aim of having 1000 signatory companies by 2005 (ESAA, 1997). Australian emissions between 1990 and 2000 were originally projected to increase by 82 megatons but abatement measures through projects such as the Greenhouse Challenge have reduced the projected growth to only 23 megatons (Greenhouse Challenge Office, 1998).

The La Trobe Valley Task Force has agreed to reduce the emission levels of CO_2 within the region through a variety of methodologies. Some of the measures taken by the Task Force include enhanced generation practices, improved generation technology, the establishment of carbon sinks, and overseas energy technology audits (La Trobe Valley Task Force, 1996). For instance, Hazelwood Power has recently invested in a commercial composting plant in Morwell that will provide an offset to its current emissions of at least 300,000 tonnes of CO_2 equivalent gas (Hazelwood Power, 1999).

The Greenhouse Challenge agreement between the Government and the La Trobe Valley Task Force is a step in the right direction to reducing the level of CO_2 emissions from the industry. If the generators and other participants of the Greenhouse Challenge agreement meet their targets, the Australian Government will be moving toward reaching its own commitment for emission reductions as agreed to at the Kyoto conference. However, even with the voluntary emission savings made through the Greenhouse Challenge program it is likely that the Government will be forced to introduce a policy measure aimed at reducing emissions below those voluntarily agreed on. To satisfy greenhouse gas emission abatement commitments, additional measures will be necessary.

As mentioned above, the La Trobe Valley generators emit 8 per cent of Australia's total greenhouse gas emissions. Combined, the generators have committed over $130 million in the next two years alone to plant refurbishment as well as to research and development to ensure that their processes are efficient and as low in greenhouse gas emissions as possible (ESAA, 2000).

The impact of a greenhouse tax upon the individual brown coal generators will depend on their ability to meet the emission targets outlined by the Government. A brief outline of the generators and their current CO_2 emission levels is included in Table 4.1. The details of emission levels for the generators is provided by the La Trobe Valley Task Force. The baseline year for emission levels used by the Task Force is 1995/96.

Table 4.1

LA TROBE VALLEY ELECTRICITY GENERATORS

Organisation	*No. of Employees*	*Plant Size*	*Emission Levels (1995/96)*	*Forecast Emission levels – no action*	*Forecast Emission levels – with action*
Edison Mission Energy	126	1000 megawatt station	4.5 million tonnes of CO_2	9.5 million tonnes of CO_2	9.5 million tonnes of CO_2
Hazelwood Power	580	1600 megawatt station	9.45 million tonnes of CO_2	15.8 megatonnes of CO_2	15.1 megatonnes of CO_2
Loy Yang Power	550	2000 megawatt station	17.4 million tonnes of CO_2	17.743 million tonnes of CO_2	17.059 million tonnes of CO_2
Yallourn Energy	600	1450 megawatt station	16 million tonnes of CO_2 (approx)	14.379 million tonnes of CO_2	14.338 million tonnes of CO_2
Energy Brix	280	170 megawatt capacity 700,000 tonnes of briquettes	1264 kilotonnes	1955 kilotonnes	1873 kilotonnes

As outlined above, many of the generators are already operating at peak efficiency and may subsequently find it difficult to reduce their emissions without the advent of new technology.

One of the main arguments against stringent greenhouse policy measures put forth by the La Trobe Valley Task Force is that "brown coal as a resource has little economic value if it is not used in the production of electricity" (La Trobe Valley Task Force, 1996). Brown coal is not an easily transportable resource due to its high water content and therefore should be used on site.

As explained in Chapter three, there are other reasons put forth as to why Australia should ensure that its greenhouse policy does not dampen the growth prospects of the electricity industry. Due to Australia's abundance of natural resources it is the world's largest coal exporter, the third largest aluminium exporter, and one of the largest energy exporters among OECD countries. Australia's exports are energy-intensive and are, on average, twice as carbon-intensive as the goods it imports (O'Sullivan, 1997). The advantage of using coal as a source of energy is due in part to the fact that it can be converted into electricity as cheaply as any other fuel. This advantage could be eroded if greenhouse policy has a greater impact upon the ESI than on alternative energy sources such as natural gas (Danoher, 1997).

According to the La Trobe Valley Task Force, Australia's domestic greenhouse policy should:

- Deliver equity to all participants
- Recognise the value brown coal generators deliver to Australia and Victoria
- Support a market based solution that provides a non-discriminatory regulatory framework. (La Trobe Valley Task Force, 1996).

The La Trobe Valley Task Force is lobbying the Commonwealth Government. It wants the Government to acknowledge the contribution made by the industry to Australia's economic performance, and to take this into consideration when greenhouse policy is formulated.

4.3.1 THE FUTURE OF THE VICTORIAN ESI

The competitive environment in the Victorian electricity market has led to lower than expected returns on investment since the privatisation of the generators. Arguably a result of this negative performance has been the sale of Yallourn Energy in 2001. Both Loy Yang Power and Hazelwood Power have also sought interested investors. The impact of greenhouse policy on these businesses is a major consideration for any potential investor.

The long term future of brown coal generation in the Australian electricity industry is partially dependent upon the success of research into the development of technologies to reduce greenhouse gas emissions from brown coal generators. At the forefront of this research is the Cooperative Research Centre for Clean Power from Lignite (CRC Clean Power).[66]

CRC Clean Power has total external funding of AUD$48 million over a period of seven years which combined with its own funding will commit in excess of AUD$75 million toward research into improving the efficiency of producing electricity using brown coal

[66] Lignite is another name for brown coal.

(CRC, 2000). Participants in the CRC include the La Trobe Valley generators, Flinders Power, and a number of leading Australian universities. CRC Clean Power employs over 100 research scientists, engineers and technical officers.

According to CRC Clean Power, the reason for brown coal's comparatively high emissions of CO_2 is due to its high moisture content. In the process of drying out the coal, relatively more emissions are released into the atmosphere. CRC has developed a coal drying, dewatering characterisation program that addresses the issue of water removal.

Advanced technologies currently under development to improve the thermal efficiency of coal-fired plant include Circulating Fluid Bed Combustion (CRBC), Supercritical Pulverised Coal Fired Boilers (SCPC), Pressurised Fluid Bed Combustion (PFBC), Integrated Gasification Combined Cycle (IGCC) and Advanced Pressurised Fluid Bed Combustion (APFBC) cycles (CRC, 1999).

Another possibility is the further development of technology into ceramic fuel cells. "Solid oxide (or ceramic) fuel cells are electrochemical devices which directly convert fuels such as natural gas, methane, hydrogen and gasified coal into electricity. They are widely recognised as the most efficient means for converting fossil fuels to electricity" (CRC, 1999).

Research conducted by CRC Clean Power into the market for electricity supply in VIC over the next 40 years, envisages a continued role for brown coal generated electricity. The implementation of APFBC technology offers significant potential to reduce CO_2 emissions from the brown coal generators. The estimates of electricity demand used in the study are based on the assumption that the Government's 2 percent renewable target is met, and that with current estimates of growth, renewables would produce 16 percent of total electricity supply in VIC in 2040.

Under these assumptions, and taking into account a growth rate in demand for Victorian electricity of 1.5 percent per annum, it is estimated that VIC would require seven new 1000 MW power stations by 2040. This assumes that the existing Hazelwood Power and Yallourn Energy stations will have reached the end of their commercial life. CRC predicts that the new generation plant will be made up of APFBC brown coal plant, combine cycle gas turbine plant and renewables.

The CRC research predicts that the use of natural gas as a fuel for electricity will grow modestly over the next decade. The argument is based on the fact that after 2010 the price of natural gas will increase in response to its scarcity. With the price of natural gas rising and the relative price of brown coal generation remaining stable, brown coal electricity generation is forecast by CRC to remain the base supplier in VIC.

The CO_2 emission savings are substantial under the scenario that the APFBC technology is introduced. By 2040 the annual CO_2 emission rate is expected to fall by 36 percent relative to the basecase where emissions from brown coal generators improve only slightly in accordance with the Australian Government's Greenhouse Challenge initiative. This is equivalent to 500Mt of CO_2 to 2040, relative to business as usual.

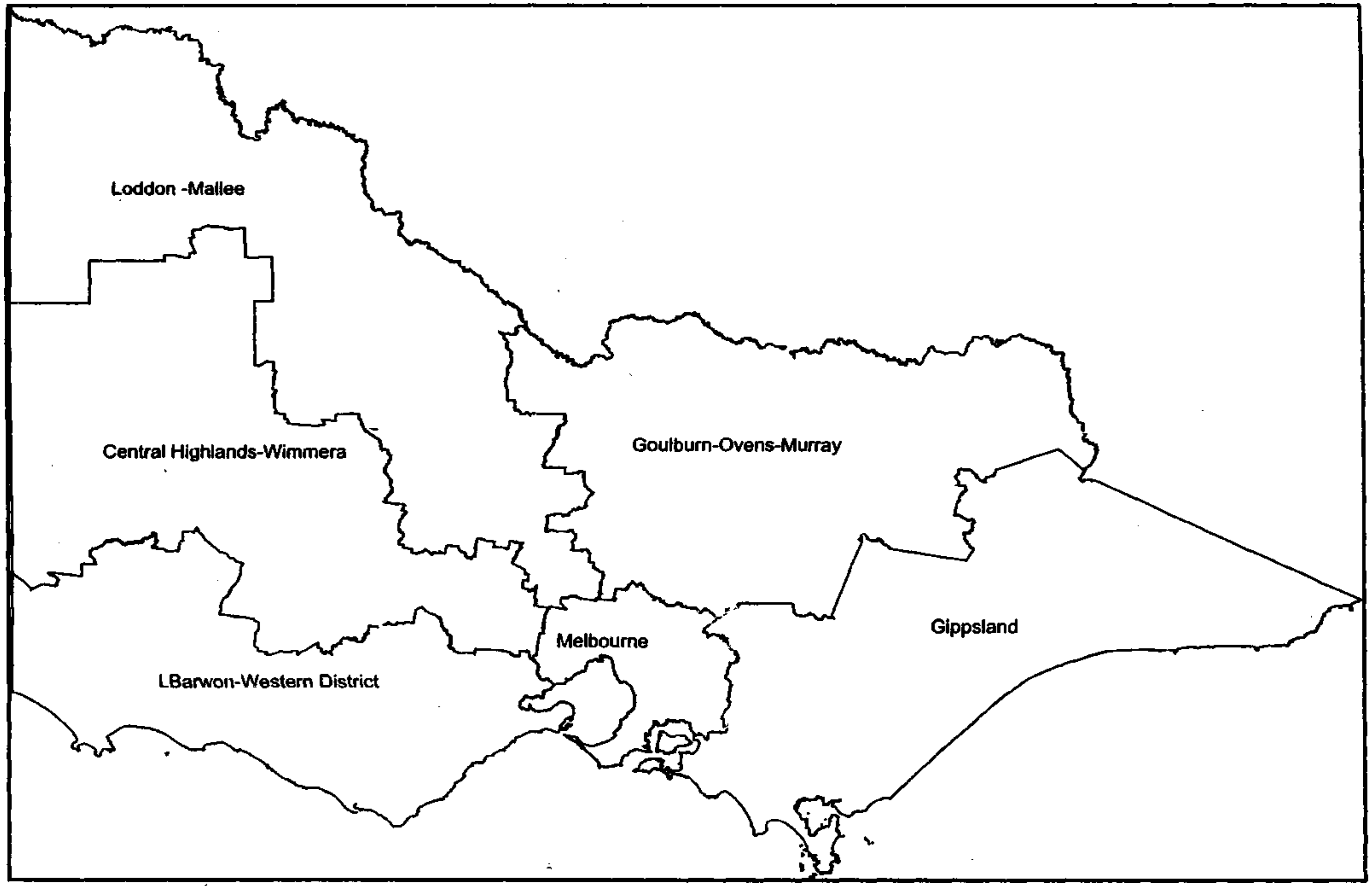
As recognised by CRC Clean Power, the main barrier to the implementation of the new technology is the tremendous capital cost. The capital costs of adapting mature plants to the new technology is approximately AUD $1350/kW to $1800/kW. Demonstration plants are needed before commercial commitment is made. According to CRC, Government assistance is required to fund part of the cost of the demonstration plant as it is beyond the scope of any one electricity generator operating in a competitive environment. Such Government assistance is forthcoming with financial commitments made by both the Victorian and Commonwealth Governments.

4.4 THE VICTORIAN ESI AND THE LA TROBE VALLEY REGION

As mentioned above, the Victorian ESI is located predominantly in the La Trobe Valley region in the State of Victoria. This section explores the inter-relationship between the industry and the state within which it resides.

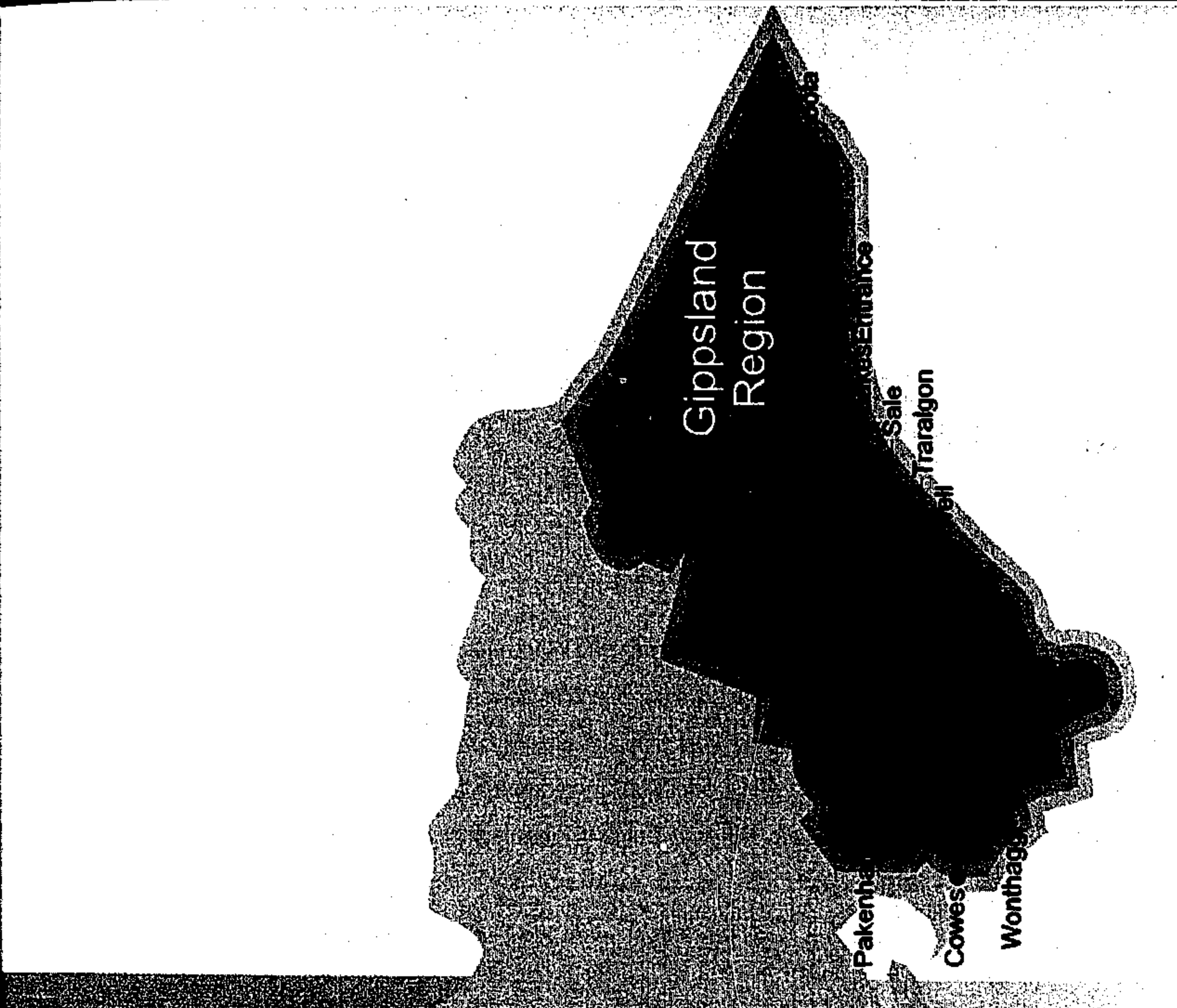
The Gippsland region in the State of Victoria has a wealth of natural resources from which its main industries have evolved (see Maps 4.4 and 4.5 for an illustration of the Gippsland region in the State of Victoria). Natural-resourced based industries fostering economic growth in the region include electricity supply, forestry, pulp manufacturing, and agriculture and farming. The industrial base of the Gippsland region lies in the City of Latrobe. The population of the Latrobe City stands at approximately 73,000, of which 35 percent are between the ages of 20 to 49 years. Only 10 percent of the workforce are professionals, with the most prevalent occupations being tradespersons and labourers (GRIS, 2000).

La Trobe City is made up of the regional towns of Traralgon, Morwell and Moe with a number of smaller towns in surrounding areas (see Map 4.3). The La Trobe Valley region has experienced negative economic growth over the past decade due largely to the restructure of the Victorian ESI. Today the ESI remains one of the most important industries in the region, however it is no longer the largest employer. A pen-picture of the region is outlined below to illustrate the key economic indicators.



Loddon -Mallee
Central Highlands-Wimmera
Goulburn-Ovens-Murray
Melbourne
LBarwon-Western District
Gippsland

Map 4.4



Map 4.5

Table 4.2

POPULATION

Region	1991	1996	% Change
La Trobe	71086	67564	-4.95
Gippsland	224978	222389	-1.15
Victoria	4244221	4373520	3.05

Source: 1991, 1996 Australian Census, ABS

Table 4.2 indicates that the La Trobe Valley experienced a decline in its population whilst over the same period the population of Victoria rose. The difference in population growth between La Trobe Valley and Victoria is equal to 8 percent. The decline in population over this period suggests that a number of La Trobe Valley residents relocated to another region. Research has overwhelmingly found that the prospect of better employment opportunities in other regions was the main reason residents left the La Trobe Valley during this period (Foster, B., Kazakevitch, G., and Stone, S[67]., 1997).

A more recent publication by the Victorian Department of Infrastructure, *Victorian Future* (2000), suggests that the resident population in the La Trobe Valley between 1996 and June 2000 has fallen by 0.5 percent. The natural rate of population growth in the La Trobe Valley is 0.5 percent per annum (ABS, 2000).[68] The reduction in resident population therefore indicates that outward regional migration is still occurring, although the rate has slowed.

As explained in Section 4.3 it was during the period between 1991 and 1996 that the Victorian ESI underwent major reform. Many of the functions previously performed by the SECV were outsourced to private organisations. Employees were offered voluntary departure packages and many who were unable to find work with the new contractors migrated to other regions seeking employment opportunities.

[67] S. Stone is the maiden name of the author S. Enzinger.

There were significant multiplier effects felt throughout the regional economy of the La Trobe Valley beyond the immediate reduction in expenditure by the electricity sector. There was an initial injection of VDP money into the economy in the short-run. Many employees took the opportunity to open their own businesses in the region with the money they had been paid (Foster et al, 1997). In the long-run, a large percentage of VDP recipients found themselves out of work and those who had gone into business struggled to remain afloat as the region became economically depressed. The regional economy was on a downward economic spiral. Evidence to support this can be found in the collapse of the region's property market. The median sale price of residential dwellings between 1987 and 1998 increased by 18 percent[69] in the La Trobe Valley, 34 percent in country Victoria, and 71 percent in Melbourne (GRIS, 2000).

Table 4.3

UNEMPLOYMENT RATE (%)

REGION	1990	1991	1992	1993	1994	1995	1996	1997
La Trobe Shire	6.5	12.8	10.1	15.8	17.0	10.4	11.5	14.8
Gippsland	5.3	11.9	9.8	12.7	14.1	8.3	9.1	12
Victoria	5.2	10.3	11.7	12.0	10.8	10.8	8.4	9

Source: Department of Employment, Workplace Relations and Small Business

As shown in Table 4.3, in 1997 the La Trobe Valley region had an unemployment rate almost 6 percent above that of Victoria and 3 percent above greater Gippsland. The unemployment rate in the La Trobe Valley has been consistently higher since the reform of the ESI. As the unemployment rate is one of the key economic indicators, it is reasonable to assume that during this period the La Trobe Valley region was in a worse economic position relative to Gippsland or Victoria[70]. Additional evidence to support this theory is

[68] Population projections for the La Trobe Valley by the Department of Infrastructure are an increase of 8.5 percent between 1996 and 2021. This remains below projections for other regions.
[69] This figure is not adjusted for inflationary impacts.
[70] The La Trobe Valley region has more infrastructure than the rest of Gippsland and therefore in terms of employment opportunities it traditionally had more to offer.

found in Birrell (2001). The percentage of families without a breadwinner[71] in the towns of Moe, Morwell and Traralgon are 29.8, 34.2, and 20.7 respectively. This is in contrast to the percentage of families without a breadwinner in Melbourne of 17.7 (Birrell, 2001).

Table 4.4

UNEMPLOYED PERSONS BY AGE (%)

	AGE						
REGION	**15-19**	**20-24**	**25-34**	**35-44**	**45-54**	**55-59**	**60-64**
La Trobe Shire	12.3	23.0	24.3	17.8	14.3	6.0	2.1
Gippsland	11.2	20.4	25.1	19.6	15.2	6.2	2.2
Victoria	9.0	23.2	26.9	18.3	14.5	5.8	2.2

Source: 1991, 1996 Australian Census, ABS

Table 4.4 shows the distribution of unemployed people by age group between the three regions. The number of unemployed in the 25–54 age bracket for the La Trobe Valley is slightly lower. The result suggests that this may be the mobile bracket of wage earners who relocate if they experience unemployment. This observation is supported by the Victorian Department of Infrastructure projections to the year 2011, which suggest a loss of young people in the under 25 years group of more than 580, and a corresponding decline in the age group 25-50 years (the wage earners who drive economic activity) (Foster and Homes, 1998).[72]

According to ABS data, the net number of males in the 15-24 age bracket to relocate from the Gippsland region between 1991 and 1996 was 3,012, or 18.2 percent[73]. The percentage of males in the same age bracket in the rest of Victoria is 11.6. According to Birrell (2001) the most unusual characteristic of the Gippsland migration data is that whilst it is common for males in the 15-24 age bracket to leave regional areas, many of these people subsequently return when they reach the age bracket of 25-44. However the data for males in the Gippsland 25-44 age bracket indicates that the opposite is true. The net rate of

[71] A breadwinner is defined as a family where neither parent reports any income from employment, whether part-time or full-time.
[72] Department of Infrastructure population projections based on the 1991 census data.
[73] The La Trobe Valley region is included as part of greater Gippsland in this data.

migration for Gippsland males in this age bracket is 5.5 percent, compared to the rate for the rest of Victoria of 1.5 percent.

The unemployment rate for those people in the 15-19 age bracket is relatively higher for the La Trobe Valley. The SECV was traditionally a large employer of people in this age group, offering many apprenticeships and trainee positions. With the deregulation of the ESI these opportunities became few and far between. Graduate employment with the electricity generating companies almost ceased entirely.

Table 4.5

NUMBER OF WELFARE BENEFITS RECIPIENTS

BENEFIT	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Sole Parent	1530	1621	1650	1719	1796	1822	1948	1985	2062
Unemployment	3142	3933	5219	5180	4744	4837	4965	4819	5598

Source: GRIS Latrobe Statistical Profile (2000)

Table 4.5 is important as it shows that whilst the region's population levels were declining, the number of welfare benefit recipients increased. According to a study by Foster and Homes (1998), 42 percent of the population in Gippsland[74] aged 15 years and over are living on $200 a week or less. This should be compared to the figure for Victoria as a whole, which is 36.6 percent. The large incidence of welfare recipients in the region is further supported by conclusions in Birrell (2000 and 2001) that current residents are likely to be disadvantaged, at least relative to their metropolitan counterparts.

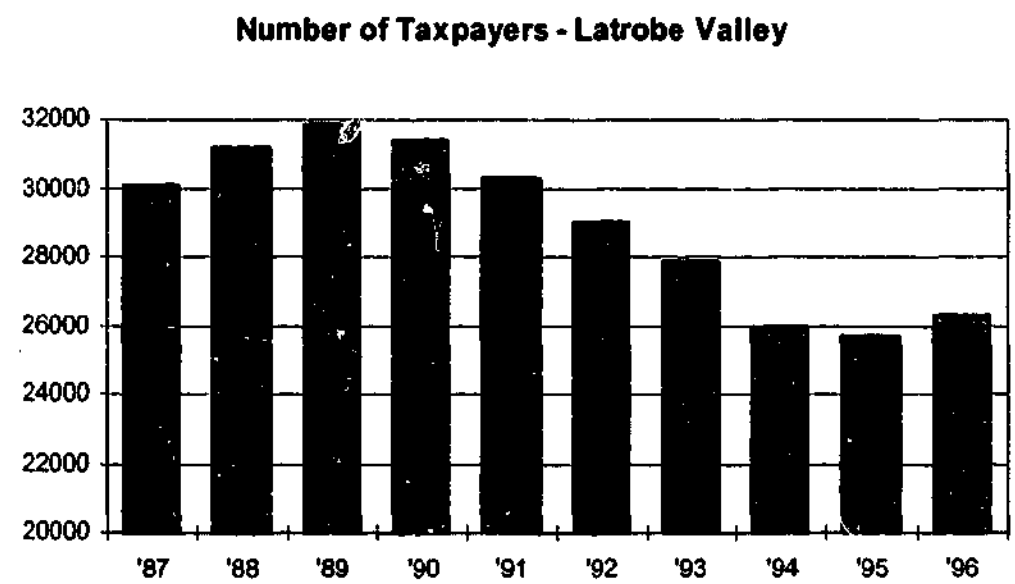
The above tables suggest that the La Trobe Valley region suffered economically following the reform of the ESI. In addition to the information supplied by statistical bodies such as the ABS, the physical indication of economic depression was evident to those who reside and work in the region. The most prevalent signals were the increase in the volume of houses for sale and the closure of numerous small businesses. These figures do not appear in the Census data explicitly but they are inherent in the tables above.

[74] In this reference the La Trobe Valley is included as part of greater Gippsland.

A limitation of the ABS Census data is that it does not include information relating to the present day. It is possible that the economic indicators have stabilised more recently. Evidence to support this is found in Table 4.6, which represents a time series analysis of the number of taxpayers in the La Trobe Valley region. During the period of the ESI reform (1989 – 1995), the figures show the number of taxpayers to be falling. During the last year recorded (1996), the number of taxpayers rose slightly. A higher number of taxpayers in the region suggests that the economic climate is improving. According to the Department of Employment, Workplace Relations and Small Business (2000) the unemployment rate in the La Trobe Valley has decreased from its peak in 1998 of 16 percent to 14 percent in 1999 and 13.5 percent in 2000. These unemployment rates remain well above those of Melbourne and the rest of regional Victoria. Anecdotal evidence suggests that any recovery in the La Trobe Valley has been gradual.

Table 4.6

NUMBER OF TAXPAYERS



SOURCE: Australian Taxation Office

From the evidence presented above it can be concluded that the La Trobe Valley region is in a worse economic position relative to most regions in Victoria. The Latrobe City remains an important regional centre in the State of Victoria. It is for this reason that any further challenge faced by the ESI will be watched closely by interested parties. The implementation of greenhouse policy represents such a challenge. If the greenhouse policy impacts heavily upon the region's main industries, the La Trobe Valley could become even worse off relative to the rest of Victoria and potentially the rest of Australia.

4.4.2 POSSIBLE IMPACT UPON THE LA TROBE VALLEY REGION OF GREENHOUSE POLICY

The impact of the Australian Government's greenhouse policy upon the La Trobe Valley region depends firstly on the type of tax imposed on the electricity generators who emit CO_2, and secondly upon the reaction of those companies. A detailed discussion of the La Trobe Valley electricity generators was provided in Section 4.3.

As discussed in Chapter three, one policy proposal is a tax placed on the emission of CO_2. A carbon tax levied at the rate of AUD$26 per tonne of CO_2 will significantly increase the operating costs of the generators (see Table 4.7). For instance, as Loy Yang Power emits over 17 million tonnes of CO_2 per annum, it would incur a carbon tax in the vicinity of AUD$442 million. This figure would more than likely eliminate all revenue earned by the electricity generator.

Table 4.7

LA TROBE VALLEY ELECTRICITY GENERATORS

Organisation	***Emission Levels (1995/96)***	***Carbon Tax of $26 per tonne***	***Forecast Emission levels – with action***	***Carbon Tax of $26 per tonne***
Edison Mission Energy	4.5 million tonnes of CO_2	$117 million	9.5 million tonnes of CO_2	$247 million
Hazelwood Power	9.45 million tonnes of CO_2	$245.7 million	15.1 megatonnes of CO_2	$392.6 million
Loy Yang Power	17.4 million tonnes of CO_2	$452.4 million	17.059 million tonnes of CO_2	$443.6 million
Yallourn Energy	16 million tonnes of CO_2 (approx)	$416 million	14.338 million tonnes of CO_2	$372.8 million
Energy Brix	1264 kilotonnes	$33 million	1873 kilotonnes	$48.7 million

If we assume that the Government introduces a greenhouse tax, the impact upon the La Trobe Valley will depend on the reaction of the taxed companies operating in the region. Chapter six discusses in detail the results of greenhouse policy simulations upon the region. The first option for the ESI is to absorb the cost of the tax. Whilst this may appear an unlikely scenario, the generators operate in a very competitive environment and may have no option other to bear the cost of the tax internally. The cost of this option would be borne by the foreign owners of the generators, with no direct impact upon the La Trobe Valley region unless the individual companies attempt to offset the tax with a reduction in costs such as labour.

The second reaction of the ESI may be to pass the tax onto its consumers. If all members of the ESI act in this manner it is unlikely to damage the revenue and subsequent profits of any one firm. The likelihood of such an agreement is very slim as the different codes of electricity generation rarely act in unison. The impact on the La Trobe Valley region of this option may be varied. The most obvious consequence is likely to be an increase in electricity prices for energy intensive businesses and households. Consumers in the La Trobe Valley will have to pay more for their electricity but this will be in line with all consumers across the State of Victoria, and possibly the rest of Australia. According to Hamilton (1998) the welfare sector has argued that raising the prices of electricity will affect poor households disproportionately. As discussed earlier, the La Trobe Valley region has a larger percentage of poor or disadvantage households relative to the rest of Victoria (GRIS, 2000). Based on this, a conclusion could be drawn that a rise in electricity prices could disproportionately cause greater hardship in the La Trobe Valley relative to other regions.

An interdependence exists between the Victorian ESI and the La Trobe Valley. Table 5.4 in Section 5.3.1 of Chapter five shows the significance of the ESI to the La Trobe Valley's economy. The dependence of the ESI on the La Trobe Valley stems from the region's plentiful resources of brown coal. Without the reliance on brown coal as a natural resource in the production of electricity, the ties with the La Trobe Valley will become weaker. In other words, if at some time in the future Victoria sources its electricity from fuel other than brown coal there would be no reason for the industry to remain located in the La Trobe Valley. For instance, if there was an increase in demand toward wind generated electricity, the industry would find itself predominantly located on the coastal regions of the State.

In the short run the industry is unlikely to relocate due to the considerable capital investment already made. However if a new plant is built using innovative technology such as combined-cycle then it may be located elsewhere. In fact, as the owners of the brown coal electricity generators are predominantly large multinational corporations, new investment projects would not necessarily be made in Australia. If one of the current generating companies decides to relocate to another region, the potential negative consequences for the La Trobe Valley are large.

As one would expect, the La Trobe Valley hosts the necessary support services for brown coal electricity generation. Many of these services are transferable to other methods of electricity generation and could readily relocate to another region if the right encouragement was offered. For instance, the State of NSW could offer a tax incentive to those firms who agree to relocate.

Brown coal is the cheapest method of producing energy given the existing technology. If however, the Government imposes large environmental taxes on the brown coal generators, whilst at the same time encouraging the renewable forms of energy production, renewable energy may become relatively cheaper. If renewable energy is entering the market at a lower price than brown coal electricity, this will pose serious problems for the La Trobe Valley region.

The commitment by the Government to renewable energy means that energy from these sources will be in greater demand and will compete with the brown coal generators in supplying to the NEM. The Government's interest stems from the fact that new methods of producing electricity such as combined cycle plants, fuel cells and cogeneration, emit less CO_2 than brown coal generators during the production process. For instance, Integrated Drying Gasification Combined Cycle Process (IDGCC) boasts 30 percent lower CO_2 emissions per MWh.[75]

[75] However it is currently only a 10 megawatt scale facility

If the Government places a substantial carbon tax on CO_2 emissions, the private owners of the brown coal generators may decide to enter the renewable energy market themselves. Depending on the severity of the tax, the ESI may decide that it should focus its production techniques on more efficient methods of producing energy. The generators could diversify their operations toward renewable energy projects. Again this may come at a large cost to the La Trobe Valley region if there is a shift away from brown coal electricity generation. The impact upon the La Trobe Valley region will depend on the time lag and most importantly whether the operations remain in the region.

4.5 CONCLUDING COMMENTS

This chapter has outlined the significant structural reform of the Australian ESI over the last decade. Particular attention has been paid to the reform of the Victorian ESI which devastated the regional economy of the La Trobe Valley. The implementation of greenhouse policy has the potential to further modify the industry and in doing so create new challenges for the ESI and for the residents of the La Trobe Valley.

CHAPTER FIVE

THE MONASH-ELECTRICITY MODEL

5.1 INTRODUCTION

This chapter provides an overview of the model used to predict the economic impact of the Australian Government's greenhouse policy. The model is called MONASH-Electricity. It is based on the MONASH model of the Australian economy. Section 5.2 provides an overview of the MONASH model and its regional equation system. Section 5.2.1 draws on Adams et al (2000b).

The modifications to the original MONASH model occurred in two stages. The rest of this chapter is accordingly divided into two main sections. Section 5.3 outlines the first modification which involved updating the database to incorporate a more detailed electricity sector than was previously available. Much of the database alteration involved disaggregating elements of the existing database. Particular focus is given to improving the database for the electricity sector in the model to facilitate substitution between the sources of electricity generation. Section 5.3 additionally explains the database modifications at the statistical division (SD) level.

The second structural change to the MONASH model occurred in the Tablo system of input equations. An explanation of the model modifications is presented in Section 5.4. The primary new mechanism that allows the impact of greenhouse policy to be analysed is the substitution between the electricity generators.

Section 5.5 concludes the chapter.

5.2 OVERVIEW OF MONASH-MRES

The research uses computable general equilibrium modelling techniques to analyse the economic impact of a greenhouse policy upon the Australian electricity industry and the La Trobe Valley. The CGE model employed is the MONASH-Electricity model of the Australian economy. MONASH-Electricity is a modified version of the dynamic MONASH model, developed by the Centre of Policy Studies at Monash University.

5.2.1 MONASH: THE GENERAL EQUILIBRIUM CORE

Core Model

The MONASH model is a dynamic CGE model of the Australian economy. The dynamic nature of the model allows it to produce sequences of annual solutions connected by dynamic relationships. There are five agents represented in the core model: industries, capital creators, households, government, and foreigners. The standard version of MONASH identifies 115 commodities produced by 113 industrial sectors. For each sector there is an associated capital creator. With the exception of a few of the agricultural industries, each industry produces a single commodity. There is a single household sector and a single government represented in the model. The behaviour of foreigners is summarised by export demand curves for each commodity and by supply curves for international imports.

Data Requirements for MONASH

The general equilibrium core of the MONASH model requires a input-output table together with values for the CES nests of the specifications of technologies and preferences. The government finance block requires data on revenue and expenditure. The labour market block includes demographic, employment and labour force data.

Computing Solutions for MONASH

MONASH is solved using the GEMPACK software. A linear, differential version of the MONASH equation system is specified in syntax very similar to ordinary algebra.

GEMPACK solves the system of non-linear equations as an Initial Value problem, using a standard method such as Euler.[76]

The Nature of Markets

The MONASH model determines supplies and demands of commodities through optimising behaviour of agents in competitive markets. Optimising behaviour also determines industry demands for labour and capital. Labour supply is determined by demographic factors, whilst capital supply responds to rates of return.

There is equality between the producer's price and the marginal cost in each sector of the model. This is based on the assumption of competitive markets. With the exception of the labour market, where excess supply conditions can hold, demand is assumed to equal supply in all markets. The Government can intervene in a market by imposing sales taxes on commodities. This acts as a wedge between the price paid by the consumer and the price received by the producer. The costs of margins are also included in purchasers' prices. Margin commodities such as retail trade and road transport freight, are required for each market transaction where the commodity is passed from the producer to the consumer.

Demands for Inputs to be used in the Production of Commodities

Intermediate inputs and primary factors are the two broad categories of inputs recognised in the MONASH model. Firms in each sector are assumed to choose the mix of inputs which minimises the costs of production for their level of output. Firms are however constrained in their choice of inputs by a three-level nested production technology (see Figure 5.1). At the first level, intermediate-input bundles and primary-factor bundles are used in fixed proportions to output. There is no substitution at this level between the use of inputs. The second level adopts CES and CRESH specifications for the bundles of intermediate inputs and primary-factor inputs respectively. Intermediate-input bundles are a CES combination of domestically produced goods and imported goods. The primary-

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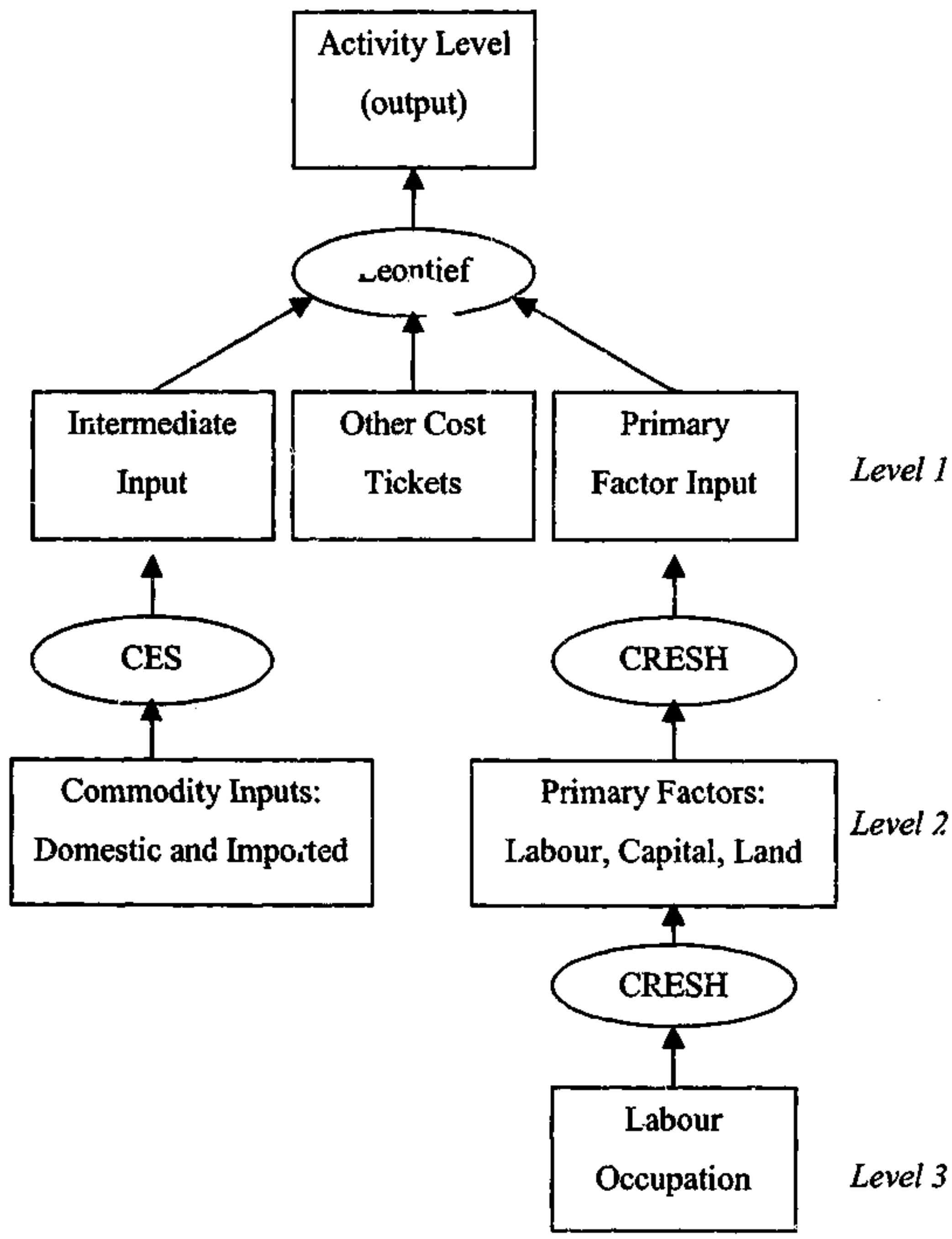
[76] The Euler method was used in the simulations described in Chapter six.

factor bundle is a CRESH[77] combination of labour, capital and land. At the third level of the nested production function, the input of labour is specified as a CRESH combination of labour from eight different occupational categories.

Figure 5.1

MONASH PRODUCTION TECHNOLOGY



[77] The CRESH specification is more flexible than CES as the elasticities of substitution between the inputs do not have to have the same value. However the flexibility of CRESH has not been of practical significance to the MONASH model to date.

Household Demands

In the MONASH model the household sector of the economy purchases bundles of goods to maximise a utility function subject to a household expenditure constraint. The bundles are combinations of imported and domestic goods. A Keynesian consumption function is used in the model to determine household expenditure as a function of household disposable income.

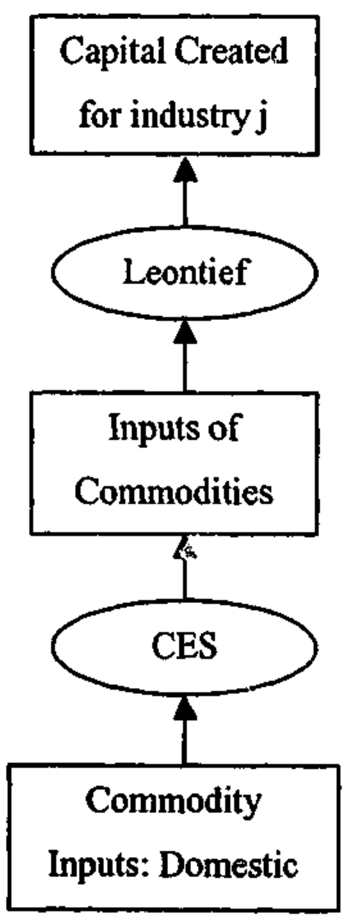
Demands for Inputs to Capital Creation and the Determination of Investment

Units of capital stock are created for each sector from a combination of inputs, as shown on the two-level production function in Figure 5.2. At the first level of the production function, commodities are combined via a Leontief function. This means that there is no price-induced substitution between inputs. At the second level, a CES function is used to combine domestic and imported goods. In choosing inputs, it is assumed that any given level of capital creation for an industry is achieved at minimum cost.

There are no primary factors or other costs tickets used in the creation of capital. The use of these inputs is recognised through inputs of the construction commodity. Construction services act as a major input to capital creation.

Figure 5.2

PRODUCTION FUNCTION



Government Demand for Commodities

Demand for commodities by the Government are not explained in the MONASH model. There are however several ways of handling this demand, including: (i) endogenously, by a rule which moves government expenditure with household consumption expenditure or with domestic absorption; (ii) endogenously, as an instrument which varies to accommodate an exogenously determined target such as the required level of government deficit; (iii) exogenously.

Foreign Demand (international exports)

The MONASH model includes four categories of exports: traditional, non-traditional, tourism, and special. The model allows a different treatment of export demands for each of these categories. The traditional export sector is the largest category, representing 65 percent of total exports. For exports in this category, the percentage change in export demand depends on percentage changes in price and a series of variables which allow for movements in export-demand curves, depending upon the influence on the product of world prices.

Government Finances

For the government accounts, MONASH includes revenue equations for income taxes, sales taxes, excise taxes, taxes on international trade and for receipts from government-owned assets. The model includes outlay equations for the Government to transfer payments to the household sector. Transfer payments include pensions, sickness benefits and unemployment benefits.

MONASH: a Dynamic Model

As MONASH is a dynamic general equilibrium model it produces sequences of annual solutions connected by dynamic relationships such as physical capital accumulation. Policy analysis with MONASH involves the comparison of two alternative sequences of solutions, one generated without the policy (basecase) and the other with the policy introduced. The basecase operates as an initial path from which deviations are measured in assessing the impact of the policy.

Two of the most important dynamic features of the MONASH model are its inter-temporal links accommodating physical capital accumulation and lagged adjustment processes. An example of a lagged adjustment process included in the model is found in the labour market. The model allows real wages to be sticky in the short-run but flexible in the long-run, whilst the reverse is true for employment. In the policy simulation it is assumed that the deviations in the national real wage rate increase through time in proportion to the deviation in aggregate employment from its basecase level.

Simulations

Each MONASH simulation produces year-by-year projections for the economy over the period to 2010 under a particular set of assumptions. Firstly a base forecast which excludes the policy shock is computed. Typically the basecase includes a number of economic forecasts from external sources. Further inclusions in the basecase are forecasts of changes in production technologies and households' preferences based on studies of recent history conducted at CoPS. These include assumptions about electricity generation, including fuel usage.[78] A deviation simulation is then computed using the policy shocks. By comparing the growth paths of variables in the deviation simulation with their growth paths in the base simulation the effects on the economy of the policy shock can be deduced (Dixon, Parmenter and Rimmer, 1999). The differences between the two results are reported as explicit percentage deviations from the basecase. The forecasting and policy closures are discussed in Chapter six.

The standard version of MONASH includes a single electricity-generating industry (*I84 Electricity*) which produces a single commodity (*C86 Electricity*). Data on inputs and sales of this industry represent an aggregation of data for the electricity-generating plants existing in the model's base year.

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78 Assumptions relating to the electricity industry included in the basecase are: coal-saving technical change in the electricity generation and primary-factor-saving technical change in electricity generation at an average annual rate of about 1.9 and 4.15 percent respectively. Partly offsetting the saving of primary factors is an increase in the usage of services. After accounting for this, all-input-saving technical change in electricity generation averages about 1.15 per cent per annum (Dixon, Parmenter and Rimmer 1999).

MONASH: Regional Equation System

The regional equation system of the MONASH model (MRES) is a tops-down regional disaggregation facility based on the ORANI regional equation system described in Dixon et al (1982). MRES uses a two-stage procedure to disaggregate Australia-wide MONASH results, first to the state level, then to the finer level of statistical divisions (Adams and Dixon, 1995).

At both the state and statistical division level, the 115 commodities used in the model are identified as either national or local. At the state level, *national* commodities are those that are traded extensively across state borders. *Local* commodities are those for which demand in each state is satisfied mainly from production in the state. At the statistical division level, *national-region* commodities are those which are commonly traded across regional boundaries. The regional outputs of industries producing *national-region* commodities are assumed to grow in line with the state-wide growth rates as calculated at the state level. *Local-region* commodities, on the other hand, are those for which demand within a region is satisfied from production in that region. At both the state and statistical division level, the effect on growth of a favourable mix of *national* or *national-region* industries is multiplied through induced effects on the growth rates of the local industries.

For industries which produce national commodities, MRES usually allocates to each state the same growth rate in output.

$$g(j,r) = g(j,A) \qquad \text{for all State } r; \text{ and for } j = \text{national industries,}$$

where g(j,r) is the growth rate for national industry *j* in State *r* and g(j,A) is the Australia-wide growth rate for industry *j*.

For local commodities, MRES imposes market clearing in each state. This means that the growth rate of an industry's output in a given state is equal to the growth rate in demand for the commodity in that particular state. State demand for a commodity is a function of: intermediate and investment demands by both local industries and national industries located in the state; state household demands; government demand; and if the commodity is used as a margin, demand for margin commodities.

The data requirements for MRES are relatively modest. For a base year, the data requirements are S(j,r), State r's share in Australia's output from industry *j*, for national commodities and final demands by state for local commodities.

There is a difference between the treatment of a local commodity at the state and statistical division level. Whereas a local commodity at the state level is assumed to only satisfy demand from within the state, a local commodity at the statistical division level is allowed to satisfy limited demand from outside its own statistical division. This is based on the fact that the data implies that for most commodities there is an imbalance between demand and supply at the statistical division level. Bearing this in mind, the treatment of local-region commodities at the statistical division level is based on the assumption that:

$$T(i,d) = Q(i,d) - D(i,d) \qquad \text{for all } i = \text{local-region commodity; and } d = \text{region}$$

where

T(i,d) is net intra-state exports of *i* from *d*

Q(i,d) is production of *i* in *d*

D(i,d) is demand for *i* in *d*

If T(i,d) is negative, the statistical division is a net intra-state importer of the commodity. For the purposes of the simulations, the percentage growth rates in the statistical division's intra-state imports are set equal to its output of the commodity. In other words, it is assumed that the ratio of intra-state imports of the commodity to production within the statistical division remains constant.

If T(i,d) is positive, the statistical division is a net intra-state exporter of the commodity. In this case, the percentage growth in the statistical division's intra-state exports of the commodity is set equal to the percentage growth in total intra-state exports of the commodity in the state which contains the statistical division. This holds constant the share of the statistical division in the total intra-state exports of the commodity in the state within which the statistical division is located.

Once again the data requirement for the statistical division component of MRES are relatively modest. The model can disaggregate the macroeconomic national results of a policy simulation to the statistical division level provided that base year data for value added by industry in each statistical division is available. The principal source for updating the regional data component of the model is employment data from the most recent ABS Census of Population and Housing at the statistical division level by industry.

Electricity was originally classified in the MRES model as a *local* commodity at the state level. Hence, the model assumed that all of Victoria's demand for electricity is satisfied from Victoria's supply of electricity. As will be explained in detail later, the incorporation of the National Electricity Grid in the MONASH-Electricity model changed this classification. At the statistical division level, electricity is treated as a *national-region* commodity as it is readily traded across regional boundaries. The La Trobe Valley statistical division exports electricity to most other regions.

5.3 MODIFICATIONS TO THE MONASH MODEL

The modifications to the original MONASH model bring about substantial improvements in modelling policy shocks associated with the electricity sector of the Australian economy. The implications of greenhouse policy upon the different electricity generators will be of interest to many groups within the economy, including policy makers, local government, and the generators themselves.

The disaggregation of each relevant sector in the model was undertaken in two parts. The first was the disaggregation of what is known as the core database. The core database records information relating to the intermediate flows of commodities between industries. The majority of information in the core database is expressed in monetary terms.

The second part involved the disaggregation of the relevant sectors in the regional equation database. This database complements the core database with information on the level of employment by industry in each state and statistical division. The majority of data in the regional equation database is expressed in terms of the number of people employed by industry by region.

The data used to disaggregate the core database and the regional equation database were at times sourced from different places. This is mainly due to differences between the financial data provided to disaggregate the core database and the employment data used to disaggregate the regional equation database.

The following sections of this chapter are organised so that the modifications made to each of the industries in the MONASH-Electricity model are explained in full. Section 5.3.1 explains the disaggregation of the electricity sector. The disaggregation involves modifications to both the core database and the regional equation database. An important aspect of the change to the regional equation database is the location of the energy sector by state and statistical division. Modifications to the fuel source industries are explained in Section 5.3.2. Modifications to the energy intensive industries are explored in Section 5.3.3.

Core Database

The core database comes from the ABS input-output tables of the Australian economy. It includes the cost and revenue structure of each industry in the model; information relating to the production of commodity by industry; and details on the intermediate usage of commodities in the production of a unit of industry output. The inter-relationships between industries is an important element found in the core database.

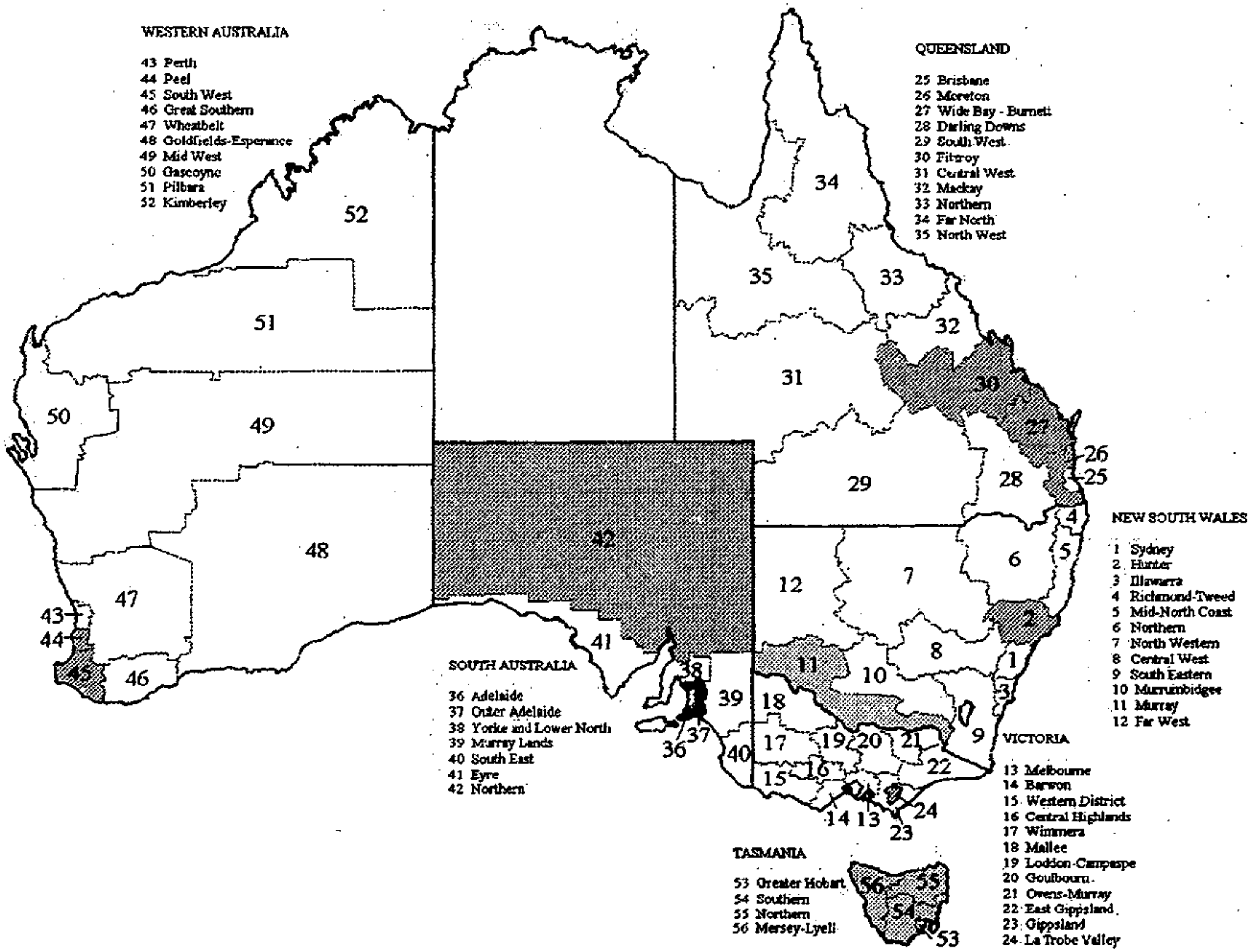
The process of disaggregating the core database is made complicated by the need to maintain these relationships within the model. Unless data is available otherwise, the key relativities pertaining to a particular industry must be preserved. For instance, the labour to capital ratio should remain unchanged between the original industry and the disaggregated elements. Likewise, the share of sales of a commodity across industries should remain unchanged.

Regional Equation Database

The objective of this section is to describe the procedure involved in allocating the Australian economy's energy industries to the statistical division in which they are located. A statistical division is a region in Australia based on the Australian Standard Geographical Classification (*ABS Cat. No. 1216.0*). Each State of Australia is divided into a number of statistical divisions (see Map 5.1 on the following page) Statistical divisions of particular importance to this project are those whose industry base includes part of the energy sector.

When using a regional model such as the tops-down MRES, the data requirement at the statistical division level are relatively modest (Adams et al, 1995). As outlined above, the data at the statistical division level is based upon employment by industry. In MRES the impact of a policy shock occurs initially at the macro level. The results for each industry are initially disaggregated to the state level and finally to the statistical division level.

The impact upon a statistical division of a national policy will depend on the outcome of its main industries at the national level. If the main industries in a statistical division produce *national-region* commodities, the activity levels of these industries will dictate the activity level of the statistical division.


WESTERN AUSTRALIA
43 Perth
44 Peel
45 South West
46 Great Southern
47 Wheatbelt
48 Goldfields-Esperance
49 Mid West
50 Gascoyne
51 Pilbara
52 Kimberley
QUEENSLAND
25 Brisbane
26 Moreton
27 Wide Bay - Burnett
28 Darling Downs
29 South West
30 Fitzroy
31 Central West
32 Mackay
33 Northern
34 Far North
35 North West
NEW SOUTH WALES
1 Sydney
2 Hunter
3 Illawarra
4 Richmond-Tweed
5 Mid-North Coast
6 Northern
7 North Western
8 Central West
9 South Eastern
10 Murrumbidgee
11 Murray
12 Far West
SOUTH AUSTRALIA
36 Adelaide
37 Outer Adelaide
38 Yorke and Lower North
39 Murray Lands
40 South East
41 Eyre
42 Northern
VICTORIA
13 Melbourne
14 Barwon
15 Western District
16 Central Highlands
17 Wimmera
18 Mallee
19 Loddon-Campaspe
20 Goulbourn
21 Ovens-Murray
22 East Gippsland
23 Gippsland
24 La Trobe Valley
TASMANIA
53 Greater Hobart
54 Southern
55 Northern
56 Mersey-Lyell

Map 5.1

Given that the policy impact upon a statistical division is determined by its industry base, it becomes apparent why care must be taken to ensure the employment by industry data for each statistical division is as accurate as possible.

The benefits of the regional allocation of the Australian energy sector are realised when analysing the results of greenhouse simulations (outlined in Chapter six). Those statistical divisions whose industry base is centred on the energy sector will be more heavily impacted by greenhouse policy in the first instance, relative to other statistical divisions.

5.3.1 ELECTRICITY

DISAGGREGATION OF ELECTRICITY – CORE DATABASE

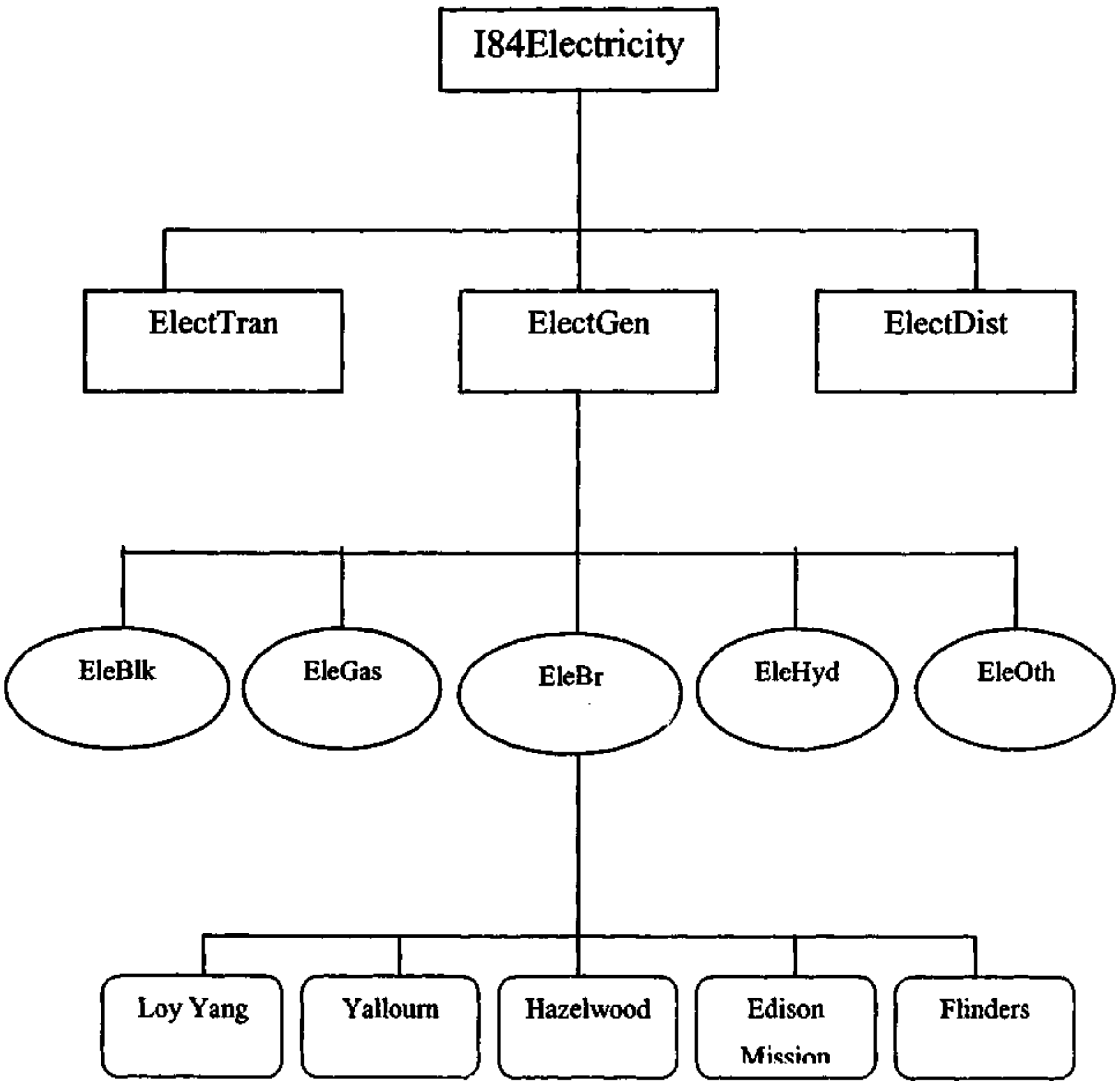
Development of MONASH-Electricity involved a number of changes to the existing core database to improve the way in which the electricity sector of the Australian economy is modelled.

One of the main limitations of the original energy sector in the MONASH model is the sole electricity industry which is responsible for the production of the economy's electricity. The industry is constrained in that it cannot substitute between different fuel sources. This inability to substitute has implications for greenhouse modelling as different sources of fuel used in the generation of electricity emit different levels of greenhouse gas. As greenhouse policy increases the cost of one fuel relative to another, the electricity industry would have to incur the burden of the higher cost of fuel in the absence of substitution.

The following sections outline how the original electricity industry, *I84Electricity*, was disaggregated into a detailed electricity sector (see Figure 5.3). There are three tiers to the new industry structure. The first tier relates to distribution - the physical flow of electricity as it passes from the generators via the transmission lines to the electricity retailer. The role of the distributor is to sell the electricity to the end user. The second tier relates to the electricity generators. Each of the generators at this level of disaggregation produces electricity using a different fuel as the intermediate input. The technology and physical location of the power stations also differs between each of these generators. The final tier relates to the brown coal electricity generators who supply electricity to the brown coal electricity industry. The majority of these generators are located in the La Trobe Valley region of Victoria.

Figure 5.3

FLOW CHART OF ELECTRICITY DISAGGREGATION



Electricity Generation, Transmission and Distribution

The impact of greenhouse policy will not be felt equally by all sectors of the electricity industry. In the first instance, any negative ramifications will fall upon the generation sector of the electricity industry. The electricity generators are responsible for a very large proportion of Australia's total greenhouse gases and are therefore likely to be the predominant target of greenhouse policy.

The transmission sector of the industry is responsible for the delivery of the electricity from the power stations to the end user. This sector is largely capital intensive as it owns and operates the infrastructure associated with the power lines and grid networks. Relatively few greenhouse gases are emitted by this arm of the electricity industry.

The retail, or distribution, sector of the electricity industry is responsible for the sale of electricity to consumers such as households and businesses. This is the public face of the electricity industry. The retail sector purchases electricity from the generators and rents the power lines from the transmission companies. Once again, greenhouse gas emissions from this tier of the electricity industry are relatively inconsequential.

As the ABS collects aggregated data on the electricity industry, it is unable to provide a detailed breakdown of the generation, transmission and distribution arms of the industry. The only source of information available to disaggregate *I84Electricity* came from an Electricity Supply Association of Australia (ESAA) publication, *Electricity Australia.* Whilst the most recent edition of *Electricity Australia 2000* does not include detailed information on the different sectors of the industry, this data was published in *Electricity Australia 1997.*

The reason the data is precluded from editions after 1997 is due to the microeconomic reform of the electricity sector, as explained in Chapter four. With the exception of Western Australia (WA) and the Northern Territory (NT), the vertical integration of the electricity industry in the States of Australia has been dissolved and the sectors operate as individual entities. The introduction of the NEM has also changed the way in which these entities operate with many generators and distributors supplying electricity across interstate boundaries.

The most recent data on operating expenditure by state is published for 1995 (ESAA, 1997). Operation and maintenance cost data, including fuel, for each of the states for the period 1995/96 is available. The costs are expressed as \$/MWh[79] and are provided for the generation, transmission and distribution arms of the industry (see Table 5.1). To provide a basis for measurement, the Australian average operation and maintenance cost for each of the sectors was calculated. Using this average cost figure, the percentage share of generation, transmission and distribution in total costs was derived. These shares were used as the main basis to disaggregate *I84Electricity* into three new industries, *I84aElectGen, I84bElectTrn* and *I84cElectDist.* These industries will hereafter be referred to as *ElectGen, ElectTrn* and *ElectDist.*

Table 5.1

OPERATION & MAINTENANCE COSTS (excluding fuel)

Electricity Sector	**\$/MWh**	**Percentage share of industry**
Generation	23.9125	58.8
Transmission	1.545	3.8
Distribution	15.1975	37.4

Source: ESAA

Each of the newly created industries produce a single commodity (*C86aElectGen, C86bElectTrn* and *C86cElectDist*). It is assumed that only *ElectDist* is sold to end users of electricity such as households and businesses. *ElectDist* assumes the role of the electricity retailer who purchases the electricity from the NEM and supplies it to consumers. All of the commodity output of *ElectTrn* is sold to the industry *ElectDist* as an intermediate input.

[79] Dollar per megawatt hour of electricity generated.

It is assumed that the generators themselves do not sell electricity directly to final consumers. The current structure of the electricity market in Australia does not allow households to choose their own electricity retailer[80]. Over the next decade however, the market for contestable customers will enable most electricity consumers serviced by the NEM to choose who supplies their electricity. Households will predominantly negotiate between electricity retailers, whereas businesses are likely to enter into contracts directly with the generator. The market for contestable customers could be incorporated into further long-run simulations using the MONASH-Electricity model.

It is assumed that the commodity *ElectGen* is not sold to *ElectTrn* but directly to *ElectDist*. The underlying reason for this is that in the Australian electricity market the generators do not sell electricity to the transmission arm of the industry. As explained in Chapter four, the electricity is sold to retailers and distributors via the NEM's pool system. The generators and the retailers rent the transmission lines.

One significant modification to the core database was the eradication of the 'own cell' intermediate flow of electricity. In the original MONASH model database, sales of *C86Electricity* to *I84Electricity* were equal to $4541.56 million. This represented approximately 52 percent of *I84Electricity*'s intermediate input costs.

It is important to recall that the original data for *I84Electricity* included the generation, transmission and distribution arms of the sector. Personal communication with input-output specialists at the ABS confirmed that this flow is most likely to represent the sales of electricity from the generation to the distribution arms of the industry. This is supported by the close proximity between the intermediate input share of 52 percent and the share of electricity generation in industry activity of 58 percent (see Table 5.1). To avoid the scenario where sales of commodity *ElectDist* are split between the three disaggregated industries, it is assumed that the own cell figure was zero. This avoids the unrealistic situation where 34 percent of *ElectDist* sales are to the electricity consortium.

[80] The electricity retailer for each household is based upon geographical zones.

Brown Coal, Black Coal, Gas, Hydro and Renewable Electricity Generation

As discussed in Chapter four, the Australian electricity supply industry was historically established on a state basis. Each State Government was responsible for the supply of electricity to its constituents. The type of power station built depended greatly on the availability of the fuel source in the state. For this reason, the Australian electricity industry is relatively diverse in nature.

To accurately model the electricity industry, the newly formed electricity generation industry, *ElectGen*, was further disaggregated into five electricity generating industries – electricity brown (*EleBr*), electricity black (*EleBlk*), electricity gas (*EleGas*), electricity hydro (*EleHyd*), and electricity other (*EleOth*). These industries produce electricity and sell all of their output to *ElectDist*.

For the implications of greenhouse policy to be modelled accurately, the disaggregation of the existing database for *ElectGen* to these new industries was very important. In Australia the majority of electricity is generated using fossil fuels. There is however a significant difference in the type of fossil fuel found in different regions of Australia. In the States of NSW and QLD the fuel source is predominantly black coal, whereas in the State of VIC brown coal is found in abundant supply. These fuel sources, and others such as natural gas and hydro, all have different CO_2 emission intensities. It is therefore desirable to construct a database with each of these generators treated as separate industries so that the substitution possibilities can be comprehensively explored.

The data requirement for disaggregation to the generation level were met primarily from existing data files which facilitated the calculation of market shares. The main data sources came from the ESAA's publication *Electricity Australia 1999*. This material provided invaluable information on electricity generation per plant type, and generator shares in total output.

The data was supplied according to plant type by state of generation. The task of disaggregation was made more difficult as the plant types did not correspond to the newly created generation industries. To overcome this obstacle, research into the type of plant found in each state was conducted. The resulting outcome was the percentage each generator contributed to total electricity generation in Australia (see Table 5.2).

Table 5.2

PERCENTAGE SHARES OF ACTUAL GENERATION IN THE AUSTRALIAN ELECTRICITY MARKET

Generator	**%**
Electricity Brown	27
Electricity Black	59.5
Electricity Gas	4
Electricity Hydro	9
Electricity Other	0.5

The most accurate method of assimilating the new industries was to disaggregate the intermediate usage base of *ElectGen* and to allocate these costs across the new industries, according to the share of generation activity. The original input-output data for *ElectGen* was multiplied by the shares and allocated to the new industries accordingly. The sum of the new industries intermediate input equals the original figure for the same commodity in *ElectGen*[81]. Once the disaggregation was complete, the costs and sales of each of the new industries were recorded to ensure that they were equal.[82]

Edison Mission, Energy Brix, Hazelwood Power, Loy Yang Power, Yallourn Energy and Flinders Power

A final disaggregation of the electricity industry was deemed necessary given the focus on the regional economic implications of greenhouse policy for the La Trobe Valley. To capture the substitution possibilities between the Victorian electricity generators, the brown coal generation industry *EleBr* was disaggregated into six components. Each

[81] Following the disaggregation, *ElectGen* was removed from the database as it served no further purpose.

[82] It is essential that the pure profit condition (sales equal to costs), is satisfied by the new industries.

element of the disaggregation is representative of an existing brown coal electricity generator – Edison Mission (*Edis*), Energy Brix (*EBrix*), Hazelwood Power (*Haz*), Loy Yang Power (*LoyY*), Yallourn Energy (*Yall*) and Flinders Power (*Flin*).

Each of the generators in the La Trobe Valley emit a different level of CO_2 during the production of one MWh of electricity. The main reasons attributed to the differences are the grade of coal used in the production process, and the technology used by the power station itself.

The Victorian Government commissioned the construction of the power stations over a number of decades in accordance with the State's demand for electricity. Each generator was built using the most advanced technology available at that point in time. It therefore follows that the newer generators such as Loy Yang Power and Edison Mission, are far more technologically advanced than the older stations such as Hazelwood Power.

The disaggregation of *EleBr* also included the company NRG Flinders which is located in Port Augusta, South Australia. The inclusion of this South Australian electricity generator in the disaggregation of the core database is due to its use of brown coal as an intermediate fuel input.

NRG Flinders operates two power stations and a coalfield. The organisation remains Government owned but has recently been leased to NRG by the South Australian Government for a period of 100 years. The coal at the Leigh Creek Coalfield is classified for the purposes of the thesis as brown coal, although it is compositionally different from the grade of brown coal found in the La Trobe Valley region. The moisture content of the Leigh Creek coal is lower than that found in La Trobe Valley coal, and consequently the level of CO_2 emitted per MWh is also lower.

The disaggregation was based upon the generation capacity of each of the power stations. It was assumed that the use of labour and capital was in direct correlation to the size of the plant itself. Although the technology of the plants differ, such differences were addressed during the application of the CO_2 emission intensity of each power station. The sales of electricity to the *EleBr* industry are also assumed to be in the same proportion of the power stations share of the brown coal electricity market (see Table 5.3).

Table 5.3

SHARES OF BROWN COAL ELECTRICITY GENERATORS ACCORDING TO INSTALLED CAPACITY

Brown Coal Electricity Generator	% of market
Edison Mission	14.5
Energy Brix	2.5
Hazelwood Power	23
Loy Yang Power	29
Yallourn Energy	21
NRG Flinders	10

DISAGGREGATION OF THE GIPPSLAND STATISTICAL DIVISION

This section explains the modification to the regional component of the MRES model. Most of the modifications relating to the regional equation database elucidate the disaggregation of an industry according to employment shares. The modification explained in this section is unique as it involved the disaggregation of an entire statistical division, as opposed to one industry within an existing region. The explanation of this statistical division disaggregation is important to the following discussion of database modifications to the regional equation system. This is mainly due to the fact that the Victorian brown coal electricity generators are located within one of the disaggregated statistical divisions. Hence, in the absence of this discussion, the regional database modifications would not make sense.

As outlined in Chapter four, the Victorian electricity supply industry is almost entirely located in the La Trobe Valley region in Eastern Victoria. The La Trobe region is part of greater Gippsland.

In the original version of the MRES model, there was only one region which encompassed both the La Trobe Valley and the Rest of Gippsland. Although the La Trobe Valley is geographically located within the Gippsland region, the industrial structures of the two areas are quite distinct.

The existing statistical division for the Gippsland region has been disaggregated into two separate regions; La Trobe Valley and the Rest of Gippsland. As the ESI is almost entirely located in the La Trobe Valley, the disaggregation enabled the impact of greenhouse policy to be analysed in that part of Gippsland which is most affected. With the addition of the La Trobe Valley, there are currently 56 statistical divisions in the model. Both the La Trobe Valley and the Rest of Gippsland statistical divisions are shown on Map 5.1. An enlargement of the La Trobe Valley statistical division is shown on Map 5.2 (located on the following page).

Data used to disaggregate the existing Gippsland region in the MRES model into two separate statistical divisions included: *Employed persons in Local Government Area La Trobe Shire* – 1996 ABS Census; *Statistical Profile La Trobe Shire 1997;* and *ABS Regional Statistics Victoria 1314.2.*

The main difference between the La Trobe Valley and the Rest of Gippsland[83] is the importance of the electricity industry. As Table 5.4 shows, over 11 percent of total employment in the La Trobe Valley region is found in the *Electricity, Gas and Water Supply* sector. Only 2 percent of total employment in Gippsland is found in this sector. Hence, we would expect the impact of greenhouse policy upon the electricity industry to have a greater economic bearing on the La Trobe Valley. The other main difference between the regions is Gippsland's relative agricultural intensity.

[83] From herein referred to as Gippsland.

Shire of La Trobe

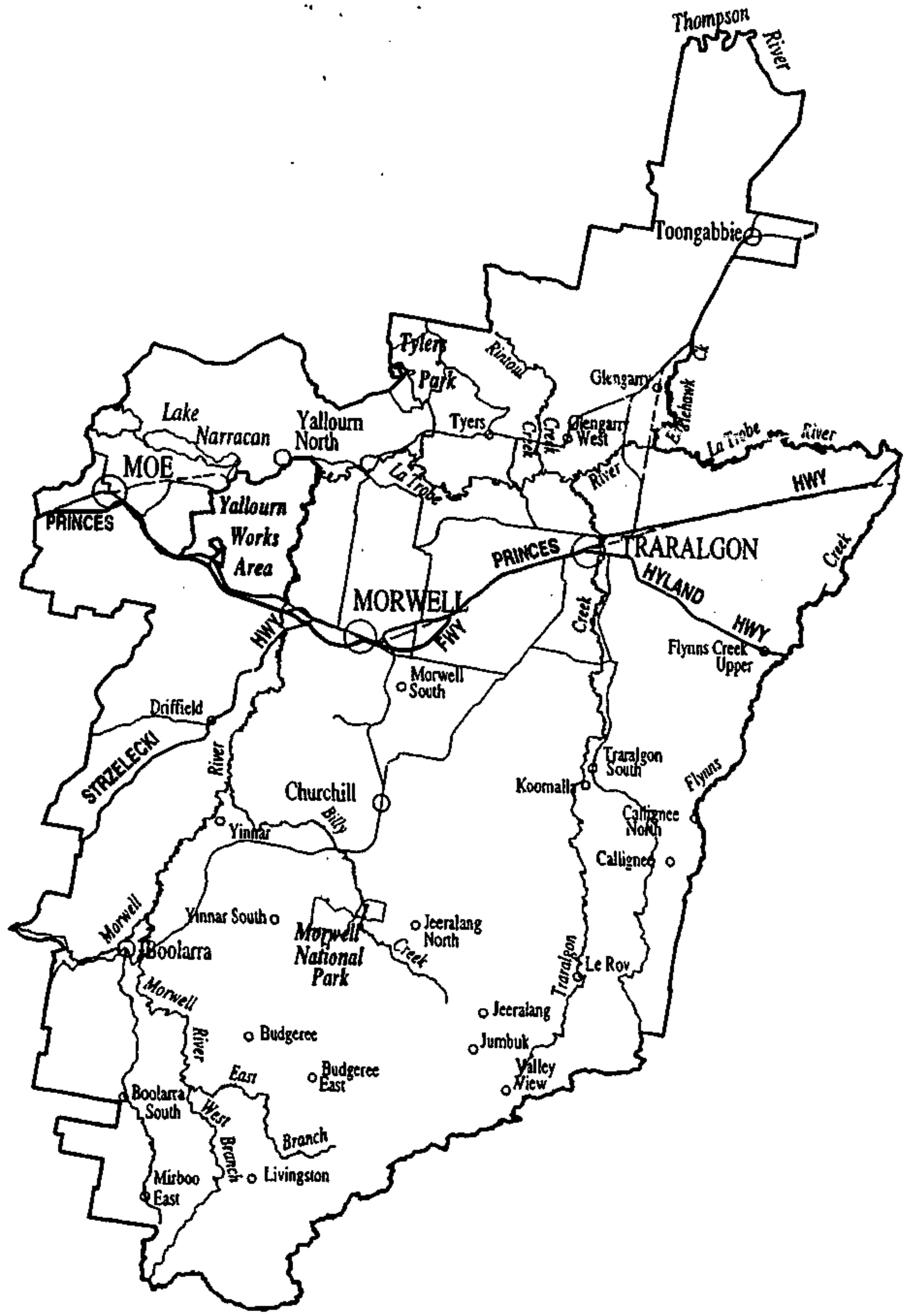


Table 5.4

INDUSTRY SHARES IN TOTAL EMPLOYMENT

Industry, 1996 Census Data	La Trobe %	Rest of Gippsland %
Agriculture, forestry & fishing	4	25
Manufacturing	14	14
Electricity, gas & water supply	11	2
Construction	11	8
Retail Trade	22	16
Accommodation, cafes & restaurants	5	5
Transport & storage	3	4
Communication services	2	2
Government administration & defence	5	4
Education	11	10
Health & community services	12	11
Total employment by region	100	100

Source: Occupation and Industry Statistics – ABS Regional Statistics Victoria 1314.2.

The methodology used to disaggregate the original statistical division of Gippsland is outlined in the following explanation.

The data used was sourced from the 1996 Census for employment by industry in the La Trobe Valley region. The most disaggregated 1996 Census data relating to employment by industry in the La Trobe Valley came from the publication *Employed persons in Local Government Area La Trobe Shire* (see Table 5.5 on the following page). Where there were no employees recorded in an industry in greater Gippsland, this insinuated there were also no employees in this industry in the La Trobe Valley.

The Australian and New Zealand Standard Industrial Classification (ANZSIC) 1993 publication was used to allocate the 1996 Census data to the MONASH model's industry classification (see Table 5.6). Where possible, the employment by industry figures for the

Table 5.5

EMPLOYED PERSONS IN LOCAL GOVERNMENT AREA LA TROBE VALLEY

Sector	Male	Female	Persons
A, F & F: Undefined	3	3	6
A, F & F: Agriculture	374	223	597
A,F & F: Services to Agriculture; Hunting & Trapping	18	12	30
A, F & F: Forestry and Logging	115	19	134
A, F & F: Commercial Fishing	8	4	12
A, F & F: Total	**518**	**261**	**779**
Mining: Mining, undefined	11	3	14
Mining: Coal Mining	158	6	164
Mining: Oil and Gas Extraction	17	0	17
Mining: Metal Ore Mining	3	0	3
Mining: Other Mining	31	3	34
Mining: Services to Mining	21	11	32
Mining: Total	**241**	**23**	**264**
Manufacturing: Manufacturing, undefined	45	11	56
Manufacturing: Food, Beverages and Tobacco	120	63	183
Manuf.: Textile, Clothing, Footwear and Leather	74	166	240
Manuf.: Wood and Paper Products	1003	86	1089
Manuf.: Printing, Publishing and Recorded Media	63	79	142
Manuf.: Petroleum, Coal, Chemical & Assoc. Products	132	19	151
Manuf.: Non-Metallic Mineral Products	88	12	100
Manuf.: Metal Products	322	34	356
Manuf.: Machinery and Equipment	131	27	158
Manuf.: Other	93	23	116
Manuf.: Total	**2071**	**520**	**2591**
E, G & WS: Undefined	0	0	0
E, G & WS: Electricity and Gas Supply	1763	125	1888
E, G & WS: Water Supply, Sewerage & Drainage Services	55	42	97
E, G & WS: Total	**1818**	**167**	**1985**
Construction: Construction, undefined	124	15	139
Construction: General Construction	468	44	512
Construction: Construction Trade Services	1143	126	1269
Construction: Total	**1735**	**185**	**1920**
Wholesale Trade: Wholesale Trade, undefined	10	7	17
Wholesale Trade: Basic Material Wholesaling	245	72	317
Wholesale Trade: Machinery and Motor Vehicle Wholesaling	286	87	373
Wholesale Trade: Personal and Household Good Wholesaling	125	70	195
Wholesale Trade: Total	**666**	**236**	**902**
Retail Trade: Retail Trade, undefined	24	56	80
Retail Trade: Food Retailing	594	920	1514
Retail Trade: Personal and Household Good Retailing	548	930	1478
Retail Trade: Motor Vehicle Retailing and Services	685	197	882
Retail Trade: Total	**1851**	**2103**	**3954**
Accommodation, Cafes and Restaurants	329	573	902

Table 5.5 Continued

Sector	Male	Female	Persons
Transport and Storage: Transport and Storage, undefined	36	9	45
Transport and Storage: Road Transport	319	55	374
Transport and Storage: Rail Transport	41	3	44
Transport and Storage: Water Transport	4	0	4
Transport and Storage: Air and Space Transport	5	3	8
Transport and Storage: Other Transport	3	0	3
Transport and Storage: Services to Transport	21	24	45
Transport and Storage: Storage	5	5	10
Transport and Storage: Total	**434**	**99**	**533**
Communication Services	208	191	399
Finance and Insurance: Finance and Insurance, undefined	0	0	0
Finance and Insurance: Finance	125	334	459
Finance and Insurance: Insurance	131	422	553
Finance and Insurance: Services to Finance and Insurance	32	29	61
Finance and Insurance: Total	**288**	**785**	**1073**
Property and Business Services: Undefined	0	0	0
Property and Business Services: Property Services	129	103	232
Property and Business Services: Business Services	1076	759	1835
Property and Business Services: Total	**1205**	**862**	**2067**
Govt Administration and Defence: Undefined	3	4	7
Govt Administration and Defence: Govt Administration	352	513	865
Govt Administration and Defence: Defence	16	4	20
Govt Administration and Defence: Total	**371**	**521**	**892**
Education	715	1359	2074
Health and Community Services: Undefined	4	28	32
Health and Community Services: Health Services	334	1156	1490
Health and Community Services: Community Services	86	498	584
Health and Community Services: Total	**424**	**1682**	**2106**
Cult & Rec Services: Undefined	4	0	4
Cult & Rec Services: Motion Picture, Radio & TV Services	41	39	80
Cult & Rec Services: Libraries, Museums & the Arts	15	40	55
Cult & Rec Services: Sport and Recreation	113	124	237
Cult & Rec Services: Total	**173**	**203**	**376**
Personal & Other Services: Undefined	0	0	0
Personal & Other Services: Personal Services	139	276	415
Personal & Other Services: Other Services	243	120	363
Personal & Other Services: Prvte Hholds Employing Staff	0	4	4
Personal & Other Services: Total	**382**	**400**	**782**
Non-classifiable economic units	248	112	360
Not stated	180	183	363
Total	**13857**	**10465**	**24322**

ABBREVIATIONS

A, F & F = Agricultural Forestry and Fishing   Manuf. = Manufacturing

Cult & Rec = Cultural and Recreational   Prvte Hholds = Private Households

E, G & WS = Electricity Gas and Water Supply

Table 5.6

MATCHING ANZSIC CLASSIFICATION WITH MONASH INDUSTRIES

MONASH Industry	Employment by IND Original SD GIPPSLAND	Industry Category	ANZSIC Classification
I1Pastoral	0	1	A, F and F
I2WheatSheep	0	1	
I3HighRain	1.084	1	
I4NthBeef	0	1	
I5MilkCattle	1.437	1	
I6OthExport	0.224	1	
I7ImportComp	0.336	1	
I8Poultry	0.14	1	
I9AgServ	0.244	1	
I10Forestry	1.201	1	
I11Fishing	0.128	1	
I12IronOre	0	2	Mining
I13NFerrous	0	2	
I14BlkCoal	0.006	2	
I15OilGas	1.272	2	
I16OthMin	0.081	2	
I17MinServ	0.111	2	
I18Meat	0.442	3.1	Manufacturing - food, beverages
I19Dairy	1.118	3.1	
I20FrtVeg	0.036	3.1	
I21OilFat	0	3.1	
I22Flour	0.13	3.1	
I23Bakery	0.598	3.1	
I24Confect	0.023	3.1	
I25Sea_Sugar	0.054	3.1	
I26SoftDr	0.082	3.1	
I27Beer	0.003	3.1	
I28OthDrink	0.005	3.1	
I29Tobacco	0	3.1	
I30Ginning	0	3.2	Manufactoring - TCF
I31Synthetic	0.096	3.2	
I32CottonYa	0.776	3.2	
I33WoolYarn	0	3.2	
I34TextileF	0.005	3.2	
I35Carpets	0.002	3.2	
I36Canvas	0.095	3.2	
I37Knitting	0.136	3.2	
I38Clothing	0.486	3.2	
I39Footwear	0.004	3.2	
I40Sawmill	0.352	3.3	Manufactoring - wood
I41Panels	0	3.3	
I42Fittings	0.167	3.3	
I43Furniture	0.297	3.3	
I44PulpPaper	1.007	3.4	Manufactoring - Paper
I45BagsBoxes	0.111	3.4	
I46Sanitary	0	3.4	
I47NewsBooks	0.383	3.4	
I48CommPrint	0.177	3.4	

Table 5.6 Continued

MONASH Industry	Employment by IND Original SD GIPPSLAND	Industry Category	ANZSIC Classification
I49Fertilisr	0.005	3.5	Manufactoring- chemicals petroleum
I50BasicChem	0.037	3.5	
I51Paints	0.009	3.5	
I52Pharmacy	0.004	3.5	
I53Soaps	0	3.5	
I54Cosmetics	0.172	3.5	
I55Explosive	0.022	3.5	
I56Petrol	0.174	3.5	
I57Glass	0.037	3.6	Manufactoring - glass
I58ClayProd	0.041	3.6	
I59Cement	0.033	3.6	
I60Readymix	0.058	3.6	
I61Pipes	0.046	3.6	
I62Plaster	0.047	3.6	
I63IronSteel	0.051	3.7	Manufactoring - metal
I64NFerrous	0.013	3.7	
I65Structurl	0.569	3.7	
I66SheetMetl	0.119	3.7	
I67Wire	0.849	3.7	
I68MotorVeh	0.204	3.8	Manufactoring - transport equ.
I69Ships	0.038	3.8	
I70Trains	0	3.8	
I71Aircraft	0.023	3.8	
I72SciEquip	0.075	3.9	Manufactoring - other mach & equ
I73Electron	0.213	3.9	
I74HousAppl	0.008	3.9	
I75ElectEq	0.119	3.9	
I76AgMach	0.038	3.9	
I77ConMach	0.004	3.9	
I78ManuMach	0.083	3.9	
I79Leather	0.008	3.11	Manufactoring - miscellaneous
I80Rubber	0.021	3.11	
I81Plastic	0.35	3.11	
I82Signs	0.013	3.11	
I83SportEq	0.058	3.11	
I84Electrcty	7.279	4	Electricity, gas and water
I85Gas	0.089	4	
I86Water	0.33	4	
I87Resident	3.54	5	Construction
I88OthBuild	5.492	5	
I89Wholesale	3.439	6	Wholesale and retail trade
I90RetailTrd	11.552	6	
I91MechRep	2.628	6	
I92OthRepair	0.546	6	
I93RoadTrans	2.012	7	Transport and storage
I94RailTrans	0.278	7	
I95WaterTran	0.047	7	
I96AirTransp	0.053	7	
I97TransServ	0.283	7	
I98Communic	1.223	8	Communication

Table 5.6 Continued

MONASH Industry	Employment by IND Original SD GIPPSLAND	Industry Category	ANZSIC Classification
I99Banking	1.366	9	Finance, property & bus. services
I100NonBank	0.225	9	
I101Investm	0.246	9	
I102Insurnce	0.615	9	
I103OthFinan	3.903	9	
I104Dwelling	0	9	
I105PubAdmin	5.572	10	Public Admin. & Defence
I106Defence	0.087	10	
I107Health	6.629	11	Community Services
I108Educate	7.702	11	
I109Welfare	2.912	11	
I110Entrtain	1.185	12	Recreation, personal & other serv
I111Hotels	3.835	12	
I112PerServ	1.546	12	
I113Other	0	12	
Total	91.007		

La Trobe Valley were directly allocated to the new statistical division La Trobe Valley database. In many instances however, the industry classifications between the data source were not identical. As can be seen in Tables 5.5 and 5.6, there are fewer industry classifications in the *Employed persons in Local Government Area La Trobe Shire* data relative to the 113 industries in the original MONASH model. In some cases the share of La Trobe Valley's employment in more aggregated Census data could be used (see Table 5.7). For instance, the 50 percent share of retail trade in the La Trobe Valley was used to disaggregate employment in the retail trade industry (*I90RetailTrd*) between Gippsland and the La Trobe Valley. The following paragraphs indicate how further incompatibilities were treated.

Table 5.7

GIPPSLAND OCCUPATION AND INDUSTRY STATISTICS

Industry, 1996 Census	Bass Coast	Baw Baw	La Trobe	Sth Gipp	Total Gippsland	Share of La Trobe
Agriculture, forestry & fishing	830	2414	778	2785	6807	0.11
Manufacturing	766	1578	2591	943	5878	0.44
Electricity, gas & water supply	85	275	1985	130	2475	0.80
Construction	579	875	1920	539	3913	0.49
Retail Trade	1010	1783	3954	1188	7935	0.50
Accommodation, cafes & restaurants	548	339	902	312	2101	0.43
Transport & storage	202	441	529	264	1436	0.37
Communication services	90	176	399	102	767	0.52
Government administration & defence	222	460	892	342	1916	0.47
Education	513	1191	2074	655	4433	0.47
Health & community services	661	1175	2106	774	4716	0.45
Total employment by region	5506	10707	18130	8034	**42377**	0.43

Source: ABS Regional Statistics Victoria

Agriculture, Forestry and Fishing: Whilst most of the data could be allocated directly across the 113 industries, the remaining 603 people were not as obvious classifications. These employees were allocated based on the percentage shares of employment in the original Gippsland statistical division. For instance, the milk cattle industry (*I5MilkCattle*) has the largest share of employment in the Gippsland region and consequently it was allocated 272 of the remaining 603 people in this industry group for the La Trobe Valley.

Accommodation, Cafes and Restaurants: The total of 902 people employed by this sector were allocated between the industries entertainment (*I110Entrtain*), hotels (*I111Hotels*), and personal services (*I112PerServ*).

Transport and Storage: The 103 people classified by the Census data as either Undefined, Other, Services or Storage were all allocated to the transport services industry (*I97TransServ*).

Cultural and Recreational Services: The 376 people in this category were allocated to the welfare industry (*I109Welfare*).

Health and Community Services: The total employment figure for this sector was allocated to the health industry (*I107Health*).

Finance: The 459 people were allocated across the banking (*I99Banking*) and non-banking sectors (*I100NonBank*).

Property and Business Services: The 2067 people defined in this sector were allocated to the other finance industry (*I103OthFinan*). This is consistent with the data for Gippsland in terms of employment numbers.

Upon completion of the La Trobe Valley regional employment by industry database, the figures were checked for consistency with the *LRC/GRIB Latrobe Region Industry and Employment Survey* (GRIB, 1999).

The next stage involved removing the La Trobe Valley employment figures from the original Gippsland data to generate new employment figures for the Gippsland region. During this process negative employment figures in some industries were discovered. In particular, the number of people allocated to the sawmill industry (*I40Sawmill*) indicated that there were more people employed in the La Trobe Valley than in Gippsland as a whole. To correct this inconsistency, *Manufacturing: Wood and Paper Products* was combined with *Manufacturing: Printing, Pub and Recorded* and then allocated according to shares in the Gippsland region.

Further modifications were required before the La Trobe Valley could be included in the updated database. Such alteration involved the share of total state population figure to be disaggregated between the regions. The original share of employment in the Gippsland statistical division was 0.04. According to the *ABS Regional Statistics: 1314.2*, at 30 June 1996:

Statistical Division	Estimated Resident Population
La Trobe Valley	71,103
All Gippsland (inc. LV)	152,609
TOTAL	223,712
Share of La Trobe Valley	46 %

Based on the above calculations, the La Trobe Valley accounts for approximately 46 percent of the population of greater Gippsland. The new statistical division share of the population recorded in the database is therefore; statistical division Gippsland 21 percent; and statistical division La Trobe Valley 19 percent.

DISAGGREGATION OF THE ELECTRICITY INDUSTRY – REGIONAL EQUATION DATABASE

Following the disaggregation of the original Gippsland statistical division, that part of the Australian electricity industry that is located in the La Trobe Valley can now be treated as such in the regional equation database. This section describes the process involved in allocating employment in the electricity sector across the states and statistical divisions of Australia.

The location of the energy sector according to statistical division has particular implications when analysing the economic impact of greenhouse policy. Regardless of the type of greenhouse policy introduced by the Commonwealth Government, it is likely to have direct consequences upon the energy sector, and in particular the electricity industry[84].

One of the benefits of using a CGE model to analyse the impact of greenhouse policy is that the economic ramifications upon different sectors can be measured. For instance, the introduction of greenhouse policy will have a more detrimental impact upon the generators of electricity from brown coal, relative to the generators of electricity from hydro. This is attributable to the different carbon emission intensities of the generation technologies and fuels used.

If it is assumed that the greenhouse policy encourages a switch away from brown coal electricity towards hydro electricity, the model is required to accurately predict which statistical divisions in the Australian economy are going to contract and those that will be stimulated. In this example, the expected result would be a contraction in the La Trobe Valley statistical division's economic activity and an expansion in the statistical divisions of Tasmania such as Mersey-Lyell where electricity is generated using hydro schemes.

The relative impact upon the activity levels of the statistical divisions will depend on the substitutability between the electricity generators in different regions. The establishment of the NEM has facilitated the flow of electricity across state boundaries, however the limited capacity of the transmission lines imposes some restrictions.

As explained in Chapter four, there are plans to develop a transmission line between the States of VIC and TAS. If this project is implemented, the only State and Territory not connected to the National Electricity Grid will be WA and the NT. Due to the vast geographic distance between these regions and the existing network, it is not deemed to be economically feasible to construct interconnecting transmission lines. Thus, electricity produced using gas from the North-West shelf off the coast of WA is not a substitute for electricity produced from brown coal in the La Trobe Valley region of VIC.[85]

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[84] To reiterate, over 35% of Australia's total greenhouse emissions are attributable to the electricity industry (AGO,1998)

[85] This assumption is based on current market conditions.

In addition to the substitutability of electricity, the results for statistical divisions will depend upon the ability of both industry and household consumers to reduce their usage of electricity. In response to a relative increase in price, consumers may substitute electricity for another source of energy, or decrease their consumption levels.

Improvements to the regional equation database were achieved by modifying the initial data to match the geographical spread of the Australian energy industry. As mentioned above, the initial ABS data is in the form of employment by industry for each of the 56 statistical divisions in the model. Employment by industry data is not readily available from the electricity industry itself. Published data is however available on electricity generation from each fuel source in each state. For instance, in the State of NSW the generators were divided into electricity produced using black coal (*EleBlk*), gas (*EleGas*), hydro (*EleHyd*) and other fuel sources such as renewables (*EleOth*). This data played an important role in the reallocation of employment by industry numbers to the statistical divisions where the electricity is generated.

Detailed information on the electricity industry was provided by the ESAA on each power station, including its generation capacity and location.

The source data used to obtain shares of electricity output is based on generation capacity. Data is also available on actual generation but it was decided that the notion of generation capacity was more in line with analysing the impact of greenhouse policy. The reason for this lies in the importance of fuel substitution following policy implementation. At present the majority of Australia's electricity is generated using brown or black coal as the intermediate fuel base. The introduction of a greenhouse policy may alter the composition of the fuel base given that coal generators emit more CO_2 during the production process relative to other fuel sources. The use of generation capacity accurately reflects the potential for greenhouse policy to have contrasting ramifications on the activity levels of differing electricity sources. As the generators are located in many different statistical divisions, the impact of greenhouse policy upon these regions is likely to be varied.

The identification of brown and black coal generation capacity was ascertained on a state basis, as no state in Australia uses both brown and black coal to generate electricity. Using the data, the percentage contribution to generation capacity of each state was calculated.

For instance, NSW is responsible for 57 percent of the generation capacity of electricity from black coal. This percentage was then multiplied by the total number of employees in the black coal industry, according to the original ABS database.

In keeping with our example, the ABS indicated that there are 30,574 people employed in the *EleBlk* industry. Hence 17,469 people are employed in the *EleBlk* industry in the State of NSW. The same calculation was performed for *EleBlk* in the remaining States of Australia based on their respective generation capacity. An identical procedure was adopted for the other electricity generation industries, *EleBr, EleGas, EleHyd* and *EleOth*. *EleOth* is assumed to include pump storage, internal combustion, combined cycle, and wind.

At the completion of this allocative procedure, a number of areas were identified which warranted further investigation. The main problem arose with the *EleGas* industry. Because *EleGas* is a comparatively small producer of electricity in the Australian market, the allocation of employees to this sector was low. In fact, of the 51,436 people employed in the industry, only 441 were assumed to work in the production of electricity using gas-fired generation. With the majority of SA's electricity supply sourced from gas, it became obvious that further research needed to be undertaken.[86]

Further data was collected from the ESAA which listed aggregate employment figures by sector (generation, transmission and systems operations, distribution and retailing) and by state. This data facilitated two improvements to the previous work. The first is the disaggregation of the original electricity industry in the core database, as outlined in Section 5.2 above. The second was the allocation of employees according to state employee data, which could be used to disaggregate the electricity industry in the regional equation database. This also avoided the need to rely solely on generation capacity Australia wide.

[86] The Torrens Island power station which is located near Adelaide in SA, is over twice the size of the largest brown coal station in the State. The power station receives its supply of natural gas via a 780km pipeline from Moomba. As so few people were aggregately employed in the electricity gas sector of the electricity industry, the results indicated that only 32 people are employed at Torrens Island. This is in contrast to the estimates of employment in the SA brown coal stations of 3,614.

The task of disaggregating the original employment by industry data for *I84Electricity* into three new industries was complex given that WA and TAS still have vertically integrated electricity industries. Excluding WA and TAS, the percentage share of labour for each of the disaggregated sectors was calculated. The data for WA and TAS was then calibrated by multiplying the total employment figure for each state by the percentage share.

Due to the varying datum years, the employment figures for the electricity industry were different.[87] This was overcome by multiplying the percentage of labour for each sector by the total employment figure in the original ABS database. As the transmission, and distribution sectors were not disaggregated further, employment figures for each industry were allocated across statistical divisions.[88]

The final task was to allocate the new total employment figure for the generation sector of the industry across the States of Australia. The employment by state data improved the accuracy involved in the allocation of employees to states. This method was superior to the previous method of solely allocating employees according to generation capacity installed. As the ESAA data and the total employment figure in the ABS data table were different, the percentage of each state's contribution to generator employment was calculated. This percentage was subsequently multiplied by the total number of electricity generation employees to give the total state employment figure.

Once the state generator employment was known, the next step involved allocating this figure across the new electricity generation industries.[89] The ESAA data on generation plant installed was utilised to calculate the percentage contribution of each plant type to total state generation. For instance, *EleBlk* represents 95 percent of installed capacity in NSW. These percentages were then multiplied by the state employment totals to give the contribution of each sector. The employment figure of 4,447 for *EleBlk* is now significantly smaller than the figure used in our example above.

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[87] The data relied on the ABS 1994 I-O tables and the ESAA's 1998 publication of Electricity Australia.

[88] The allocative pattern was based on the original employment by statistical division data.

[89] *EleBr, EleBlk, EleGas, EleHyd, EleOth.*

Arguably the most important contribution of this work to the regional modelling of greenhouse policy is the allocation of the energy industries of the Australian economy to the statistical division within which they reside. The previous regional equation data included employment by industry information according to the ABS Census data. As mentioned above, there was no separation of the different tiers of the industry in the data collection technique.

As also eluded to above, it is important for greenhouse modelling that the generating sector of the Australian electricity industry is accurately reflected in the database. In other words, the results of greenhouse modelling simulations on the Australian economy will be distorted if the generating sector is allocated according to the ABS data which includes all facets of the industry. For example, in the original regional equation database, there are employees by electricity industry recorded in all statistical divisions of the State of Victoria. This is due to the fact that the transmission and retail arms of the electricity industry traditionally employed people across the State. The impact of greenhouse policy however, will fall upon the generation arm of the industry which is located almost entirely in the statistical division of La Trobe Valley. Therefore the database was modified to ensure that the employment data of the generation arm of the industry is located in this region, and not spread throughout the State, as is the case in the initial database.

To ensure the accuracy of the allocation, many datum sources were utilised (Appendix 5.1 located at the end of this chapter). The Internet facilitated access to individual company information. This information was often invaluable as many of the companies provided detailed descriptions of the locality of their activities. Another valuable source was the Internet based Wilmap site which allows the user to obtain detailed maps of towns and regions within Australia. Personal communication was sought when electronic information was not forthcoming.

Table 5.8 (located at the end of this section) illustrates the allocation of employees to the respective electricity generating technologies. The employment figure by industry for each state was allocated across electricity generators on a share basis. The total generation from each fuel source was calculated and then each generator's share of that total was obtained. This share was multiplied by the number of employees in that industry in the state. Returning to our example of *EleBlk* in NSW, Eraring power station has an installed generation capacity of 2640 MW. This represents 23 percent of the total *EleBlk* generation (11,562 MW). Based on this calculation, 23 percent of the total NSW employment figure for the *EleBlk* industry was allocated to this generator 1,015.[90] This procedure was performed for all other generators in NSW for *EleBlk*. An identical procedure was followed for all remaining states and electricity industries.

The Eraring black coal electricity generator is located in the Hunter statistical division within the State of NSW (see Map 5.1). As shown on Table 5.8, a number of other black coal electricity generators are also located in this statistical division. The aggregate number of employees in these generators is then allocated to the Hunter region (representing 80 percent of total black coal electricity generators). The remaining 20 percent of black coal electricity generation employees in the State of NSW are found in the Central West statistical division. Geographically the Hunter and Central West regions are located in close proximity to one another. It can therefore be predicted that the impact of greenhouse policy on the black coal electricity industry will be felt predominantly by this geographical area within NSW.

Due to the importance of the location of the electricity industry in terms of regional impacts, it is worth providing a brief summary of the generation capacity in each State of Australia, with particular focus on the most important statistical divisions. The accuracy of the database is reflected in the results of greenhouse simulations as reported in Chapter six.

New South Wales

The majority of electricity generation capacity in the State of NSW (95%) is sourced from black coal electricity generation. Of this, 80 percent of the generation occurs in the statistical division Hunter.[91]

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[90] It is important to note at this stage that it is not important whether or not Pacific Power actually employs 1,015 people at the Eraring power station. It is the generator's share of employees relative to the share of employees at other generators that is important to the results for each statistical division.

[91] In addition to electricity generation, the Illawarra statistical division of NSW is responsible for the production of 53 percent of *I63IronSteel* processing. This is mainly attributable to the BHP processing plant at Port Kembla. A further 21 percent of *I63IronSteel* output is located in the Hunter statistical division.

Victoria

The majority of electricity generation capacity in the State of VIC (88%) is sourced from brown coal electricity generation. Of this, 98 percent of the generation occurs in the La Trobe Valley statistical division. The brown coal fuel source is also predominantly found in the statistical division La Trobe Valley.

Queensland

The majority of electricity generation capacity in the State of QLD (87%) is sourced from black coal electricity generation. Of this, 61 percent of the generation occurs in the statistical division of Fitzroy, 21 percent in the statistical division of Wide Bay–Burnett, and 14 percent in Moreton.

South Australia

The majority of SA's electricity is sourced from natural gas. There is a certain percentage of electricity from brown coal generation but this is comparatively low (estimates indicate about 20 percent of State capacity is sourced from brown coal). The gas generators are mainly located in statistical division Outer Adelaide (82%). All of the brown coal electricity generators are located in the statistical division Northern.[92]

Western Australia

The majority of electricity generation capacity in the State of WA (66%) is derived from black coal electricity generation. A further 30 percent of generation capacity is sourced from gas turbine electricity generators. The black coal generators are found predominantly in either of the adjoining regions of statistical division South West (53 percent) or statistical division Peel (41 percent). The locality of the *EleGas* generators is more widely distributed, however the main regions are statistical division Wheatbelt and statistical division Pilbura.[93]

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[92] SA also produces 12 percent of the iron and steel industries (*I63IronSteel*) output at BHP's Whyalla plant in the statistical division of Nor...

[93] In addition to electricity generation, 95 percent of the total output of iron and ore (*I12IronOre*) mining is found in the Pilbura statistical division of WA.

Tasmania

The majority of electricity generation capacity in the State of TAS (90%) is sourced from hydro electricity generation. The hydro generators are located on dams throughout the natural waterways of the State. The State of TAS is divided into four statistical divisions, one of which is the metropolitan statistical division Greater Hobart.

The statistical division Mersey-Lyell is responsible for 60 percent of the generation capacity from Tasmania's hydro electric plants. The Southern statistical division is home to 36 percent of the generation capacity, whilst the Northern statistical division holds the remaining small percentage.

Snowy Mountain Hydro Electricity Authority

The Snowy Mountain Hydro Electricity Authority (SMHEA) has installed capacity of 80 percent hydro and 20 percent pump storage. The SMHEA is located entirely within the statistical division Murray.

Northern Territory

Whilst the majority of electricity generation capacity in the Northern Territory (49%) is from gas turbine electricity generation, the employees in this industry are not allocated to a statistical division. The NT is treated as a State of Australia and is not considered a statistical division. The tops-down nature of the MONASH-Electricity model will disaggregate industry results to the state level where the impact of greenhouse policy upon the NT will be measured.

Table 5.8

NSW

Power Station	Owner	Type	MW	%	Number of Employees '000	Statistical Division	Transferred Totals '000	
EleBlk	4.447							
Eraring	Pacific Power	Steam/Coal	2640	0.23	1.015	Hunter		
Bayswater	Macquarie	Steam/Coal	2640	0.23	1.015	Hunter		
Liddell	Macquarie	Steam/Coal	2000	0.17	0.769	Hunter		
Vales Point B	Delta Electricity	Steam/Coal	1320	0.11	0.507	Hunter		
Mt Piper	Delta Electricity	Steam/Coal	1320	0.11	0.507	Central West		
Wallerawang C	Delta Electricity	Steam/Coal	1000	0.09	0.384	Central West		
Munmorah	Delta Electricity	Steam/Coal	600	0.05	0.230	Hunter	Hunter	3.555
BHP RBPD	BHP	Steam/coal,gas	42	0.00	0.016	Hunter	Central West	0.892
			11562	1.00	4.447			
EleHyd	0.0463							
Shoalhaven	Pacific Power	Hydro	240	0.57	0.026	Illawarra		
Warragamba	Pacific Power	Hydro	50	0.12	0.005	Central West		
Hume	Pacific Power	Hydro	50	0.12	0.005	Murray		
Burrinjuck/Keepit	Pacific Power	Hydro	20	0.05	0.002	Murray		
Nymboida	NorthPower	Hydro	9.5	0.02	0.001	Mid-North Coast	Illawarra	0.026
Oakey	NorthPower	Hydro	5	0.01	0.0005	Northern	Central West	0.005
Burrendong	NT Power	Hydro	20	0.05	0.002	Murray	Murray	0.013
Copeton	NT Power	Hydro	20	0.05	0.002	Murray	Mid-North Coast	0.001
Yarrawanga	NT Power	Hydro	9	0.02	0.0010	Murray	Northern	0.0005
			423.5	1.00	0.046			0.046
EleGas	0.114							
Northern	Pacific Power	Gas turbine/oil	100	0.34	0.038	Hunter		
Koolkhan	Pacific Power	Gas turbine/oil	95	0.32	0.036	Mid-North Coast	Mid-North Coast	0.036
Broken Hill	Pacific Power	Gas turbine/oil	50	0.17	0.019	Far West	Far West	0.019
Hunter Valley	Macquarie	Gas turbine/oil	50	0.17	0.019	Hunter	Hunter	0.057
			295	1.00	0.113			0.114
EleOth	0.093							
Smithfield	Sithe Energies	CCGT/gas	162	0.48	0.044	Sydney		
BHP RBPD	BHP	Waste gas (cogen)	61	0.18	0.016	Illawarra		
Appin	Energy Dev	Steam/methane	54	0.16	0.014	Illawarra	Sydney	0.044
BHP RBPD	BHP	Waste gas (cogen)	22	0.06	0.006	Hunter	llawarra	0.042

Tower	Energy Dev	Steam/methane	40	0.12	0.010	Illawarra	Hunter	0.006
			339	1.00	0.093			0.093
BlkCoal	18.643							
Eraring	Pacific Power	Steam/Coal	2640	0.23	4.256	Hunter		
Bayswater	Macquarie	Steam/Coal	2640	0.23	4.256	Hunter		
Liddell	Macquarie	Steam/Coal	2000	0.17	3.224	Hunter		
Vales Point B	Delta Electricity	Steam/Coal	1320	0.11	2.128	Hunter		
Mt Piper	Delta Electricity	Steam/Coal	1320	0.11	2.128	Central West		
Wallerawang C	Delta Electricity	Steam/Coal	1000	0.09	1.612	Central West		
Munmorah	Delta Electricity	Steam/Coal	600	0.05	0.967	Hunter	Hunter	14.902
BHP RBPD	BHP	Steam/coal,gas	42	0.00	0.067	Hunter	Central West	3.741
			11562	1.00	18.643			18.643
NatGas	0.843							
Northern	Pacific Power	Gas turbine/oil	100	0.34	0.285	Hunter		
Koolkhan	Pacific Power	Gas turbine/oil	95	0.32	0.272	Mid-North Coast	Mid-North Coast	0.271
Broken Hill	Pacific Power	Gas turbine/oil	50	0.17	0.143	Far West	Far West	0.142
Hunter Valley	Macquarie	Gas turbine/oil	50	0.17	0.143	Hunter	Hunter	0.430
			295	1.00	0.843			0.843

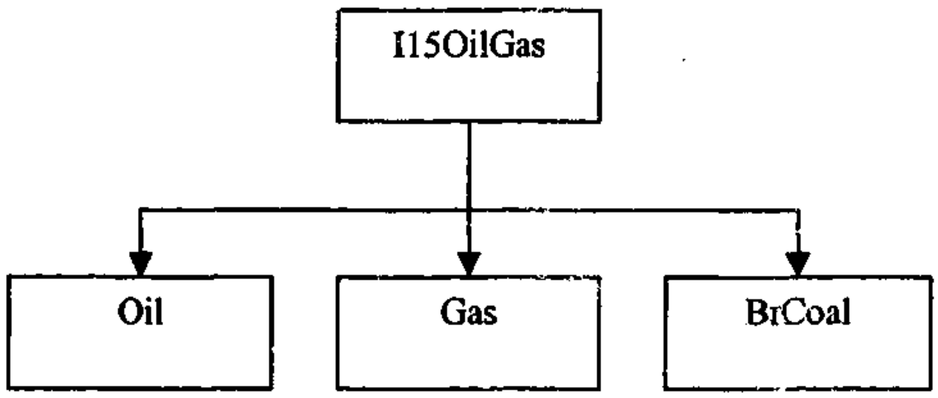
5.3.2 FUEL SOURCE SECTOR

DISAGGREGATION OF OIL, GAS AND BROWN COAL – CORE DATABASE

As part of the core database modification, the single industry *I15OilGas* in the original model was disaggregated into the unique industries; oil (*I15aOil*), gas (*I15bGas*) and brown coal (*I15cBrCoal*) (see Figure 5.4). This disaggregation was deemed essential to improve the accuracy of the energy sector of the Australian economy as depicted in the original MONASH model.

Figure 5.4

DISAGGREGATION OF THE OIL, GAS AND BROWN COAL INDUSTRIES



The disaggregation is based predominantly on the work of Adams, Fry and Parmenter (1997), *Appendix 1 – Disaggregation of Oil, Gas and Brown Coal.* Certain assumptions made by the authors of the above publication have been adopted in this thesis. The first assumption is that the only industry to use crude oil as an intermediate input is petrol (*I56Petrol*). No sales of gas or brown coal are made to this industry. The second assumption is that other than a very small percentage sold to the mining services industry (*I17MinServ*), all of the brown coal industry's sales are made to the brown coal electricity generators. The share of brown coal allocated to each industry is based on the generator's market share. This assumes that the largest generators use the largest amount of brown coal in their production process.

It is further assumed that the remaining sales of the original commodity *C17OilGas* are attributed to sales of the newly created gas commodity (*Gas*). Of these, $117.52 million, or 9 percent, represent sales of *Gas* to *EleGas*.

In order to accurately allocate the sales of *Gas* to *EleGas* and sales of brown coal (*BrCoal*) across the brown coal generators, the ESAA publication *Electricity Australia 1999* was utilised. Data is available on 'Fuel Consumed for Generation' (see Table 5.9). This method of disaggregation slightly deviates from that used by Adams et al (1997).

Table 5.9

FUEL CONSUMED FOR GENERATION

FUEL	ENERGY CONTENT (TERAJOULES)	% OF TOTAL
Brown Coal	552,455	84.5
Brown Coal Briquettes	2,211	0.05
Oil	0	0
Gas	98,782	15.5

Source: ESAA (1999)

Table 5.9 illustrates that of the fuels, brown coal accounts for 84.5 percent or $657 million, briquettes for 0.05 percent or $2.63 million, and gas for 15.5 percent or $117.5 million. The $657 million was subsequently allocated across the brown coal generators based on the share of generation. The brown coal briquette fuel usage was allocated to the Energy Brix company (*Ebrix)* who produces almost all of Australia's brown coal briquettes.

The disaggregation of sales of the original *C17OilGas* to the household sector of the economy has arbitrarily been allocated as half from *Gas* and half from *BrCoal*. Sales of gas to the household sector represent natural gas whilst sales of brown coal represent briquettes used to heat domestic dwellings.

Exports of the original *C17OilGas* are attributed only to sales of *Oil* and *Gas*. *BrCoal* is not exported due to its extremely high moisture content. The allocation of exports was based on export shares in Table 22 of ABARE's *Australian Commodities* journal (ABARE, 1998). The data values exports of crude oil at $1424 million and natural gas at $1047 million. Thus the export shares work out to be *Oil* 58 percent and *Gas* 42 percent.

Australia does not import natural gas or brown coal. It is therefore assumed that all imported flows of *C17OilGas* relate entirely to imports of crude oil.

A simple pro-rating procedure was adopted to separate the margins on flows of the original *C17OilGas* into margins on the flows of *Oil, Gas* and *BrCoal*. The same percentages as those described above are used to apply margins on total sales of *C17OilGas* to electricity generation. For instance, 85 percent of margins are allocated to the brown coal electricity generators and 15 percent are allocated to the gas electricity generators.

The industry *BrCoal* does not purchase the commodity black coal (*BlkCoal*). Sales of black coal are assumed to flow equally between *Oil* and *Gas*.

It is assumed that both commodities *Gas* and *BrCoal* sell to the mining services industry (*I17MinServ*) on an equal basis.

DISAGGREGATION OF FUEL SOURCE INDUSTRIES – REGIONAL EQUATION DATABASE

A similar allocation procedure to that described in Section 5.3 was used for the fuel source industries, namely black coal (*I14BlkCoal*), gas (*I15bGas*) and brown coal (*I15cBrCoal*). It was assumed that employment in these industries was to be allocated based on the same shares as the electricity generators. For instance, *BrCoal* was allocated across VIC and SA in line with the share of *EleBr* generators in the respective states. The exception to this rule was in the case of *Gas* where it is known that the fuel source and generation activity belong to different statistical divisions. For example, generation of the *EleGas* industry is located predominantly in the La Trobe Valley, however its fuel source is found off the coast of the East Gippsland statistical division.

An anomaly that may arise from this allocative basis is in the case where the coal mines and electricity generators are located in different statistical divisions. This may occur in states such as NSW and QLD where transport of coal from the mine to the power station occurs.

New South Wales

The Hunter statistical division is responsible for 80 percent of the black coal fuel in NSW. A further 20 percent is sourced from the statistical division Central West.

Victoria

The brown coal fuel source is predominantly mined in the statistical division La Trobe Valley.

Queensland

Approximately 60 percent of the black coal in the State of QLD is sourced from the statistical division of Fitzroy, 21 percent from the statistical division of Wide Bay–Burnett, and 14 percent from Moreton.

South Australia

The usage of the fuels, natural gas and brown coal, to generate electricity in SA are assumed to be sourced from the same statistical divisions as the generation capacity.

Western Australia

The *Gas* industry in WA is located off the North-West Shelf and enters WA via the statistical division Pilbura.

Tasmania

As the majority of electricity generation capacity in the State of TAS is sourced from hydro electricity generation, the fuel source is water from the natural waterways of the State. No fossil fuel or natural gas is used to fire electricity generation within the State.

5.3.3 ENERGY INTENSIVE SECTOR - NON FERROUS METALS

Greenhouse policy will also have an impact on those industries in the Australian economy which are considered to be electricity intensive in their production technique. The most prevalent of these is the non-ferrous metals industry, which includes aluminium refining and smelting. A large part of the output of this industry is exported.

Over recent decades the Australian aluminium industry has grown rapidly to be one of the leaders in world supply. At the turn of the century, Australia was the world leader in the production of bauxite and alumina. Australia was also the fifth largest producer of aluminium. The prosperity of the industry is due to Australia's abundance of bauxite and the availability of relatively cheap energy supplies (ACIL, 2000).

The geographic location of the industry is determined by the availability of the natural resources used as intermediate inputs. Australia's low density population has helped to foster the development of its natural resource industries as the land value in remote mining areas is relatively low.[94]

Whilst bauxite mining is capital intensive, associated labour costs represent 42 percent of the mine's total costs of operation, creating employment opportunities in regional areas (Australian Aluminium Council, 1994 and 1997). In many instances, towns have evolved solely to meet the needs of the aluminium industry. In response, town infrastructure is often funded in part by the mining company. Further employment opportunities in regional areas will arise if industry growth over the next decade reaches the 30 percent predicted by industry analysts (ACIL, 2000).

There are three main industries which are included under the umbrella of the aluminium sector. The first is the mining of bauxite. Bauxite is the main ore used in the production of alumina. Most of the world's continents have deposits of bauxite, but the majority of them are deemed to be uneconomical to mine. Bauxite is mined in Australia mainly through open cut methods. The ore is then transported by rail or road to ships or refineries. Labour

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94 This is in contrast to many countries operating in the European Union where the higher population has increased demand for available land.

costs aside, the largest cost items are the electricity and fuels required to crush and blend the ore (Australian Aluminium Council, 1997).

Bauxite is used mainly in the production of alumina. Due to the low value to weight ratio of the ore, most of the bauxite mined in Australia is used in Australia's alumina refineries. Very little bauxite ore is exported (Australian Aluminium Council, 1997).

The alumina refinery industry is the second part of the aluminium sector. The low value to weight ratio of bauxite has resulted in the development of alumina refineries in close proximity to the mines.[95] At present, approximately 80 percent of Australia's alumina production is exported. (ACIL, 2000)

"Alumina is the aluminium oxide extracted from bauxite by a refining process. It takes between two and three tonnes of bauxite to produce a tonne of alumina, depending on the grade of bauxite used. Refined alumina is valued at around ten times the value of bauxite". (ACIL 2000)

The impact of greenhouse policy upon the electricity industry is likely to flow through to alumina refining as it is considered to be a relatively energy intensive process with 16 percent of its costs attributable to electricity and gas usage. The availability of cheap energy is essential to the alumina industry if it is to compete on the world market. Australia is considered to have a comparative cost advantage in the production of alumina, however the introduction of greenhouse policy may erode this (see Table 5.10). Note that the other countries included in Table 5.10 are classified by the UNFCCC as developing countries and therefore do not have to meet CO_2 emission reduction targets under the Kyoto Protocol.

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95 The exception is the Weipa mine in Northern QLD which ships bauxite to Gladstone on the mid-east coast of the State.

Table 5.10

COMPARATIVE OPERATING COSTS OF MAJOR ALUMINA EXPORTING COUNTRIES

Country	Capacity (kt per annum)	Costs ($/tonne)
Australia	13,980	104
Brazil	3,420	147
India	1,838	124
Jamaica	3,580	154

Source: ACIL Consulting (2000)

The final sector of the aluminium industry is the process of aluminium smelting. The location of the smelters is dictated mainly by the availability of low cost energy sources. Provided the alumina can be easily transported to the smelter, it is the availability of cheap fuel which has the most significant bearing on the location of the plant (Australian Aluminium Council, 1994).

As aluminium is traded on the world market, its price is subject to large fluctuations. Supply is relatively price inelastic in the short-run due to the large development costs associated with building a new smelter. However in the long-run the price becomes elastic due to the homogenous nature of the product. If the price of Australian aluminium rose relative to other countries, buyers would substitute away from the Australian commodity.

Such a scenario may potentially arise if Australian aluminium exporters are competing with producers in developing countries who are not a Party to the Kyoto Protocol. The real world price of aluminium has been falling over recent decades and it has been observed that unless smelters and refineries stay ahead of this declining real price trend through continuous efficiency improvements and cost reductions, they will no longer be viable (ACIL, 2000). Cost increases are a likely consequence of greenhouse policy.

The input costs of aluminium smelting are mainly attributable to the use of alumina and electricity. An illustration of the importance placed on the availability of cheap electricity is found in the case of WA. Although WA produces most of Australia's alumina, its relatively high cost of electricity has deterred investors from establishing an aluminium smelter in the State. It is more cost effective to transport alumina from WA to VIC, where electricity is cheaper, rather than develop a smelter in WA where the alumina is refined.

One argument put forth in criticism of the Kyoto Protocol is that it may deter investment in the Australian aluminium industry. The objective of the Kyoto Protocol is to encourage countries to actively work together to reduce global greenhouse gas emissions. Without the inclusion of developing countries, the problem is likely to be worsened by the investment decisions of the aluminium industry.

World benchmarking studies show that Australia is one of the cheapest places in the world to mine, refine and smelter aluminium. A carbon tax or similar greenhouse policy is likely to increase the cost of producing these commodities. It would therefore seem illogical that a greenhouse policy (aimed at reducing emissions) would encourage companies to establish plant in developing countries who are not signatories to the Kyoto Protocol. The push toward developing countries will contribute to the problem. "Australia can best contribute to greenhouse gas abatement by continuing to do what it has demonstrated it does best: efficiently produce energy-intensive products like aluminium for export to countries that are less well equipped for this task." (Australian Aluminium Council, 1997) Perhaps a more appropriate global greenhouse solution is the injection of research funding into developing a more energy efficient means of producing alumina and aluminium.

Most of the aluminium mines and processing facilities are found in the States of WA and QLD. The geographical location of the refineries and the smelters will have a bearing on how much their costs increase as a direct consequence of greenhouse policy. The aluminium industry in WA relies on natural gas to generate its electricity, whereas in QLD the electricity is predominantly generated using black coal. Due to the absence of interstate trade, the WA aluminium industry will not be able to substitute between different electricity generators in other states. They can however substitute between the different fuel sources available in the State itself. QLD producers on the other hand can substitute between inter and intra state generators if the cost of black coal electricity generation increases.

Assuming the non-ferrous industry has not entered into fixed price contracts with the electricity generators, a rise in the price of electricity will increase the operating costs of the sector[96]. Even those participants in the non-ferrous industry who generate their own electricity will incur higher costs associated with greenhouse policy[97]. Given its export orientation, an increase in the domestic price of aluminium relative to its foreign competitors will result in a decrease in demand, and the contraction of the industry.

To ensure that the direct and indirect economic implications of greenhouse policy upon the non-ferrous industry are modelled accurately, data collected on output was used to disseminate the employment by industry data.

DISAGGREGATION OF NON FERROUS METALS – CORE DATABASE

In addition to the modifications to the electricity sector of the Australian economy, attention is paid to electricity intensive industries such as *I64NFerrous*. An important part of the analysis involves understanding how greenhouse policy impacts upon an industry dependent on low cost electricity.

As outlined in the above discussion, the aluminium component of the non-ferrous metals sector is electricity intensive. It is the process of refining and smelting the mineral which makes the industry particularly reliant on electricity as part of its production process. The other minerals included in the classification of the non-ferrous metal sector also use electricity as an intermediate input, but they are much less dependent on it for a large share of their costs. For this reason it was deemed worthwhile to disaggregate the aluminium industry from its traditional classification as part of the non-ferrous metals sector.

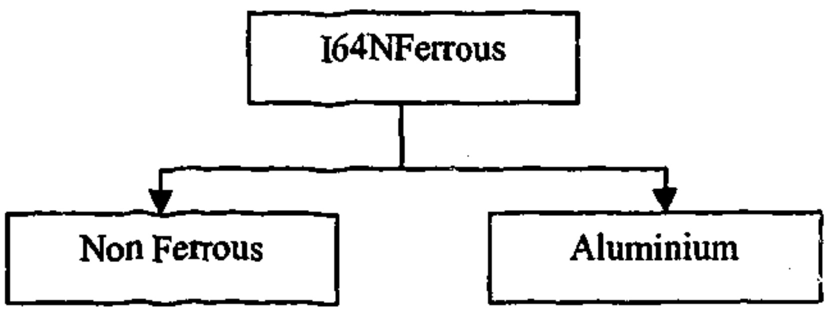
[96] Many aluminium smelters and refineries have entered into fixed term price contracts with electricity generators. It is unknown whether these contracts have taken into account the implications of greenhouse policy.

[97] Individual companies who generated their own electricity will still have to pay a carbon tax.

The data to facilitate the disaggregation of the non-ferrous metal sector came from the ABS publication *5215.0, Section 1302*. According to the ABS, the aluminium sector accounts for around 57 percent of the original non-ferrous metal and products industry. This share was used as the basis to disaggregate the original industry *I64NFerrous*, into *I64aNFerrous* and *I64bAlum* (see Figure 5.5). *I64aNFerrous* consists predominantly of the primary and secondary recovery of metals such as copper, gold, nickel, lead, silver and tin. *I64bAlum* is made up of both the alumina and aluminium activities in the Australian aluminium industry. It does not include the mining of bauxite which remains incorporated in *I13NFerrous*.

Figure 5.5

DISAGGREGATION OF NON FERROUS METALS



In addition to the split of industry activity based on production, shares were also available for import competing commodities and exports. In order to maintain the total sales split of 43 percent and 57 percent, the percentage division for domestic intermediate flows of each commodity was altered to 51 percent and 49 percent as shown on Table 5.11.

Table 5.11

Industry	Intermediate Flows %	Competing Imports %	Exports %
Non-Ferrous	51	87	35
Aluminium	49	13	65

As mentioned in the introduction to Section 5.3, it is important to ensure that the shares used to disaggregate a component of the database are used consistently. In this example, the import and export flows are consistently used for disaggregating taxes and margins.

DISAGGREGATION OF NON FERROUS METALS – REGIONAL EQUATION DATABASE

The aluminium industry is very regionalised. Any changes in the activity levels of this sector will impact on the economic forecast for a few key statistical divisions who support the aluminium industry. Data on employment in the non-ferrous sector of the Australian economy was sourced initially from ABARE's *Research Report 2000.7* on the Australian electricity industry (ABARE, 2000). The data relate to the MONASH industries iron ore mining (*I12IronOre*), ore mining (*I13Nonferrous*), iron and steel processing facilities (*I63IronSteel*) and aluminium refineries and smelters (*I64NFerrous*).

As discussed earlier, included in the original industry *I64NFerrous* are alumina production, aluminium smelting, basic non-ferrous metal manufacturing, and copper, silver, lead and zinc smelting and refining. The total employment figure in the original regional equation database could not therefore be allocated solely across the aluminium smelting sector of this broad industry classification.

In line with the core database, the original *I64NFerrous* in the regional equation database was also disaggregated into *I64aNFerrous* and *I64bAlum*[98]. The data used to facilitate the disaggregation came from an ACIL Consulting (2000) report to the Australian Aluminium

[98] Hereafter referred to as *Nferrous* and *Alum*.

Council '*Aluminium and the Australian Economy*'. The data provided total employment figures for bauxite mining, alumina refining, and aluminium smelting for the year ended 30 June 1998. A more accurate mapping of the industry employment by statistical division could have been facilitated in the event of data being available on employment by mine or manufacturing plant. Unfortunately this information is not publicly available.

As discussed above, the information at the statistical division level is based on employment by industry. The disaggregation of *NFerrous* involved removing the number of people employed in aluminium smelting from the original industry employment figure. To allocate the new employment figure for *NFerrous* across the existing statistical divisions, the percentage share of each statistical division in industry employment was calculated. To complete the disaggregation, this figure was then multiplied by the new total industry employment figure.

The allocation of industry employment to statistical divisions in *Alum* was based on production data for each smelter as published by ABARE (see Table 5.12 located at the end of this section). The data is arranged in a similar fashion to the electricity generation data described above, however the one notable difference is that some of the data relates to actual production rather than installed capacity. For each industry's output, the share of its mine or refinery was calculated. For example, Comalco's Boyne Island alumina refinery represents 25 percent of production in the refinery sector. This refinery was therefore assumed to employ 1,412 of the 5,650 people employed in the Australian alumina refining industry. The Boyne Island refinery is located in the Fitzroy statistical division in the State of QLD.

With the exception of the Gove alumina refinery located in the NT of Australia, the remaining production of Australian alumina is found in the South West statistical division of WA. The South West region of WA is the predominant location of bauxite mining, producing 74 percent of Australia's output.

Table 5.12 also shows the allocation of employment in the aluminium smelting sector across Australian statistical divisions. There is a very sharp contrast drawn between the location of the alumina refinery part of the industry and the aluminium smelting. As mentioned above, whilst the majority of alumina is refined in WA, there are no aluminium smelters located in this State. The reason is attributed to the availability of relatively lower cost electricity in other States of Australia. A case in point is VIC which does not mine bauxite or refine alumina, but is responsible for nearly 16 percent of the aluminium smelting market. Of this, 5 percent is found in statistical division Barwon and 11 percent is found in statistical division Western District.

The State of QLD is the home of 28 percent of Australia's aluminium smelters. The production is attributed to Comalco's plant, located in the statistical division of Fitzroy.

The Bell Bay region in the Northern statistical division of TAS is responsible for 4 percent of Australia's aluminium smelting and refining industry.

The remaining production of aluminium is located in the Hunter statistical division in NSW. Again, the relationship between low cost black coal electricity and the location of the aluminium smelting industry is evident.

It is of interest to note that the aluminium smelting plants are not located in the States of WA or SA where gas fired electricity generation is the predominant source. The introduction of greenhouse policy might reverse this trend.

Table 5.12

164 Nonferrous Metals

Alumina refining	5.650
Aluminium smelting	5.462

Alumina refining 5.650

Alumina refineries	**Company**	**Location**	**Production**	**%**	**Number of Employees '000**	**Statistical Division**	**Transferred Totals '000**	
Boyne Island	Comalco	QLD	3600	0.25	1.425	Fitzroy		
Gove	Gove Aluminium	NT	1780	0.12	0.704	NT is a State		
Kwinana	Alcoa Alumina	WA	1900	0.13	0.752	South West		
Pinjarra	Alcoa Alumina	WA	3100	0.22	1.227	South West		
Wagerup	Alcoa Alumina	WA	1700	0.12	0.673	South West		
Worsley	Worsley Alumina	WA	2190	0.15	0.867	South West		
			14270	1	5.65			

Aluminium smelting 5.462

Aluminium smelters

							Fitzroy	2.976
Bell Bay	Comalco	TAS	138	0.08	0.436	Northern	Peel	0
Gladstone	Comalco	QLD	490	0.28	1.551	Fitzroy	South West	3.519
Kurri Kurri	Capral Aluminium	NSW	150	0.086	0.474	Hunter	Northern	0.436
Point Henry	Alcoa of Australia	VIC	162	0.094	0.512	Barwon	Hunter	1.868
Portland	Alcoa of Australia	VIC	345	0.2	1.092	Western District	Barwon	0.512
Tomago	Tomago Alum	NSW	440	0.25	1.393	Hunter	Western District	1.092
Total			1725	1	5.462			10.407

5.4 SUBSTITUTION

After the database disaggregation there are 128 industries and 130 commodities in the MONASH-Electricity model[99]. A full list of industries and commodities is provided as part of the glossary at the beginning of the thesis.

The primary objective of the modifications to equations is to enable the model to evaluate more adequately how the imposition of a greenhouse policy impacts upon the Australian economy. An important inclusion is a set of equations which facilitate the electricity sector to substitute between the different generators.[100] Details of the equation modifications are shown in Appendix 5.2.

SUBSTITUTION BETWEEN ELECTRICITY GENERATORS

This section describes the substitution capacity of the electricity generators. The disaggregation, as shown in Figure 5.3, illustrates the nested relationship between the tiers of the electricity sector. In the first tier of the industry, the model modifications allow the electricity distribution industry (*ElectDist*) to substitute between the different sources of electricity generation. As the price of one electricity generator's output rises relative to the average price of electricity, *ElectDist* is able to purchase electricity from the cheapest source. It is important for the emission accounting to be accurate to ensure that the tax weighs heavily upon those generators who emit more CO_2 per MWh of electricity generated.

At a more disaggregated level, the model also allows *EleBr* to substitute between the brown coal electricity generators in the model. Each of the brown coal generators represent one of the companies described in Chapter four. Once again, the substitution is based on the relative price of the commodity output sold to the electricity brown industry. As mentioned previously, each of the individual generators emits a different level of CO_2

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[99] There are 115 industries and 117 commodities in the MONASH model.

[100] It is possible that the electricity generators may absorb the cost of the greenhouse tax internally to remain competitive in their bids to the NEM.

in the production of one MWh of electricity. The imposition of greenhouse policy will result in the price of the highest emitters rising above the average price.

The model has also been adapted to allow for limited substitution between the use of intermediate inputs by an industry. If the price of electricity rises relative to the price of other intermediate inputs and factors of production, an industry has the capacity to use less electricity and still maintain its existing level of output. The industry would effectively substitute away from the use of electricity and replace it with another intermediate input or more factors of production such as labour. [101]

The elasticity of substitution between the different levels of electricity generation is set at 5 for the electricity generators *EleBr, EleBlk, EleGas, EleHyd* and *EleOth*. As highlighted in Chapter two, this is on par with the elasticity of substitution used by other modellers in the greenhouse CGE area. The elasticity of substitution allows *ElectDist* to substitute away from the more expensive generators when greenhouse policy changes the relative price of electricity from the different generation sources. For instance, a 1 percent rise in the price of commodity *EleBr* relative to commodity *EleHyd* will produce a 5 percent fall in the ratio of *EleBr / EleHyd* used by industry *ElectDist*.

A higher elasticity of substitution of 10 has been set for the brown coal electricity generators *Edis, EBrix, Haz, LoyY, Yall* and *Flin*. As previously discussed, the majority of the generators in this group are located in the La Trobe Valley region of Victoria. The consumer of *EleBr* holds no preference whether the electricity is sourced from one generator or another. The elasticity is higher for the brown coal generators because there are relatively fewer differences in the fuel source and the method used to generate the electricity. In the Victorian electricity market, if one base generator faces an outage, the remaining generators are usually asked by NEMMCO to increase their output to meet

[101] The substitution is limited by the relatively low general intermediate substitution term which is generally set at 0.25. This means that if the price of ElectDist increased by 10 percent, relative to the average price of all commodities, industries would use 2.5 percent less electricity and more labour, capital or materials.

demand. The elasticity of substitution means that a 1 percent rise in the price of *EBrix* relative to *LoyY* will produce a 10 percent fall in the ratio of *EBrix / LoyY* used by *EleBr*.[102]

Verbal Description of CO_2 Accounting

The core model is altered to account for greenhouse gas emissions. As will be demonstrated in Chapter six, the database records greenhouse gas emissions from each of the electricity generators and fuels in the basecase. Equations are added to the model to allow the greenhouse tax to impact upon the various emission intensive sectors of the economy (see Appendix 5.2).

The fuel commodities which attract the greenhouse gas tax are black coal, gas and petrol. The emissions of CO_2 from black coal and gas relate to the use of these fuels to generate energy. Many industries in MONASH-Electricity consume these fuels as intermediate inputs. As the fuels are converted into energy, CO_2 emissions are released into the atmosphere. *Gas* has the lowest emission intensity of the fuels. Emissions of CO_2 from petrol (*Petrol*) relate to the usage of transportation. Such transportation includes household automobiles and road, rail, sea and air domestic and commercial transportation. Emissions from this sector of the economy constitute approximately 12 percent of Australia's total emissions (Dobes, 1998). Of this percentage, household passenger transportation accounts for 55 percent of CO_2 emissions from the transport sector (Dobes, 1998).

The industry and the household sectors of the economy use fuels as intermediate inputs. Fuels such as petrol are taxed to discourage their usage and consequently reduce emissions of CO_2. As identified in the preceding discussion, the electricity generation sector of the economy is also responsible for emissions during the production of electricity.

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[102] An experiment with the model was conducted to remove substitution between the rest of the brown coal electricity generators and *EBrix*. Energy Brix generates electricity but it is on a much smaller scale than that of the remaining generators in the La Trobe Valley region. The impact of this change upon the results for *EBrix* was a slight improvement in its activity level. The sole purchaser of its output, *ElectDist* continued to reduce its own usage of electricity and therefore it demanded less electricity from Energy Brix. The distribution industry was not able however to replace its consumption of electricity from Energy Brix with one of the other generators.

A similar equation structure is used to ascertain the increase in the power of the tax on the usage of electricity. Two series of equations are used. The first set determines the increase in the power of the tax when the CO_2 policy shock is imposed upon the following generators, *EleBlk, EleGas, EleHyd* and *EleOth.* The equations are set up to measure the CO_2 emission intensity per MWh generated and subsequently impose the tax upon this factor. The second set of equations determines the increase in the power of the tax for the brown coal electricity generators, *Edis, EBrix, Haz, LoyY, Yall* and *Flin*. The mathematics applied in both series of equations is identical.

The main difference between the calculation of emissions from the fuel and electricity sectors of the economy is attributable to how the quantity of emissions is calculated. Whereas emissions pertaining to the fuels is based on fuel coefficients, emissions from the electricity sector relies on data with respect to emissions per MWh generated.

INTRODUCTION OF CO_2 TAX ON FUELS AND ELECTRICITY GENERATION

CO_2 Emission Intensities of the Brown Coal Generators

The initial interpretation of the preliminary results indicated that a problem existed in the greenhouse gas database for the brown coal electricity generators. The introduction of greenhouse policy collapsed the cleaner emitters relative to the CO_2 intensive emitters. Thus the model substituted electricity produced by *LoyY* for electricity produced by *EBrix*. The reason for this was attributed to the fact that *LoyY* physically generated more electricity. The original database relied on the MWh generated annually multiplied by the CO_2 emission intensity per MWh. Although *LoyY* has a lower emission intensity, the magnitude of its generation meant that it was bearing the burden of the tax.

Table 5.13 below shows the ratio of annual tonnes of CO_2 emitted to annual sales of the emitting commodity.

Table 5.13

RATIO: ANNUAL TONNES OF CO_2 TO SALES

COMMODITY	CO_2	RATIO
Edison	4,942	14.14
Energy Brix	936	14.89
Hazelwood	9,493	16.97
Loy Yang	19,135	27.37
Yallourn	13,939	27.50
Flinders	5,800	23.70

Table 5.13 indicates that the emissions per dollar of activity are much higher for Loy Yang Power and Yallourn Energy. This does not reflect the case in reality. The reason for the inconsistency is due to the use of actual generation to calculate the figure for CO_2 emitted annually, rather than generation capacity.[103]

The problem was addressed in a number of stages. Firstly, the percentage share of each generator in the market was calculated. This percentage was then multiplied by the total CO_2 emissions of 54Mt per annum. If it is assumed that the emission intensity of all brown coal generators is equal, the emissions ratio will be identical as shown in Table 5.14 below.

[103] Generation capacity was used to disaggregate *EleBr* into the brown coal generating industries.

Table 5.14

RATIO: ANNUAL TONNES OF CO_2 TO SALES

COMMODITY	CO_2	RATIO
Edison	7,828	22.39
Energy Brix	1,407	22.39
Hazelwood	12,524	22.39
Loy Yang	15,655	22.39
Yallourn	11,350	22.39
Flinders	5,479	22.39

If the database was left as described in Table 5.14, the impact of the tax would be uniform for all of the brown coal electricity generators. However, by multiplying the CO_2 emitted per MWh by the market share of CO_2, the percentage share of emissions that should be attributed to each generator can be calculated. Table 5.15 illustrates these steps.

Table 5.15

RATIO: ANNUAL TONNES OF CO_2 TO SALES

COMMODITY	CO_2 MARKET	CO_2 /MWH	CO_2	% CO_2
Edison	7,828	1.25	9,785	14
Energy Brix	1,407	1.50	2,111	3
Hazelwood	12,524	1.46	18,286	25
Loy Yang	15,655	1.26	19,726	27
Yallourn	11,350	1.37	15,550	22
Flinders	5,479	1.16	6,356	9

Multiplying the percentage of CO_2 by the total emissions of 54Mt presented the new CO_2 emission figures for the brown coal generators. This figure, as shown in Table 5.16 below, is used in the database.

Table 5.16

RATIO: ANNUAL TONNES OF CO_2 TO SALES

COMMODITY	CO_2	RATIO
Edison	7,391	21.14
Energy Brix	1,595	25.36
Hazelwood	13,812	24.69
Loy Yang	14,900	21.31
Yallourn	11,746	23.17
Flinders	4,801	19.61

As can be seen in Table 5.16, the commodities with the lower CO_2 emission intensities per dollar of usage are the cleaner generators.

Allocating CO_2 Emissions from the Fuels to the Electricity Generators

An unrelated problem existed in the database for the emissions of CO_2 from the electricity generating sector. The results indicated irregularities in this sector of the model. The most concerning results related to the large collapse of electricity produced by the brown coal generators relative to the black coal generators. Even though the elasticity of substitution was high, there seemed to be a large difference in activity levels between the industries.

A further inconsistency related to the fact that the electricity black coal industry collapsed initially and then began to prosper in the face of greenhouse policy. This was a somewhat unexpected result. Although it is reasonable to assume the output of the brown coal generators would collapse further, we would expect the path of both generators to be similar. The result suggested that the price of black coal[104] may be influencing the price of *EleBlk* and therefore inducing substitution toward this electricity generator.

A decision was made to use the disaggregation of the electricity industry not only to allow substitution between generators based on their fuel usage, but on the CO_2 emissions released during the generation process. The advantage of taxing the intermediate fuels *BlkCoal, Gas, BrCoal* and *Petrol* was that the impact of greenhouse policy on a wider section of the economy could be analysed. This was the main disadvantage associated with imposing a CO_2 tax solely upon the electricity sector. The disadvantage of taxing the intermediate fuels was the fact that it did not adequately reflect the CO_2 emission intensities of the electricity generating sectors.

In the case of brown coal, which is sold almost exclusively as an intermediate input into the electricity brown market, the tax did not distinguish between the CO_2 intensities of the individual generators. It was therefore decided that the emissions from brown coal were to be attributed to the brown coal electricity generators. Hence there is no tax on the intermediate usage of brown coal as it is assumed that the brown coal commodity is not responsible for the emissions. This makes sense in the case of the La Trobe Valley. The brown coal mines emit a very small amount of CO_2 relative to the electricity generation in the power stations. If you rely on the emissions of brown coal and make no allowances for how much each power station uses in its production process,[105] there will be almost no substitution between the brown coal generators. Without the inclusion of CO_2 emission intensities, the cost of a unit of energy from brown coal will virtually increase the same for all brown coal generators with the introduction of the CO_2 tax.

The case of electricity produced using black coal and gas is more difficult because these fuels are not sold exclusively to the electricity industry. A large percentage of *BlkCoal* output is sold to the black coal electricity market, but the rest of its sales are widely dispersed across the domestic market. In addition, 40 percent of *BlkCoal* is exported. Emissions of CO_2 attributed to sales of *BlkCoal* to *EleBlk* were assumed to be zero. It was therefore possible for the model to tax intermediate usage of black coal to all other sectors

[104] The price of black coal is heavily influenced by its export market.

[105] The usage of brown coal is attributed to generation capacity.

of the economy, excluding the black coal electricity industry. Emissions of CO_2 from the black coal industry were apportioned to the commodity *EleBlk* rather than *BlkCoal*.

A similar process was followed to remove emissions of CO_2 from sales of *Gas* to the *EleGas* industry. As it was assumed that there were no emissions attributed to this intermediate sale, the emissions were apportioned to the *EleGas* industry.

The outcome of these modifications resulted in the emissions being based not on intermediate fuel usage, but on the electricity generation process itself. Once again this situation is an accurate reflection of reality as the emissions attributed to the electricity black and gas industries are due to the actual generation technique, not the sourcing of the fuel.

CO_2 EMISSION INTENSITIES OF THE ELECTRICITY GENERATORS

The important balance during this data editing process was to ensure that the total CO_2 emissions in the Australian economy remained unchanged in the reference case. Provided the aggregate emissions from all sectors were accurate, the revenue collected from the greenhouse policy will be correct. With these processes in place the impact of a $50 per tonne greenhouse tax on the level of aggregate CO_2 emissions can be ascertained.

Table 5.17 below shows the ratio of annual tonnes of CO_2 emitted to annual sales of the emitting commodity.

Table 5.17

RATIO: ANNUAL TONNES OF CO_2 TO SALES

COMMODITY	CO_2	RATIO
EleBr	54,246	22.39
EleBlk	75,591	15.78
EleGas	3,586	9.97
EleHyd	0	0
EleOth	0	0

To ensure that the ratios in Table 5.17 are correct, a series of calculations was undertaken. Firstly the percentage share of each generator in the market was calculated. This percentage was then multiplied by the total CO_2 emissions of 133Mt per annum. If we assume that the emission intensity of all generators is equal, the emissions ratio will be identical as shown in Table 5.18 below.

Table 5.18

RATIO: ANNUAL TONNES OF CO_2 TO SALES

COMMODITY	CO_2	RATIO
EleBr	39,703	16.39
EleBlk	78,478	16.39
EleGas	5,894	16.39
EleHyd	8,580	16.39
EleOth	768	16.39

If the database was left as unchanged from its form in Table 5.18, the impact of the tax would be identical for all of the electricity generators. However, the allocation of CO_2 emissions on this basis is incorrect as the hydro and renewable electricity industries do not emit any CO_2 in their generation process. By multiplying the CO_2/MWh by the market share of CO_2, the percentage share of emissions that should be attributed to each generator can be calculated. Table 5.19 explains these steps.

Table 5.19

COMMODITY	CO_2 MARKET	CO_2 /MWH	CO_2	% CO_2
EleBr	39,703	1.33	52,805	41
EleBlk	78,478	0.91	71,289	56
EleGas	5,894	0.68	4,008	3
EleHyd	8,580	0	0	0
EleOth	768	0	0	0

Multiplying the percentage of CO_2 by the total emissions of 133Mt derived the new CO_2 emission figures for the generators. This figure, as shown in Table 5.20 below, is used in the database.

Table 5.20

COMMODITY	CO_2	RATIO
EleBr	54,998	22.70
EleBlk	74,250	15.50
EleGas	4,174	11.60
EleHyd	0	0
EleOth	0	0

As can be seen in Table 5.20, the commodities with the lower CO_2 emission intensities per dollar of usage are the cleaner generators. Unlike the case for the brown coal generators, there are significant differences between the CO_2 emission intensities of the generators.

The final step in the process is to remove the CO_2 emission figure from *BlkCoal* and *Gas* respectively. The figure for CO_2 emissions from *EleBr* was also removed from the total emissions figure for the generators as it is counted as part of emissions in the brown coal generators database.

5.5 CONCLUSION

This chapter has outlined the main modifications that have transformed the existing MONASH model of the Australian economy into MONASH-Electricity. MONASH-Electricity includes a more detailed electricity sector which enables the impact of greenhouse policy to be modelled more accurately.

Changes to both the database and the equation system allow a greenhouse tax to be placed on those sectors of the economy who are considered to be emission intensive. Rather than a blanket tax on the fuel sources, three separate taxes are used to capture the economic impact of greenhouse policy. The results of simulations using these modifications are discussed in the following chapter.

Appendix 5.1

SOURCES

Australian Bureau of Statistics
Statistical Concepts Library
1216.0 - Australian Standard Geographical Classification (ASGC) 1999.
Chapter 13. Maps.
Victoria

ABARE, Profile of the Australian Electricity Industry, Dickson, Andrew and Warr, Suthida. (2000)

ESAA, Electricity Australia 1999, (1999)

Wilkan's maps search engine. http://www.wilmap.com.au/

Websites of energy companies. In many instances these sites provided useful maps.

Caltex Australia - http://www.starcard.com.au/news/media_270899.html – information about the Sithe Energies gas generation plant.

Hydro Electric Corporation – http://www.hydro.com.au/education/index.htm

Delta Electricity - www.de.com.au

Great Southern Energy - www.gsenergy.com.au

Macquarie Generation - www.macgen.com.au

Pacific Power - www.pp.nsw.gov.au

Snowy Hydro Trading Pty Limited - www.snowyhydro.com.au

Snowy Mountains Hydro-Electric Authority - www.snowyhydro.com.au

NT Power and Water Authority - http://www.nt.gov.au/pawa/

CS Energy Limited - www.csenergy.com.au

Ergon Energy - www.ergon.com.au

Stanwell Corporation Limited - www.stanwell.com

Tarong Energy Corporation Limited - www.tarongenergy.com.au

ETSA Power Pty Ltd

ETSA Utilities Pty Ltd
ElectraNet SA - www.etsa.com.au

Synergen Pty Ltd - llewellyn.carol@synergen.com.au

Aurora Energy Pty Ltd - www.auroraenergy.com.au

Transend Networks Pty Ltd - www.transend.com.au

Hydro-Electric Corporation - www.hydro.com.au

Ecogen Energy - www.ecogenenergy.com.au

Hazelwood Power - www.hazelwoodpower.com.au

Yallourn Energy Pty Ltd - www.citysearch.com.au/mel/yallournenergy

Western Power Corporation - www.wpcorp.com.au

Alcoa - http://www.alcoa.com/

CSR - http://www.csr.com.au/

Alcoa World Alumina - http://www.alcoa.com.au/

Anaconda Projects - http://www.anaconda.com.au

Tomago Aluminium - http://www.tomago.com.au/index.html

Comalco - http://www.comalco.com.au/default.htm

Robe River Project - http://www.roberiver.com.au/robe/about.html

PAWA-water - http://www.nt.gov.au/pawa/water.htm

Optima Energy - http://www.optimaenergy.com.au/main/home.asp?fp=about

Chamber of Minerals and Energy – Aluminium
http://www.harvestroad.com.au/~cmealm/page10.html

BHP Annual Report.
http://www.bhp.com.au/

Appendix 5.2

The following document outlines the main Tablo Code modifications made to the original MONASH model. The modifications include the introduction of substitution capacity between the electricity generating industries for greenhouse analysis. The commentary beginning with "SE" is added for explanation of the main theories.

The purpose of the appendix is to allow the reader to gain an understanding of the Tablo Code. The foilowing Code represents a relatively small component of the MONASH-Electricity model. For a full description of the MONASH model refer to Dixon et al (2000).

```
!*************GREENHOUSE EQUATIONS*****************!

File ELECT # Contains all data required to implement this
module#;

Set GAS # Gases to be accounted for #
Read Elements from file ELECT Header "GAS";

SE - CO2

Set FUEL # Gas emitting fuels #
Read Elements from file ELECT Header "FUEL";
Subset FUEL is subset of COM;

SE - C16BlkCoal
     C17bGas
     C17cBrCoal
     C58Petrol

Set ELECSEC # Electricity sectors #
Read Elements from file ELECT Header "ELES";
Subset ELECSEC is subset of COM;

Set ELECSECI # Electricity sectors #
Read Elements from file ELECT Header "ELEI";
Subset ELECSECI is subset of IND;

Set ELECGEN # Electricity generating sectors #
Read Elements from file ELECT Header "ELEG";
Subset ELECGEN is subset of IND;

Set ELECCOM # Electricity generating commodities #
Read Elements from file ELECT Header "ELEC";
Subset ELECCOM is subset of COM;

Set ELECNEM # Electricity supply industry - NEM #
Read Elements from file ELECT Header "ELEN";
Subset ELECNEM is subset of IND;
```

```
SE - I84cElectDist


Set ELECBR # Brown coal Electricity generator #
Read Elements from file ELECT Header "ELEB";
Subset ELECBR is subset of IND;

SE - I84aaaEleBr

Set ELECBASE # Base Electricity Generators #
Read Elements from file ELECT Header "BASE";
Subset ELECBASE is subset of IND;

Set ELECPEAK # Peak Electricity Generators #
Read Elements from file ELECT Header "PEAK";
Subset ELECPEAK is subset of IND;

Set BRGEN # Brown coal electricity Generators #
Read Elements from file ELECT Header "BREG";
Subset BRGEN is subset of IND;

SE - I84aaaaEdis
     I84aaabEBrix
     I84aaacHaz
     I84aaadLoyY
     I84aaaeYall
     I84aaafFlin

Set BRCOM # Brown coal electricity Generators #
Read Elements from file ELECT Header "BRC";
Subset BRCOM is subset of COM;

SE - C86aaaaEdis
     C86aaabEBrix
     C86aaacHaz
     C86aaadLoyY
     C86aaaeYall
     C86aaafFlin


Set NEMCOM # NEM commodity #
Read Elements from file ELECT Header "CNEM";
Subset NEMCOM is subset of COM;


Coefficient
SIGMA_ELEG # Electricity generator substitution elasticity #;

(All,f,FUEL) (All,e,ELECGEN)
SH_FUEL(f,e) # Share of fuel f in total fuel purchases by
generator g #;
```

```
(All,i,ELECCOM) (All,j,ELECNEM)
SH_NEM(i,j) # Share of generator e in total electricity
purchases by NEM #;

SIGMA_ELE # Electricity plant substitution elasticity for
user b #;

(All,i,BRCOM) (All,j,ELECBR)
SH_BR(i,j) # Share of brcoal com in total electricity pur by
elebr #;

SIGMA_FUEL # Fuel substitution elasticity #;

Read
SIGMA_ELEG from file ELECT Header "SIGN";

Read
SIGMA_ELE from file ELECT Header "SIGE";

Read
SIGMA_FUEL from file ELECT Header "SFUL";


Formula
(All,f,FUEL) (All,j,ELECGEN) SH_FUEL(f,j) =
Sum(s,SOURCE,BAS1(f,s,j) + BAS2(f,s,j) + BAS5(f,s)) /
Sum(r,FUEL,Sum(s,SOURCE,BAS1(r,s,j) + BAS2(r,s,j) +
BAS5(r,s)));

(All,i,ELECCOM) (All,j,ELECNEM)
SH_NEM(i,j) = Sum(s,SOURCE,BAS1(i,s,j) + BAS2(i,s,j) +
BAS5(i,s)) /
Sum(r,ELECCOM,Sum(s,SOURCE,BAS1(r,s,j) + BAS2(r,s,j) +
BAS5(r,s)));

(All,i,BRCOM) (All,j,ELECBR)
SH_BR(i,j) = Sum(s,SOURCE,BAS1(i,s,j) + BAS2(i,s,j) +
BAS5(i,s)) /
Sum(r,BRCOM,Sum(s,SOURCE,BAS1(r,s,j) + BAS2(r,s,j) +
BAS5(r,s)));


Coefficient
(all,i,COM) IsELEC(i) # 1 for types of electricity,else 0 #;
(all,j,IND) IsELECDIST(j) # 1 for EndUseElec, else 0 #;
(All,s,SOURCE) IsDOM(s) #1 for domestic, else 0 #;
(All,i,COM) IsELECB(i) # 1 for brcoal gen, else 0 #;
(All,j,IND) IsELECBR(j) # 1 for ElectBr, else 0 #;

Formula
(all,i,COM)      IsELEC(i) = 0.0;
(all,j,IND)      IsELECDIST(j) = 0.0;
```

```
(all,i,ELECCOM) IsELEC(i) = 1.0;
(All,j,ELECNEM) IsELECDIST(j) = 1.0;
(All,s,SOURCE)  IsDOM(s) = 0.0;
                IsDOM("dom") = 1.0;
(All,i,COM)     IsELECB(i) = 0.0;
(All,j,IND)     IsELECBR(j) = 0.0;
(All,i,BRCOM)   IsELECB(i) = 1.0;
(All,j,ELECBR)  IsELECBR(j) = 1.0;


Variable
aelec # ray movement of frontier +ve=efficiency loss #;

pRawElec #ave price to ElectDist of electricity #;

aelec_b # ray movement of frontier +ve=efficiency loss #;

pRawElec_b #ave price to EleBr of electricity #;

pRawFuel #ave price of fuel #;


Variable
(All,i,COM) (All,j,IND)
p1o(i,j) #Price, inputs for current production# ;

Equation E_p1o #Price, inputs for current production #
(All,i,COM) (All,j,IND)
(TINY + TPURCHVAL1(i,j))*p1o(i,j) =
Sum(s,SOURCE,PURCHVAL1(i,s,j)*p1csi(i,s,j)) ;

Equation E_pRawElec
(All,j,ELECNEM)
sum{i,ELECCOM,TPURCHVAL1(i,j)}*pRawElec =
sum{i,ELECCOM,TPURCHVAL1(i,j)*
            p1o(i,j)};

Equation E_pRawElec_b
(All,j,ELECBR)
sum{i,BRCOM,TPURCHVAL1(i,j)}*pRawElec_b =
sum{i,BRCOM,TPURCHVAL1(i,j)*
            p1o(i,j)};

Equation E_pRawFuel
sum{i,FUEL,Sum(j,IND,TPURCHVAL1(i,j))}*pRawFuel =
sum{i,FUEL,Sum(j,IND,TPURCHVAL1(i,j)*
            p1csi(i,"dom",j))};


Variable
(all,i,ELECCOM) (all,s,SOURCE)
 elecprice(i,s) # price to ElectDist of Electricity #;
Equation E_elecprice # price to ElectDist of Electricity #
```

```
(all,i,ELECCOM)(all,s,SOURCE)(All,j,ELECNEM)
 elecprice(i,s) = p1csi(i,s,j) ;

Variable
(all,i,BRCOM)(all,s,SOURCE)
 elecprice_b(i,s) # price to EleBr of Electricity #;
Equation E_elecprice_b # price to EleBr of Electricity #
(all,i,BRCOM)(all,s,SOURCE)(All,j,ELECBR)
 elecprice_b(i,s) = p1csi(i,s,j) ;

Set NONFUEL #COM - FUEL#
Read Elements from file ELECT Header "NFUE";
Subset NONFUEL is subset of COM;
Mapping COM2FUEL from COM to FUEL;
Coefficient (all,i,COM) ISFUEL(i);
Formula
 (all,i,FUEL)     COM2FUEL(i) =  $POS(i);
 (all,i,NONFUEL) COM2FUEL(i) =  1; ! arbitrary!
 (all,i,FUEL)     ISFUEL(i) = 1.0;
 (all,i,NONFUEL) ISFUEL(i) = 0.0;

Equation E_x1csi
  # Demands for intermediate inputs #
  (All,i,COM)(All,s,SOURCE)(All,j,IND)
  x1csi(i,s,j) = z(j)
  - SIGMA1(i) *{ p1csi(i,s,j) -
Sum(t,SOURCE,SOURCE_SHR1(i,t,j)*p1csi(i,t,j)) }
  + a1(j) + a1ci(i,j) +  a1csi(i,s,j)
  - SIGMA1(i) *{ a1csi(i,s,j) -
Sum(t,SOURCE,SOURCE_SHR1(i,t,j)*a1csi(i,t,j)) }
  - { SOURCEDOM(s) - SOURCE_SHR1(i,"dom",j) }*twist_src(i)
  + { 1 - SOURCEDOM(s) }*TRANSERVDUM(i)*f1_trans(j)
  + { 1 - SOURCEDOM(s) }*COMMUNICDUM(i)*f1_commun(j)
+ IsELEC(i)*IsELECDIST(j)*[aelec - SIGMA_ELEG*
(p1o(i,j) - pRawElec)]
+ IsELECB(i)*IsELECBR(j)*[aelec_b - SIGMA_ELE*
(p1o(i,j) - pRawElec_b)];
```

SE - The above equation allows the user of the intermediate input, electricity, to substitute between generators. In the first instance the equation ensures that the commodity is an electricity generator who sells to the I84cElectDist industry. The technology term 'aelec' is exogenous. The equation says that if the price of electricity from a particular generator rises above the average price of electricity from all generators, the electricity distribution industry will substitute away from the use of that commodity. The elasticity of substitution is relatively high. This means that for every one percent rise in the price of EleBr relative to the average price of electricity, I84cElectDist will source five percent less of its electricity from EleBr and five percent more from EleOth for instance.

```
!************New Greenhouse Equations*************!


Set NONELE #COM - ELECCOM#
Read Elements from file ELECT Header "NELE";
Subset NONELE is subset of COM;

Set NONELEB #COM - BRCOM#
Read Elements from file ELECT Header "NELB";
Subset NONELEB is subset of COM;

Mapping COM2ELE from COM to ELECCOM;
Formula
 (all,i,ELECCOM)    COM2ELE(i) =  $POS(i);
 (all,i,NONELE) COM2ELE(i) =  1; ! arbitrary!

Mapping COM2ELEB from COM to BRCOM;
Formula
 (all,i,BRCOM)    COM2ELEB(i) =  $POS(i);
 (all,i,NONELEB) COM2ELEB(i) =  1; ! arbitrary!

File (NEW) Writ ;
Write
(all,i,ELECSEC)(all,s,SOURCE)(all,j,ELECSECI)
 BAS1(i,s,j) to file Writ header "ELC1"
longname "Basic values of intermediate electricity flows";
(all,i,ELECSEC)(all,s,SOURCE)(all,j,ELECSECI)
 PURCHVAL1(i,s,j) to file Writ header "ELC2"
longname "Purchasers values of intermediate electricity
flows";


! Subsection 2.8.5:  Tax rates !

Variable
 (all,i,Fuel)(all,s,SOURCE)(all,j,IND)
 fueltax1(i,s,j) # Percentage change in the power of a tax
user 1#;
 (all,i,Fuel)(all,s,SOURCE)
 fueltax3(i,s) # Percentage change in the power of a tax user
3 # ;
```

SE - fueltax1 is the increase in the power of the tax on industry intermediate users of the fuel commodities. Fueltax3 is the increase in the power of the tax on intermediate usage of the fuel commodities by the household sector of the economy. These variables flow through to represent the tax in percentage change form.

```
Variable
(change)
deltax3comp #compensation component of fpowtax3g, probably
negative#;
```

SE - This variable represents the compensation given back to the household sector of the economy as a reduction in consumption tax. It is used in greenhouse policy analysis for the treatment of revenue recycling. The variable is exogenous under the grandfathering treatment of revenue. Specifically this variable returns tax revenue collected from the tax on usage of intermediate fuels by both industry and the household sector.

```
Variable
(change)
deltax3comp2 #compensation component of fpowtax3g, probably
negative#;
```

SE - This variable returns tax revenue collected from the tax on emissions of CO_2 from electricity generators.

```
Variable
(change)
deltax3comp3 #compensation component of fpowtax3g, probably
negative#;
```

SE - This variable returns tax revenue collected from the tax on emissions of CO_2 from the brown coal electricity generators.

```
Variable
(all,i,ELECCOM)(all,s,SOURCE)(All,j,ELECNEM)
electtax(i,s,j) #Percentage change - power of tax on
intermediate# ;
```

SE - This variable represents the percentage change in the power of the tax on intermediate sales of electricity to the electricity distribution industry.

```
Variable
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
elebrtax(i,s,j) #Percentage change - power of tax on
intermediate# ;
```

SE - This variable represents the percentage change in the power of the tax on intermediate sales of electricity to the brown coal electricity industry.

```
Coefficient
(All,j,IND) IsELECGEN(j) # 1 for elect gen, else 0 #;
(All,j,IND) IsBRGEN(j) # 1 for br elect gen, else 0 #;

Formula
(All,j,IND)      IsBRGEN(j) = 0.0;
(All,j,IND)      IsELECGEN(j) = 0.0;
(All,j,BRGEN)    IsBRGEN(j) = 1.0;
```

```
(All,j,ELECGEN)  IsELECGEN(j) = 1.0;

Set NONELEI #IND - ELECGEN#
Read Elements from file ELECT Header "NELI";
Subset NONELEI is subset of IND;

Mapping IND2ELE from IND to ELECGEN;
Formula
 (all,j,ELECGEN)    IND2ELE(j) =  $POS(j);
 (all,j,NONELEI) IND2ELE(j) =  1; ! arbitrary!

Set NONELEIB #IND - BRGEN#
Read Elements from file ELECT Header "NEIB";
Subset NONELEIB is subset of IND;

Mapping IND2ELEB from IND to BRGEN;
Formula
 (all,j,BRGEN)    IND2ELEB(j) =  $POS(j);
 (all,j,NONELEIB) IND2ELEB(j) =  1; ! arbitrary!

Set NONNEM #IND - ELECNEM#
Read Elements from file ELECT Header "NNEM";
Subset NONNEM is subset of IND;

Mapping IND2NEM from IND to ELECNEM;
Formula
 (all,j,ELECNEM)    IND2NEM(j) =  $POS(j);
 (all,j,NONNEM) IND2NEM(j) =  1; ! arbitrary!

Set NONBR #IND - ELECBR#
Read Elements from file ELECT Header "NBR";
Subset NONBR is subset of IND;

Mapping IND2BR from IND to ELECBR;
Formula
 (all,j,ELECBR)    IND2BR(j) =  $POS(j);
 (all,j,NONBR) IND2BR(j) =  1; ! arbitrary!

! Specification of powers of taxes by commodity, source and
user !

Equation E_powtax1
  # Power of tax on sales to intermediate users #
  (All,i,COM)(All,s,SOURCE)(All,j,IND)
  powtax1(i,s,j) = powtaxgg(i,s) + fpowtax1gg(i,s,j)
  + SOURCEDOM(s)*powtax4sph(i) + powtaxphph(i,s) +
fpowtax1phph(i,s);

Equation E_powtax2
  # Power of tax on sales to capital creators #
  (All,i,COM)(All,s,SOURCE)(All,j,IND)
  powtax2(i,s,j) = powtaxgg(i,s) + fpowtax2gg(i,s)
  + SOURCEDOM(s)*powtax4sph(i) + powtaxphph(i,s) +
```

```
fpowtax2phph(i,s);

Equation E_powtax3
  # Power of tax on sales to consumers #
  (All,i,COM) (All,s,SOURCE)
  powtax3(i,s) = powtaxgg(i,s) + fpowtax3g(i,s) +
powtax3vg(i)+ SOURCEDOM(s)*powtax4sph(i) + powtaxphph(i,s) +
fpowtax3ph(i,s);

Equation E_powtax4
  # Power of tax on exports #
  (All,i,COM)
  powtax4(i) = powtax4g(i) + powtax4sph(i) + powtax4ph(i);

Equation E_powtax5
  # Power of tax on sales to government users #
  (All,i,COM) (All,s,SOURCE)
  powtax5(i,s) = powtaxgg(i,s) + fpowtax5g(i,s)
  + SOURCEDOM(s)*powtax4sph(i) + powtaxphph(i,s) +
fpowtax5ph(i,s);
```

SE - The above equations play an important role as the increase in the price of electricity flows through the variable fpowtax1gg and fpowtax3g to increase the power of the tax.

```
Variable
  (All,i,COM) (All,s,SOURCE)
f_powtaxgg(i,s);
powtaxggu;
  (All,i,COM) (All,s,SOURCE)
ff1_ptaxgg(i,s);
  (All,i,COM) (All,s,SOURCE)
ff2_ptaxgg(i,s);
  (All,i,COM) (All,s,SOURCE)
ff3_ptaxg(i,s);
  (All,i,COM) (All,s,SOURCE)
ff5_ptaxg(i,s);

Equation E_powtaxgg
  (All,i,COM) (All,s,SOURCE)
  powtaxgg(i,s) = powtaxggu + f_powtaxgg(i,s);

Equation E_fpowtax1gg
  (All,i,COM) (All,s,SOURCE) (All,j,IND)
  fpowtax1gg(i,s,j) = powtaxggu + ff1_ptaxgg(i,s)
+ IF(ISFUEL(i) ne 0,ISFUEL(i)*fueltax1(COM2FUEL(i),s,j))
   + ISELEC(i) *IsELECDIST(j)
*electtax(COM2ELE(i),s,IND2NEM(j))
+ ISELECB(i) *IsELECBR(j) *elebrtax(COM2ELEB(i),s,IND2BR(j));
```

SE - The alterations to the above equation included a provision that if the commodity was one of the fuels, the fueltax1 would be added to the other power of tax variables. The same rule applies to the electricity generating sectors. The reason for fueltax1 appearing in this equation rather than E_powtax1 is due to the need for the greenhouse tax to be treated as a genuine tax, and not a phantom tax.

```
Equation E_fpowtax2gg
  (All,i,COM)(All,s,SOURCE)
  fpowtax2gg(i,s) = powtaxggu + ff2_ptaxgg(i,s);

Coefficient
  (All,i,COM)(All,s,SOURCE)
DBAS(i,s) #Used to avoid dividing by zero# ;

Formula
  (All,i,COM)(All,s,SOURCE)
DBAS(i,s) = 0.0 + IF(BAS3(i,s) ne 0, BAS3(i,s)/
(BAS3(i,s) + TAX3(i,s)));
```

SE - DBAS is used to convert the variable deltax3comp from a change (really a percentage change) to a power variable. POW = 1+T.

```
Equation E_fpowtax3g
  (All,i,COM)(All,s,SOURCE)
  fpowtax3g(i,s) = powtaxggu + ff3_ptaxg(i,s)
+IF(ISFUEL(i) ne 0,ISFUEL(i)*fueltax3(COM2FUEL(i),s))
+ [DBAS(i,s)* deltax3comp]
+ [DBAS(i,s)* deltax3comp2]
+ [DBAS(i,s)* deltax3comp3];
```

SE - Increase in the genuine power of the tax on intermediate usage of the fuel commodities by households. There are two parts to this equation. The first part is the tax imposed on households. The second part relates to the reduction in the consumption tax. If the Government decides to recycle the tax revenue back into the economy via a reduction in the consumption tax paid by households, this variable will be used.

```
Equation E_fpowtax5g
  (All,i,COM)(All,s,SOURCE)
  fpowtax5g(i,s) = powtaxggu + ff5_ptaxg(i,s);
```

```
Equation E_z
  # Zero pure profits in production #
  (All,j,IND)
  p0ind(j) =  a(j) +
  [1/COSTS(j)]*{Sum(i,COM, Sum(s,SOURCE,
PURCHVAL1(i,s,j)*p1csi(i,s,j)))
                 + Sum(m,OCC, LABOCCIND(m,j)*c1laboi(m,j))
                 + CAPITAL(j)*p1cap(j)
                 + LAND(j)*p1land(j)
                 + 100*ROTHCOST(j)*del_ploct(j) }
 +   IsELECDIST(j)*sum(i,ELECCOM,TPURCHVAL1(i,j)*aelec);
```

```
Variable (change)
TAXDivert
  # indirect tax revenue diverted from Govt #;
```

SE - The variable taxdivert is used in the case where the Government decides to grandfather the tax revenue to the owners of the firms. Taxdivert is equal to the revenue collected from the greenhouse tax. This specific variable relates to revenue collected from the tax imposed on CO_2 emissions released during the intermediate usage of a fuel.

```
Variable (change)
TAXDivert2
  # indirect tax revenue diverted from Govt #;
```

SE - Taxdivert2 is equal to the revenue collected from the tax imposed on CO_2 emissions released from the electricity generators.

```
Variable (change)
TAXDivert3
  # indirect tax revenue diverted from Govt #;
```

SE - Taxdivert3 is equal to the revenue collected from the tax imposed on CO_2 emissions released from the brown coal electricity generators.

```
Coefficient
HOUS_DIS_INC # Household disposable income #;
```

```
Equation E_taxind
  # Aggregate value of indirect taxes #
  AGGTAX*taxind = AGGTAX1*taxrev1 + AGGTAX2*taxrev2 +
AGGTAX3*taxrev3
  + 100*del_tot_tax4 + 100*del_tot_tax5 + AGGTAXM*taxrevm
-100*TAXDivert - 100*TAXDivert2 - 100*TAXDivert3;
```

SE - This equation already existed in the MONASH code, however it has been modified to include the Taxdivert variables. The taxdivert variables are taken away from the value of indirect taxes as this money is returned to the household sector as an increase in household disposable income. The revenue collected from the tax is already implicitly included in the calculation of aggregate indirect taxes through the variables taxrev1 and taxrev3. If the revenue is recycled through the economy as a reduction in consumption tax, it is included in this equation as a lower value of taxrev3 than would be the case under the grandfathered method.

```
Equation E_gdpinc
  # Nominal GDP from income side #
  GDPIN*gdpinc = AGGLND*lndrev + AGGCAP*caprev +
AGGLAB*labrev
  + AGGOCT*octrev + AGGTAX*taxind
+100*TAXDivert + 100*TAXDivert2 + 100*TAXDivert3;


Variable
     (all,i,COM)(all,j,IND)
 agreen(i,j) # general intermediate substitution term #;


Equation E_alci
  (All,i,COM)(All,j,IND)
  alci(i,j) = ac(i) + falc(i) + falci(i,j) + agreen(i,j);
```

SE - The variable agreen is used to facilitate substitution between the usage of commodities as intermediate inputs. If the price of an intermediate input rises relative to the average price of all intermediate inputs, the industry is able to substitute away from using the more expensive input and replace it with more labour, capital or another intermediate input. It is included in E_alci to represent input saving technical change in current production.

```
Set FinalUser # Household user of fuel #
Read Elements from file ELECT Header "RESD";

Set FuelUser # IND plus Household users of fuel #
!FuelUser= IND union FinalUser;!
Read Elements from file ELECT Header "FUSR";
Subset IND is subset of FuelUser;
Subset FinalUser is subset of FuelUser;

Coefficient
 (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
  QGAS(i,s,u) # emissions matrix #;
```

SE - main database of CO_2 emissions per dollar of fuel usage. There are no emissions of brown coal. There are no emissions from I84EleBlk from the use of C16BlkCoal. There are no emissions from I84EleGas from the use of C17bGas.

```
Variable
 (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
  xgas(i,s,u) # full % change emissions matrix #;
Read  QGAS from file ELECT Header "QGAS";
Update
 (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
  QGAS(i,s,u) = xgas(i,s,u);

Coefficient ENERINDEX # price to which gas tax is indexed #;
Variable    gastaxindex # price to which gas tax is indexed
#;
Read        ENERINDEX from file ELECT Header "ENDX";
Update      ENERINDEX = gastaxindex;
Equation E_gastaxindex # price to which gas tax is indexed #
gastaxindex = xi3;

Coefficient       (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
   ETAXRATE(i,s,u) # specific rate of new energy tax #;
Variable (change) (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
  delgastax(i,s,u) # specific tax on emissions #;
Read ETAXRATE from file ELECT Header "ETXR";
Update (change) (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
  ETAXRATE(i,s,u) = delgastax(i,s,u);
```

SE -- The variable delgastax is the shocked variable. The shock of 0.05 means that a tax equivalent to $50 per tonne of CO_2 emitted is imposed. The shocked variable is on emissions from the use of C16BlkCoal, C17bGas and C58Petrol.

```
![[!
Formula
(all,i,FUEL)(all,s,SOURCE)(all,j,IND)
ETAXRATE(i,s,j) = BAS1(i,s,j) * (TAX1(i,s,j)/BAS1(i,s,j))/
   QGAS(i,s,j) * ENERINDEX;!]]!

Coefficient (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
     ETAX(i,s,u) # revenue from new energy tax #;
Read ETAX from file ELECT Header "ETAX";
Update (Change)
 (all,i,FUEL)(all,s,SOURCE)(all,u,FuelUser)
ETAX(i,s,u)= ENERINDEX*QGAS(i,s,u)*delgastax(i,s,u)
             + ETAX(i,s,u)*0.01*[xgas(i,s,u)+gastaxindex];
![[!
formula   ETAX(f,s,u,q)=
ETAXRATE(f,s,u,q)*QGAS(f,s,u,q)*ENERINDEX;
 ordinary change is:    SEI(s+e+i)/100
                   =    SEI.s/100 + SEI(e+i)/100
```

```
                    =   EI.delS + SEI(e+i)/100
where SEI is ETAX and EI is ENERINDEX*QGAS !]]!

Coefficient TAX3COMP;
Read TAX3COMP from file ELECT Header "COMP";
Update (Change)
 TAX3COMP = 0.01*deltax3comp;

Variable
(change)  deletaxrv # ordinary change in energy tax revenue
#;

Variable
 (change) fTAXDivert # shifter for gas tax diversion #;
Equation E_TAXDivert # equation to divert gas tax from Govt #
TAXDivert = deletaxrv+ fTAXDivert;

Variable
(change) delcomp3 # ordinary change in compensation tax
revenue #;
Equation E_delcomp3
delcomp3 =
Sum{i,COM, Sum{s,SOURCE,
 BAS3(i,s)*0.01*[deltax3comp + TAX3COMP*[x3cs(i,s)+p0(i,s)]]
}};
```

SE - This equation determines the value for deltax3comp or how much needs to be returned to consumers as a reduction in their consumption tax. The variable delcomp3 is determined in the following equation to be equal to the revenue collected from the greenhouse tax. This revenue is then redistributed across the household sector. The equation is only operational when the Government adopts revenue recycling.

```
Variable
(change) fcomp3 # % change in compensation tax revenue #;
Equation E_deltax3comp # give energy tax back as consumption
subsidy #
delcomp3 = - deletaxrv + fcomp3;

![[! Equation
E_fueltax1 # specific fuel tax rate user 1 #
 (all,i,FUEL)(all,s,SOURCE)(all,j,IND)
100 * delgastax(i,s,j)/ETAXRATE(i,s,j) + xgas(i,s,j) +
gastaxindex =
p0(i,s) + x1csi(i,s,j) + fueltax1(i,s,j)*((BAS1(i,s,j) +
TAX1(i,s,j))
/BAS1(i,s,j)) * (BAS1(i,s,j)/TAX1(i,s,j));!]]!

Coefficient
(all,i,FUEL)(all,s,SOURCE)(all,j,FuelUser)
ETAXRATE_Z(i,s,j) #Used to avoid dividing by zero# ;
```

```
Formula
(all,i,FUEL)(all,s,SOURCE)(all,j,FuelUser)
ETAXRATE_Z(i,s,j) = 0.0+
IF(ETAXRATE(i,s,j)>0.0000001, 100/ETAXRATE(i,s,j));

Coefficient
(all,i,FUEL)(all,s,SOURCE)(all,j,FuelUser)
SEI(i,s,j) #Specific tax times CO2 emissions# ;

Formula
(all,i,FUEL)(all,s,SOURCE)(all,j,FuelUser)
SEI(i,s,j) = ETAXRATE(i,s,j)*QGAS(i,s,j)*ENERINDEX ;

Coefficient
(all,i,FUEL)(all,s,SOURCE)(all,j,IND)
TBAS(i,s,j) #Used to avoid dividing by zero# ;

Zerodivide Default 1;

Formula
(all,i,FUEL)(all,s,SOURCE)(all,j,IND)
TBAS(i,s,j) = (BAS1(i,s,j) + SEI(i,s,j)/
SEI(i,s,j));

Zerodivide off;

Coefficient
(all,i,FUEL)(all,s,SOURCE)(all,j,FinalUser)
TBASH(i,s,j) #Used to avoid dividing by zero# ;

Zerodivide Default 1;
Formula
(all,i,FUEL)(all,s,SOURCE)(all,j,FinalUser)
TBASH(i,s,j) = (BAS3(i,s) + SEI(i,s,j)/
SEI(i,s,j));

Zerodivide off;

Equation
E_fueltax3
(all,i,FUEL)(all,s,SOURCE)
        fueltax3(i,s) =
Sum(j,FinalUser,[TBASH(i,s,j)
*[(ETAXRATE_Z(i,s,j)*delgastax(i,s,j))
 + (xgas(i,s,j) + gastaxindex - p0(i,s) - x3cs(i,s))]]) ;
!]]!


![[!
! The equations below replace
E_fueltax1
E_fueltax3
```

```
E_deletaxrv.

There is a new header array element - TREV.
Initially this contains just zeros !]]!

Coefficient
(All,i,FUEL)(All,s,SOURCE)(All,j,FuelUser)
TaxRev(i,s,j);

Read TaxRev from file ELECT header "TREV";
Variable
(change)(All,i,FUEL)(All,s,SOURCE)(All,j,FuelUser)
del_TaxRev(i,s,j)  # Revenue from emissions tax on fuel i
from s to user j #;
Update
(change)(All,i,FUEL)(All,s,SOURCE)(All,j,FuelUser)
TaxRev(i,s,j) = del_TaxRev(i,s,j);

Coefficient
(all,i,FUEL)(all,s,SOURCE)(all,j,FuelUser)
TXRV(i,s,j) #Used to avoid dividing by zero# ;

Formula
 (all,i,FUEL)(all,s,SOURCE)(all,j,FuelUser)
TXRV(i,s,j) = TaxRev(i,s,j)/100;

Variable
(All,i,FUEL)(All,s,SOURCE)(All,j,IND)
ffueltax1(i,s,j) #Shifter to allow fueltax1 to be zero for
C16Blkcoal#;

Equation
E_fueltax1
(All,i,FUEL)(All,s,SOURCE)(All,j,IND)
del_TaxRev(i,s,j) = (0.0001+BAS1(i,s,j)+TaxRev(i,s,j))/100 *
    (fueltax1(i,s,j) + ffueltax1(i,s,j)) +
                              (TaxRev(i,s,j)/100) *(p0(i,s) +
x1csi(i,s,j));
```

SE - This equation is written in the format above to solve for the variable fueltax1. The variable del_TaxRev is the change in total revenue collected from imposing a tax on CO_2 emissions from the usage of fuels as intermediate inputs. With the value for del_TaxRev known, the rest of the equation solves the value for fueltax1 for each fuel from each source across all industries. The equation is established in this way to ensure that the revenue collected by the Government is equal to the revenue redistributed by the Government throughout the economy.

```
E_fueltax3
(All,i,FUEL)(All,s,SOURCE)(All,j,FinalUser)
del_TaxRev(i,s,j) = (0.0001+BAS3(i,s)+TaxRev(i,s,j))/100 *
```

```
fueltax3(i,s) + (TaxRev(i,s,j)/100) *(p0(i,s) + x3cs(i,s));

E_delTaxRev
(All,i,FUEL)(All,s,SOURCE)(All,j,FuelUser)
del_TaxRev(i,s,j) = (QGAS(i,s,j)*ENERINDEX) *
delgastax(i,s,j) +
                    (TaxRev(i,s,j)/100)     * (xgas(i,s,j) +
gastaxindex);
```

SE - This equation calculates the tax revenue. It multiplies the emissions of CO_2 by the shock in question.

```
E_deletaxrv
deletaxrv =
Sum(i,Fuel,Sum(s,Source,Sum(j,FuelUser,del_TaxRev(i,s,j))));
```

SE - This equation ensures that the revenue collected is equal to the revenue redistributed by the Government.

```
Coefficient
(All,i,ELECCOM)(All,s,SOURCE)(All,j,ELECNEM)
MWH(i,s,j) # MWh generated by electricity producer j #;

(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
MWHB(i,s,j) # MWh generated by brown coal electricity
producer j #;


Read
MWH from file ELECT Header "MWH";

MWHB from file ELECT Header "MWHB";

Coefficient
(All,i,ELECCOM)
C_CO2(i) # Emissions of CO2 - tonnes/MWh #;

SE - 1.33
     0.90
     0.68
     0
     0

Read
C_CO2 from file ELECT Header "CO2E";
```

```
Coefficient
(All,i,BRCOM)
C_CO2B(i) # Emissions of CO2 - tonnes/MWh #;

SE - 1.25
     1.50
     1.46
     1.26
     1.37
     1.16

Read
C_CO2B from file ELECT Header "CO2B";

Variable
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
q_co2b(i,s,j) # Emissions of CO2 #;

Coefficient
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
QCO2B(i,s,j) #Total CO2 emitted from br elect gen# ;

SE - The emissions from the brown coal generators is based on
the market share of the industry (sales of electricity to
I84cElecDist), multiplied by the emission intensity
coefficient.

Read
QCO2B from file ELECT Header "QO2B";

Update
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
QCO2B(i,s,j) = q_co2b(i,s,j);

Variable
(All,i,ELECCOM)(All,s,SOURCE)(All,j,ELECNEM)
v_mwh(i,s,j) # mwh generated #;

Update
(All,i,ELECCOM)(All,s,SOURCE)(All,j,ELECNEM)
MWH(i,s,j) = v_mwh(i,s,j);

Variable
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
v_mwhb(i,s,j) # mwh generated #;

Update
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
MWHB(i,s,j) = v_mwhb(i,s,j);

Variable (change)
(All,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
delgastax2(i,s,j) #tax on elect emissions, to be shocked# ;
```

```
Coefficient  (All,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
   ETAXRATE2(i,s,j) # specific rate of new energy tax #;
Read ETAXRATE2 from file ELECT Header "ETX2";
Update (change) (All,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
  ETAXRATE2(i,s,j) = delgastax2(i,s,j);

Coefficient
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
ETAXRATE_Z2(i,s,j) #Used to avoid dividing by zero# ;

Formula
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
ETAXRATE_Z2(i,s,j) = 0.0+
IF(ETAXRATE2(i,s,j)>0.0000001, 100/ETAXRATE2(i,s,j));


Variable
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
q_co2(i,s,j) # Emissions of CO2 #;

Coefficient
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
QCO2(i,s,j) #Total CO2 emitted from elect gen# ;

Read
QCO2 from file ELECT Header "QCO2";

Update
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
QCO2(i,s,j) = q_co2(i,s,j);

Coefficient
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
SEIG(i,s,j) #Specific tax times CO2 emissions# ;

Formula
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
SEIG(i,s,j) = ETAXRATE2(i,s,j)*QCO2(i,s,j)*ENERINDEX ;

Coefficient
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
TBAS2(i,s,j) #Used to avoid dividing by zero# ;

Formula
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
TBAS2(i,s,j) = 0.0+
IF(SEIG(i,  j) ne 0, SEIG(i,s,j)/
(BAS1(i,s,j) + SEIG(i,s,j)));
```

```
Coefficient
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
TaxRevE(i,s,j);

Read TaxRevE from file ELECT header "TRV2";
Variable
(change)(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
del_TaxRev2(i,s,j)# Revenue from emissions tax on fuel i from
s to user j #;
Update
(change)(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
TaxRevE(i,s,j) = del_TaxRev2(i,s,j);

Variable
(change)  deletaxrv2 # ordinary change in energy tax revenue
#;

Equation
E_electtax
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
del_TaxRev2(i,s,j) = (0.0001+BAS1(i,s,j)+TaxRevE(i,s,j))/100
* electtax(i,s,j)
                      +   (TaxRevE(i,s,j)/100) *(p0(i,s) +
x1csi(i,s,j));
```

SE - this equation is identical in structure to E_fueltax1 however it applies to the electricity generators.

```
E_delTaxRev2
(all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
del_TaxRev2(i,s,j) = (QCO2(i,s,j)*ENERINDEX) *
delgastax2(i,s,j) +
                    (TaxRevE(i,s,j)/100) * (q_co2(i,s,j) +
gastaxindex);

E_deletaxrv2
deletaxrv2 =
Sum(i,ELECCOM,Sum(s,Source,Sum(j,ELECNEM,del_TaxRev2(i,s,j)))
);



Variable (change)
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
delgastax3(i,s,j) #tax on electBR emissions, to be shocked# ;

Coefficient  (All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
   ETAXRATE3(i,s,j) # specific rate of new energy tax #;
Read ETAXRATE3 from file ELECT Header "ETX3";
Update (change)  (All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
  ETAXRATE3(i,s,j) = delgastax3(i,s,j);
```

```
Coefficient
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
ETAXRATE_Z3(i,s,j) #Used to avoid dividing by zero# ;

Formula
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
ETAXRATE_Z3(i,s,j) = 0.0+
IF(ETAXRATE3(i,s,j)>0.0000001, 100/ETAXRATE3(i,s,j));


Coefficient
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
SEIB(i,s,j) #Specific tax times CO2 emissions# ;

Formula
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
SEIB(i,s,j) = ETAXRATE3(i,s,j)*QCO2B(i,s,j)*ENERINDEX ;

Coefficient
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
TBAS3(i,s,j) #Used to avoid dividing by zero# ;

Formula
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
TBAS3(i,s,j) = 0.0+
IF(SEIB(i,s,j) ne 0, SEIB(i,s,j)/
(BAS1(i,s,j) + SEIB(i,s,j)));


Coefficient
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
TaxRevB(i,s,j);

Read TaxRevB from file ELECT header "TRV3";
Variable
(change)(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
del_TaxRev3(i,s,j)# Revenue from emissions tax on fuel i from
s to user j #;
Update
(change)(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
TaxRevB(i,s,j) = del_TaxRev3(i,s,j);

Variable
(change)  deletaxrv3 # ordinary change in energy tax revenue
#;

Equation
E_elebrtax
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
del_TaxRev3(i,s,j) = (0.0001+BAS1(i,s,j)+TaxRevB(i,s,j))/100
* elebrtax(i,s,j) +   (TaxRevB(i,s,j)/100) *(p0(i,s) +
x1csi(i,s,j));
```

```
E_delTaxRev3
(all,i,BRCOM)(all,s,SOURCE)(all,j,ELECBR)
del_TaxRev3(i,s,j) = (QCO2B(i,s,j)*ENERINDEX) *
delgastax3(i,s,j) + (TaxRevB(i,s,j)/100) * (q_co2b(i,s,j) +
gastaxindex);

E_deletaxrv3
deletaxrv3 =
Sum(i,BRCOM,Sum(s,Source,Sum(j,ELECBR,del_TaxRev3(i,s,j))));


Coefficient (all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
     ETAX2(i,s,j) # revenue from new energy tax #;
Read ETAX2 from file ELECT Header "TAX2";
Update (Change)
 (all,i,ELECCOM)(all,s,SOURCE)(all,j,ELECNEM)
ETAX2(i,s,j)= QCO2(i,s,j)*ENERINDEX*delgastax2(i,s,j)
     +  ETAX2(i,s,j)*0.01*[q_co2(i,s,j)+gastaxindex];


Coefficient TAX3COMP2 ;
Read TAX3COMP2 from file ELECT Header "CMP2";
Update (Change)
 TAX3COMP2 = 0.01*deltax3comp2;


Variable
 (change) fTAXDivert2 # shifter for gas tax diversion #;
Equation E_TAXDivert2 # equation to divert gas tax from Govt
#
TAXDivert2 = deletaxrv2+ fTAXDivert2;

Variable
(change) delcomp32 # ordinary change in compensation tax
revenue #;
Equation E_delcomp32
delcomp32 =
Sum{i,COM, Sum{s,SOURCE,
 BAS3(i,s)*0.01*[deltax3comp2 +
TAX3COMP2*[x3cs(i,s)+p0(i,s)]] }};

Variable
(change) fcomp32 # % change in compensation tax revenue #;
Equation E_deltax3comp2 # gives energy tax back as
consumption subsidy #
delcomp32 = - deletaxrv2 + fcomp32;
```

```
Coefficient (All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
    ETAX3(i,s,j) # revenue from new energy tax #;
Read ETAX3 from file ELECT Header "TAX3";
Update (Change)
 (All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
ETAX3(i,s,j)= QCO2B(i,s,j)*ENERINDEX*delgastax3(i,s,j)
   +  ETAX3(i,s,j)*0.01*[q_co2b(i,s,j)+gastaxindex];


Coefficient TAX3COMP3 # ad valorem rate of compensation: not
% points #;
Read TAX3COMP3 from file ELECT Header "CMP3";
Update (Change)
 TAX3COMP3 = 0.01*deltax3comp3;


Variable
 (change) fTAXDivert3 # shifter for gas tax diversion #;
Equation E_TAXDivert3 # equation to divert gas tax from Govt
#
TAXDivert3 = deletaxrv3+ fTAXDivert3;

Variable
(change) delcomp33 # ordinary change in compensation tax
revenue #;
Equation E_delcomp33
delcomp33 =
Sum{i,COM, Sum{s,SOURCE,
 BAS3(i,s)*0.01*[deltax3comp3 +
TAX3COMP3*[x3cs(i,s)+pu(i,s)]] }};

Variable
(change) fcomp33 # % change in compensation tax revenue #;
Equation E_deltax3comp3 # gives energy tax back as
consumption subsidy #
delcomp33 = - deletaxrv3 + fcomp33;


Coefficient
MWH_TOTAL #Total MWH generated by Electgen # ;

Formula
MWH_TOTAL =
Sum{i,ELECCOM,Sum{s,SOURCE,Sum(j,ELECNEM,MWH(i,s,j))}};

Variable
v_mwhtot # total % change in mwh #;
```

```
Equation
E_v_mwhtot
MWH_TOTAL * v_mwhtot = Sum{i,ELECCOM,Sum{s,SOURCE,
   Sum(j,ELECNEM,MWH(i,s,j)*v_mwh(i,s,j))}};


Coefficient
MWHB_TOTAL #Total MWH generated by BRGEN # ;

Formula
MWHB_TOTAL =
Sum{i,BRCOM,Sum{s,SOURCE,Sum(j,ELECBR,MWHB(i,s,j))}};

Variable
v_mwhbtot # total % change in mwh #;

Equation
E_v_mwhbtot
MWHB_TOTAL * v_mwhbtot = Sum{i,BRCOM,Sum{s,SOURCE,
    Sum(j,ELECBR,MWHB(i,s,j)*v_mwhb(i,s,j))}};


Equation ! equations explaining emissions !
E_q_co2G # intermediate % change emissions matrix #
(All,i,ELECCOM)(All,s,SOURCE)(All,j,ELECNEM)
q_co2(i,s,j) = IF(QCO2(i,s,j) ne 0,x1csi(i,s,j));
```

SE - This equation states that the percentage change in the quantity of CO_2 emissions moves in line with the percentage change in demands for inputs to current production. This means that if the demand for C86EleBr falls, its quantity of emissions will also fall.

```
Equation ! equations explaining emissions !
E_q_mwhG # intermediate % change emissions matrix #
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
q_co2b(i,s,j) = IF(QCO2B(i,s,j) ne 0,x1csi(i,s,j));

Equation ! equations explaining emissions !
E_v_mwhG # intermediate % change emissions matrix #
(All,i,ELECCOM)(All,s,SOURCE)(All,j,ELECNEM)
v_mwh(i,s,j) = IF(MWH(i,s,j) ne 0,x1csi(i,s,j));

Equation ! equations explaining emissions !
E_v_mwhbG # intermediate % change emissions matrix #
(All,i,BRCOM)(All,s,SOURCE)(All,j,ELECBR)
v_mwhb(i,s,j) = IF(MWHB(i,s,j) ne 0,x1csi(i,s,j));


Coefficient
(all,j,FuelUser) IsRES(j) # 1 for HH, else 0 #;
```

```
Formula
(all,j,FuelUser)     IsRES(j) = 0.0;
(All,j,FinalUser) IsRES(j) = 1.0;


Coefficient
     (all,i,COM)(all,j,IND)
sigmagreen(i,j)
# general intermediate substitution elasticity, expect
positive around 0.25 #;
Read sigmagreen from file ELECT header "SGRN";

Equation E_agreen # general intermediate substitution term #
     (all,i,COM)(all,j,IND)
 agreen(i,j) =  - sigmagreen(i,j)*[plo(i,j)- p0ind(j)];


Equation ! equations explaining emissions !
E_xgasA # intermediate % change emissions matrix #
 (all,f,FUEL)(all,s,SOURCE)(all,j,IND)
  xgas(f,s,j) = xlcsi(f,s,j);
```

SE - The percentage change in the quantity of emissions from a fuel source moves in line with demand for that commodity by industry.

```
E_xgasC # household % change emissions matrix #
 (all,f,FUEL)(all,s,SOURCE)(All,j,FinalUser)
  xgas(f,s,j) = x3cs(f,s);



! Addup over source !
Coefficient (all,f,FUEL)(all,u,FuelUser)
  QGAS_S(f,u) # emissions summed over source #;
Formula     (all,f,FUEL)(all,u,FuelUser)
  QGAS_S(f,u) = Sum{s,SOURCE, QGAS(f,s,u)};
Variable    (all,f,FUEL)(all,u,FuelUser)
  xgas_s(f,u) # % change emissions matrix summed over source
#;
Equation E_xgas_s # % change emissions matrix summed over
source #
 (all,f,FUEL)(all,u,FuelUser)
   [TINY+QGAS_S(f,u)]*xgas_s(f,u)=
     Sum{s,SOURCE, QGAS(f,s,u)*xgas(f,s,u)};

! more addups over fuel, and user!

Coefficient
 (all,u,FuelUser) QGAS_SF(u) # emissions #;
 (all,f,FUEL)    QGAS_SU(f) # emissions #;
 (all,f,FUEL)(all,u,FuelUser)   QGAS_SQ(f,u) # emissions #;
```

```
Formula
 (all,u,FuelUser) QGAS_SF(u) = Sum{f,FUEL,QGAS_S(f,u)};
 (all,f,FUEL)    QGAS_SU(f) = Sum{u,FuelUser, QGAS_S(f,u)};
 (all,f,FUEL)(all,u,FuelUser)    QGAS_SQ(f,u) =  QGAS_S(f,u);

Variable
 (all,u,FuelUser) xgas_sf(u) # emissions #;
 (all,f,FUEL)     xgas_su(f) # emissions #;
 (all,f,FUEL)(all,u,FuelUser)    xgas_sq(f,u) # emissions #;

Equation E_xgas_sf # emissions matrix #
 (all,u,FuelUser)
  [TINY+QGAS_SF(u)]*xgas_sf(u)=
        Sum{f,FUEL, QGAS_S(f,u)*xgas_s(f,u)};

Equation E_xgas_su # emissions matrix #
 (all,f,FUEL)
  [TINY+QGAS_SU(f)]*xgas_su(f)=
      Sum{u,FuelUser, QGAS_S(f,u)*xgas_s(f,u)};

Equation E_xgas_sq # emissions matrix #
 (all,f,FUEL)(all,u,FuelUser)
  [TINY+QGAS_SQ(f,u)]*xgas_sq(f,u)=
        QGAS_S(f,u)*xgas_s(f,u);

! vector addups !
Variable
 (all,u,FuelUser) xgasUser(u) # emissions #;

 (all,f,FUEL)    xgasFuel(f) # emissions #;

Coefficient
 (all,u,FuelUser) QGASUser(u) # emissions #;

 (all,f,FUEL)    QGASFUEL(f) # emissions #;

Formula
 (all,u,FuelUser) QGASUser(u) = Sum{f,FUEL, QGAS_SQ(f,u)};

 (all,f,FUEL)    QGASFUEL(f) = QGAS_SU(f);

Equation E_xgasUser  (all,u,FuelUser)
[TINY+QGASUser(u)]*xgasuser(u)= Sum{f,FUEL,
QGAS_SQ(f,u)*xgas_sq(f,u)};


Equation E_xgasFuel (all,f,FUEL)
[TINY+QGASFUEL(f)]*xgasFuel(f)= QGAS_SU(f)*xgas_su(f);

! total addup !
Variable
  xgasTot # emissions total #;
```

```
Equation E_xgasTot
0=Sum{u,FuelUser,QGASUser(u)*[xgastot - xgasuser(u)]};


Coefficient
(all,f,FUEL)(all,s,SOURCE)(all,j,FuelUser)
 FUELUSE(f,s,j) # value of fuel use #;
Formula
 (all,f,FUEL)(all,s,SOURCE)(all,j,IND)
  FUELUSE(f,s,j) =  BAS1(f,s,j);
 (all,f,FUEL)(all,s,SOURCE)(All,j,FinalUser)
  FUELUSE(f,s,j) =   BAS3(f,s);

Coefficient AllGasTax # totals emissions tax revenue#;
Formula AllGasTax =
Sum{f,FUEL, Sum{s,SOURCE, Sum {u,FuelUser,
   ETAX(f,s,u) }}};


Coefficient
GasTaxOvrGDP # emissions tax revenue as fraction of GDP #;
Formula GasTaxOvrGDP = AllGasTax/GDPEX;

FILE (NEW) GasSumry
  #  output file for gas results #;
Write
 QCO2 to file GasSumry Header "QCO2";
 QCO2B to file GasSumry Header "QCOB";
 ETAX to file GasSumry Header "ETAX";
 ENERINDEX to file GasSumry Header "ENDX";
 QGAS to file GasSumry Header "QGAS";
 FuelUse to file GasSumry Header "FUSE";
AllGasTax to file GasSumry Header "GTAX";
GasTaxOvrGDP to file GasSumry Header "TRAT";
TaxRev to file GasSumry Header "TXRV";


!************End of Greenhouse Equations********************!
```

CHAPTER SIX

THE ECONOMIC IMPACT UPON THE AUSTRALIAN ECONOMY OF GREENHOUSE POLICY

6.1 INTRODUCTION

This chapter explains the results of a simulation to predict how greenhouse policy implemented at the macroeconomic level impacts upon the Australian economy. Particular attention is paid to the implications of greenhouse policy on the electricity sector. Regional results such as those for the La Trobe Valley are also given focus.

Chapter six contains a further five sections. Section 6.2 recounts the alternative greenhouse options currently being reviewed by the Australian Government. Market based policy mechanisms will be explored in this section. The treatment of the greenhouse policy revenue is outlined in Section 6.3.

Section 6.4 reviews aspects of simulation design, including closure and the basecase simulation. Section 6.5 provides an overview of the grandfathering and auctioning policy simulations that have been modelled. The simulation shocks are also explored in this section.

The results of the grandfathering simulation are reported in Section 6.6. Included in Section 6.6.1 are the macroeconomic results and industry results. This is followed by a discussion of the results for the States of Australia and the statistical divisions.

The results of the second simulation where the permits are auctioned are reported in Section 6.7. The macroeconomic and industry results are discussed initially. The impact of these results upon the states and statistical divisions are then explored. The results for the auctioned simulation are expressed as differences from the grandfathered results.

6.2 GREENHOUSE POLICY

As discussed in Chapter three, to date the Australian Government is yet to formulate its greenhouse policy. The two most likely policy instruments are a tax on emissions per tonne of CO_2 or the establishment of a domestic emissions trading market.

If the Australian Government decides to establish a market for emissions trading, it needs to address the issue of how domestic permits are to be allocated. Under the grandfathering method, the available permits are issued to those firms who are currently emitting CO_2 on a pro-rata basis free of charge.

A separate permit allocation option available to the Government is to auction the permits. The advantage of this method is that the sale of the permits would represent greenhouse revenue to the Government.[106] The Government could then use this money to stimulate other areas of the economy.

6.3 THE TREATMENT OF GREENHOUSE REVENUE

If the permits are auctioned, revenue is collected by the Government and can be recycled throughout the economy. On the other hand, if the permits are grandfathered the Government does not receive the revenue but the costs to the industrial sector are effectively reduced. Both of these policy options are modelled separately to analyse the different impacts upon the whole economy and that of the La Trobe Valley region.

The grandfathering method adopted in the first section of this chapter ultimately returns the greenhouse revenue to the owners of the firms.[107] It is assumed that 80 percent of capital infrastructure ownership in the economy is owned domestically and that the remaining 20

[106] Greenhouse revenue is the revenue associated with the imposition of greenhouse policy upon sectors of the Australian economy. For example, the revenue collected by the government from the sale of emission permits.
[107] The household sector of the economy is assumed to be the shareholders of the firms.

percent belongs to foreign investors.[108] Based on this assumption, 80 percent of the revenue collected is returned to the household sector.

The alternative treatment of auctioning the permits and then recycling the revenue collected by the Government is explored in the latter part of the chapter. In this simulation compensation is offered to households in the form of reducing the amount of sales tax they have to pay.[109]

If the Government does in fact collect taxation revenue from CO_2 emitters it faces many alternative uses. One revenue treatment option is to return the revenue to those industries who are most effected by the policy itself. The risk of this option is that it may eliminate the positive impact of reducing greenhouse emissions. The predominant reason for introducing a greenhouse policy is to reduce Australia's aggregate CO_2 emissions. As part of the process, energy intensive industries will suffer negative ramifications by way of reducing their output levels or being forced to invest in new technology. If these industries are not damaged sufficiently to encourage them to partake in greenhouse abatement, Australia will find it difficult to meet its international environmental commitments.

One method of compensating those who are most damaged by greenhouse policy, without encouraging them to maintain the same level of emissions, is for the Government to offer abatement incentive schemes. Part of the greenhouse taxation revenue could be used to fund research into developing new methods to produce energy without the same level of emissions. For instance, a program could be established whereby industry and the Government match dollar for dollar funding into new research.

Another area of consideration for the Australian Government is whether they enter the debate on who carries the burden of greenhouse policy. Depending on the type of policy mechanism adopted, the initial burden could rest with industry or the household sector. For instance, the electricity industry could potentially pass all of its greenhouse policy costs onto consumers. In

[108] Based on information provided by the Allen Consulting Group. This is a reasonable assumption for the Australian electricity industry as with the exception of the Victorian sector (which is predominantly owned by foreign investors), the industry is owned either by State Governments or private Australian investors.

some sectors of the industry, the generators may be in such a strong market position that they can avoid incurring the greenhouse tax internally. If such a situation arose the Government may decide to compensate the consumers of energy for any increase in price. One way to do this is to offer rebates on household energy bills. This practice has been used in the past by the Victorian Government which returned a rebate on energy bills to every household following the success of the State's privatisation scheme.

Individual industry sectors such as the refining of non-ferrous metals could also be offered compensation. This sector is electricity intensive and is likely to suffer severely if greenhouse policy increases the cost of energy. A rebate or research-based incentive could be offered to the industry to improve its economic outlook.

6.4 SIMULATION DESIGN

Forecasting and Policy Closures

In simulations with MONASH-Electricity, movements in the endogenous variables away from their values in a basecase solution, caused by movements in the exogenous variables away from their values in the basecase simulation, are computed. The choice of exogenous variables used in a simulation is found in the model's closure.

Forecasting and policy closures are used in the simulations explored in this chapter. The forecasting closure is used to generate basecase forecasts of the Australian economy for the simulation period. A policy closure is then used to generate deviations from the basecase forecasts that would arise following the introduction of greenhouse policy.

In constructing a forecasting closure, the exogenous variables chosen represent elements that are considered to be known about the future. Thus, in MONASH-Electricity forecasts, naturally endogenous variables are exogenised. To assist the model in predicting how the economy will look between the period 2001 - 2010, a number of external sources who have

[109] Whilst not explored in this thesis, another method of revenue recycling is to reduce the amount of income tax paid by income earners. For reference refer to Enzinger (1999).

expert knowledge in a particular field of economic activity are drawn upon. Included in the basecase forecast are:

- macroeconomic forecasts from Access Economics and State Treasury departments;
- national-level forecasts of inbound tourism numbers from the Tourism Forecasting Council and forecasts of real foreign-tourist expenditure by region from Access Economics;
- assumptions for changes in industry production technologies and in household preferences from CoPS; and
- forecasts for the quantities of agricultural and mineral exports, and estimates of capital expenditure on major minerals and energy projects from ABARE[110].

To allow these variables to be exogenously treated in the forecasting closure, numerous naturally exogenous variables are classified as endogenous. Examples of endogenous variables in the forecasting closure include the positions of foreign demand curves, the positions of domestic export supply curves and some macro coefficients.

The basecase uses the forecasting closure to project how the economy would appear in the absence of greenhouse policy.

The policy closure is used to predict the impact of the greenhouse policy upon the Australian economy. As mentioned above, the simulation results are expressed as percentage deviations from the result in the basecase. The policy simulation analyses changes in the economic position of the economy from where it would otherwise be.

Many of the variables that have been defined as exogenous under the forecasting simulation are endogenous in the policy simulation. Whereas in the forecasting simulation variables such

[110] ABARE forecasts come from its publication *Australian Commodities*, and from personal communication between ABARE and CoPS staff. The closure also makes use of ABARE estimates for growth in the production of minerals and energy commodities and for capital expenditure in large minerals and energy development projects. The production forecasts come from an earlier version of ABARE (1999b), *Australian Energy: Market Developments and Projections to 2014-15*, Research Report 99.4. Estimates of capital expenditure come from ABARE (1998) *Australian Commodities*. (Adams et al, 2000)

as export growth are exogenised, these are defined as endogenous in the policy simulation to enable them to respond to the policy change in question. The values for naturally exogenous variables, such as the positions of foreign demand curves, calculated in the forecasting simulation are applied to the policy closure.

In a policy simulation most of the exogenous variables have the same values they had in the forecast simulation. The specific policy variables have different values to what they had in the forecast simulation. For instance, a greenhouse policy shock is applied to the relevant exogenous variables in the policy closure. Any differences between the results can then be attributed to the impact of the policy and can be expressed as deviations from the basecase.

Macroeconomic Inputs to Basecase Projection

Table 6.1 shows the results for the main macroeconomic variables in the basecase. The basecase provides a picture of the economy without the introduction of greenhouse policy. The basecase forecasts are expressed as cumulative growth, in keeping with how the simulation results are reported later in this chapter.

Table 6.1

BASECASE MACROECONOMIC FORECASTS EXPRESSED AS CUMULATIVE PERCENTAGE ANNUAL CHANGES

Variable	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Real Investment	0.4	9.5	16.7	23.4	25.4	23.1	26.8	30.6	34.6	38.6
Export Volumes	7.0	12.9	20.3	26.6	32.7	39.0	46.0	53.3	61.0	69.0
Import Volumes	6.2	16.8	26.5	34.7	34.7	34.7	34.7	34.7	34.7	34.7
Real GDP	0.6	1.9	3.4	5.1	7.2	8.5	11.1	13.8	16.7	19.6
Aggregate Employment	1.5	3.5	5.5	7.4	8.5	9.1	10.8	12.4	14.1	15.8
Aggregate Capital Stock	0.3	0.7	1.6	2.9	4.3	5.6	6.5	7.8	9.0	10.5
Real Wage	-2.0	-2.5	-1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
CPI	3.5	5.6	7.7	11.1	14.9	17.1	18.8	20.6	22.4	24.3
Terms of Trade	1.0	4.0	7.7	6.6	4.2	5.2	5.2	5.2	5.2	5.2
Real Devaluation	-3.7	-5.0	-11.3	-12.2	-10.7	-10.6	-10.1	-9.6	-9.0	-8.5
GDP Deflator	4.0	7.4	10.8	14.9	18.7	21.5	23.8	26.2	28.6	31.1

There is steady growth in real Gross Domestic Product (GDP). Growth in real investment in the first year is predicted to be modest before strong growth in 2002 which continues throughout the remainder of the simulation period.

Both real international exports and imports continue their rapid growth relative to real value added. Factors encouraging growth in these areas, such as reduced trade protection in Australia and abroad, and technological changes favouring the use of import-intensive goods such as computer equipment, are expected to persist (Adams et al, 2000). There is an improvement in the terms of trade and a significant devaluation of the dollar throughout the simulation period. The devaluation stimulates export volumes relative to import volumes.

The growth in aggregate employment will exceed that of the capital stock. The real wage is predicted to fall initially and then recover to 0.5 percent thereafter.

Assumptions for Changes in Technology and Tastes

Tables 6.2 and 6.3 (shown over page) respectively show the assumptions drawn about changes in the production technologies of industries and in the preferences of households.

The first column of Table 6.2 shows the all-factor technical change in the usage of primary-factor per unit of industry output. Each industry is provided with its own technical change assumption. For example, it is assumed that the aluminium industry's (*Alum*) output will increase by 2.5 percent relative to the industry's aggregate usage of primary factors such as labour and capital. A negative figure in the column represents a benefit to the industry.

In the MONASH model, household preferences are described by a utility function leading to demand functions of the form:

$$X_i = T_i * H_i (P,C)$$

where,

X_i	is consumption of commodity i by the household;
T_i	is the taste change variable;
H_i	is a function of P and C;
P	is the vector of commodity prices;
C	is the total consumption expenditure by the household.

Referring to Table 6.3, it is assumed that household consumption of the electricity distribution commodity (*ElectDist*) will increase at a rate of 0.3 percent per annum faster than can be explained on the basis of changes in prices and changes in the average budget of households.

Table 6.2

ASSUMPTIONS FOR CHANGES IN TECHNOLOGY - PERCENTAGE CHANGE

INDUSTRY	Technology Primary factor using %	INDUSTRY	%	INDUSTRY	%
I1Pastoral	-1.8	I46Sanitary	-0.9	I84aacEleGas	-2.0
I2WheatSheep	-2.6	I47NewsBooks	0.0	I84aadEleHyd	-2.0
I3HighRain	-1.5	I48CommPrint	0.0	I84aaeEleOth	-2.0
I4NthBeef	-1.0	I49Fertilisr	0.0	I84bElectTrn	-2.0
I5MilkCattle	-2.9	I50BasicChem	0.0	I84cElectDist	-2.0
I6OthExport	-2.0	I51Paints	-0.1	I85Gas	-2.7
I7ImportComp	-2.7	I52Pharmacy	0.0	I86Water	-2.4
I8Poultry	-4.6	I53Soaps	0.0	I87Resident	0.0
I9AgServ	0.0	I54Cosmetics	-0.9	I88OthBuild	0.0
I10Forestry	0.0	I55Explosive	-0.5	I89Wholesale	0.0
I11Fishing	-3.9	I56Petrol	0.0	I90RetailTrd	-0.1
I12IronOre	-7.1	I57Glass	-0.2	I91MechRep	0.0
I13NFerrous	-5.4	I58ClayProd	0.0	I92OthRepair	0.0
I14BlkCoal	0.0	I59Cement	-0.4	I93RoadTrans	-0.8
I15aOil	0.0	I60Readymix	-1.6	I94RailTrans	-6.6
I15bGas	0.0	I61Pipes	-1.3	I95WaterTran	-1.2
I15cBrCoal	0.0	I62Plaster	-2.5	I96AirTransp	-4.7
I16OthMin	-0.2	I63IronSteel	-1.4	I97TransServ	0.0
I17MinServ	0.0	I64aNFerrous	-2.5	I98Communic	-5.5
I18Meat	-1.3	I64bAlum	-2.5	I99Banking	-4.1
I19Dairy	-3.7	I65Structurl	0.0	I100NonBank	-6.1
I20FrtVeg	-6.5	I66SheetMetl	-0.3	I101Investm	-4.1
I21OilFat	0.0	I67Wire	0.0	I102Insurnce	-3.6
I22Flour	0.0	I68MotorVeh	-0.4	I103OthFinan	0.0
I23Bakery	0.0	I69Ships	-4.0	I104Dwelling	0.0
I24Confect	-0.3	I70Trains	-3.7	I105PubAdmin	-0.1
I25Sea_Sugar	-1.1	I71Aircraft	-5.1	I106Defence	-1.4
I26SoftDr	0.0	I72SciEquip	-3.6	I107Health	-0.4
I27Beer	0.0	I73Electron	-2.4	I108Educate	-0.4
I28OthDrink	0.0	I74HousAppl	-2.9	I109Welfare	0.0
I29Tobacco	0.0	I75ElectEq	-2.7	I110Entrtain	0.0
I30Ginning	-1.9	I76AgMach	0.0	I111Hotels	0.0
I31Synthetic	-1.1	I77ConMach	0.0	I112PerServ	0.0
I32CottonYa	-1.2	I78ManuMach	0.0	I113Other	0.0
I33WoolYarn	0.0	I79Leather	0.0		
I34TextileF	-0.5	I80Rubber	-0.4		
I35Carpets	-3.2	I81Plastic	0.0		
I36Canvas	-2.0	I82Signs	0.0		
I37Knitting	-1.1	I83SportEq	0.0		
I38Clothing	-2.8	I84aaaEleBr	-2.0		
I39Footwear	-1.1	I84aaaaEdis	-2.0		
I40Sawmill	0.0	I84aaabEBrix	-2.0		
I41Panels	0.0	I84aaacHaz	-2.0		
I42Fittings	0.0	I84aaadLoyY	-2.0		
I43Furniture	0.0	I84aaaeYall	-2.0		
I44PulpPaper	-0.3	I84aaafFlin	-2.0		
I45BagsBoxes	-1.5	I84aabEleBlk	-2.0		

Table 6.3

ASSUMPTIONS FOR CHANGES IN TASTES - PERCENTAGE CHANGE

COMMODITY	Household Preferences %	COMMODITY	%	COMMODITY	%
C1Wool	-0.5	C46PulpPaper	1.8	C86aaafFlin	0.3
C2Sheep	1.6	C47BagsBoxes	18.8	C86aabEleBlk	0.3
C3Wheat	-0.4	C48Sanitary	7.8	C86aacEleGas	0.3
C4Barley	17.5	C49NewsBooks	-2.4	C86aadEleHyd	0.3
C5OthGrains	1.9	C50CommPrint	4.4	C86aaeEleOth	0.3
C6MeatCattle	0.9	C51Fertilisr	3.8	C86bElectTrn	0.3
C7MilkCattle	0.2	C52BasicChem	7.8	C86cElectDist	0.3
C8OthExport	-1.4	C53Paints	3.3	C87Gas	0.3
C9ImportComp	0.8	C54Pharmacy	4.6	C88Water	-0.5
C10Poultry	1.0	C55Soaps	-1.9	C89Resident	6.3
C11AgServ	-1.9	C56Cosmetics	0.9	C90OthBuild	6.3
C12Forestry	-0.9	C57Explosive	10.1	C91Wholesale	-4.2
C13Fishing	1.1	C58Petrol	-2.7	C92RetailTrd	-3.3
C14IronOre	-1.3	C59Glass	-3.4	C93MechRep	-2.8
C15NFerrous	-1.0	C60ClayProd	-4.2	C94OthRepair	-3.7
C16BlkCoal	-3.7	C61Cement	0.2	C95RoadTrans	-1.6
C17aOil	-1.3	C62Readymix	-0.9	C96RailTrans	-2.9
C17bGas	-1.3	C63Pipes	-3.0	C97WaterTran	-6.2
C17cBrCoal	-1.3	C64Plaster	6.3	C98AirTransp	1.7
C18OthMin	1.8	C65IronSteel	5.2	C99TransServ	-0.3
C19MinServ	-4.1	C66aNFerrous	6.7	C100Communic	0.0
C20Meat	1.7	C66bAlum	6.7	C101Banking	0.1
C21Dairy	1.0	C67Structurl	-0.8	C102NonBank	3.2
C22FrtVeg	3.9	C68SheetMetl	-7.6	C103Investm	2.4
C23OilFat	-2.7	C69Wire	-0.1	C104Insurnce	5.7
C24Flour	1.0	C70MotorVeh	3.4	C105OthFinan	0.3
C25Bakery	-2.3	C71Ships	-2.2	C106Dwelling	0.2
C26Confect	-2.0	C72Trains	-6.0	C107PubAdmin	-1.8
C27Sea_Sugar	1.3	C73Aircraft	0.4	C108Defence	-1.1
C28SoftDr	1.4	C74SciEquip	5.6	C109Health	0.3
C29Beer	-2.2	C75Electron	6.1	C110Educate	4.7
C30OthDrink	-1.5	C76HousAppl	-3.5	C111Welfare	-1.5
C31Tobacco	-4.1	C77ElectEq	-5.7	C112Entrtain	1.7
C32Ginning	16.4	C78AgMach	5.1	C113Hotels	-1.5
C33Synthetic	3.0	C79ConMach	1.8	C114PerServ	-1.0
C34CottonYa	-0.8	C80ManuMach	1.5	C115Other	-2.7
C35WoolYarn	-3.2	C81Leather	-3.6		
C36TextileF	0.0	C82Rubber	3.3		
C37Carpets	-6.7	C83Plastic	0.9		
C38Canvas	0.1	C84Signs	-1.7		
C39Knitting	-3.0	C85SportEq	-3.3		
C40Clothing	-2.7	C86aaaEleBr	0.3		
C41Footwear	-3.0	C86aaaaEdis	0.3		
C42Sawmill	-6.2	C86aaabEBrix	0.3		
C43Panels	5.4	C86aaacHaz	0.3		
C44Fittings	-3.1	C86aaadLoyY	0.3		
C45Furniture	-0.7	C86aaaeYall	0.3		

Table 6.4

ASSUMPTIONS FOR CHANGES IN TECHNOLOGY - PERCENTAGE CHANGE

COMMODITY	Technology Commodity using %	COMMODITY	%	COMMODITY	%
C1Wool	0.0	C46PulpPaper	0.4	C86aaafFlin	1.7
C2Sheep	-1.6	C47BagsBoxes	0.1	C86aabEleBlk	1.7
C3Wheat	0.0	C48Sanitary	-4.8	C86aacEleGas	1.7
C4Barley	5.0	C49NewsBooks	-3.3	C86aadEleHyd	1.7
C5OthGrains	1.6	C50CommPrint	2.2	C86aaeEleOth	1.7
C6MeatCattle	-1.3	C51Fertilisr	1.2	C86bElectTrn	1.7
C7MilkCattle	0.4	C52BasicChem	3.8	C86cElectDist	1.7
C8OthExport	-0.8	C53Paints	0.9	C87Gas	0.6
C9ImportComp	0.4	C54Pharmacy	5.0	C88Water	-0.2
C10Poultry	1.1	C55Soaps	-5.0	C89Resident	1.6
C11AgServ	0.0	C56Cosmetics	-5.0	C90OthBuild	2.0
C12Forestry	1.7	C57Explosive	4.3	C91Wholesale	-1.9
C13Fishing	-0.6	C58Petrol	0.2	C92RetailTrd	-0.4
C14IronOre	-0.3	C59Glass	0.3	C93MechRep	-2.7
C15NFerrous	-4.6	C60ClayProd	-0.2	C94OthRepair	-2.0
C16BlkCoal	-2.1	C61Cement	-1.2	C95RoadTrans	0.5
C17aOil	0.9	C62Readymix	0.0	C96RailTrans	0.0
C17bGas	0.9	C63Pipes	0.6	C97WaterTran	-5.0
C17cBrCoal	0.9	C64Plaster	2.9	C98AirTransp	-2.1
C18OthMin	1.3	C65IronSteel	2.3	C99TransServ	0.8
C19MinServ	-4.0	C66aNFerrous	3.0	C100Communic	5.0
C20Meat	1.7	C66bAlum	3.0	C101Banking	5.0
C21Dairy	1.1	C67Structurl	2.8	C102NonBank	5.0
C22FrtVeg	0.0	C68SheetMetl	-2.7	C103Investm	5.0
C23OilFat	-3.6	C69Wire	3.0	C104Insurnce	5.0
C24Flour	0.6	C70MotorVeh	5.0	C105OthFinan	1.4
C25Bakery	0.0	C71Ships	1.4	C106Dwelling	0.0
C26Confect	0.0	C72Trains	-5.0	C107PubAdmin	0.0
C27Sea_Sugar	-1.6	C73Aircraft	-1.2	C108Defence	0.0
C28SoftDr	0.0	C74SciEquip	5.0	C109Health	0.0
C29Beer	0.0	C75Electron	5.0	C110Educate	0.0
C30OthDrink	0.0	C76HousAppl	5.0	C111Welfare	0.0
C31Tobacco	0.0	C77ElectEq	2.5	C112Entrtain	2.2
C32Ginning	0.0	C78AgMach	5.0	C113Hotels	-1.3
C33Synthetic	1.9	C79ConMach	5.0	C114PerServ	0.0
C34CottonYa	-1.1	C80ManuMach	3.7	C115Other	0.0
C35WoolYarn	-3.5	C81Leather	-4.3		
C36TextileF	-0.2	C82Rubber	1.9		
C37Carpets	-0.7	C83Plastic	0.2		
C38Canvas	-0.3	C84Signs	-3.7		
C39Knitting	-2.7	C85SportEq	-3.2		
C40Clothing	0.0	C86aaaEleBr	1.7		
C41Footwear	0.0	C86aaaaEdis	1.7		
C42Sawmill	-3.5	C86aaabEBrix	1.7		
C43Panels	1.9	C86aaacHaz	1.7		
C44Fittings	-1.3	C86aaadLoyY	1.7		
C45Furniture	5.0	C86aaaeYall	1.7		

Table 6.4 (shown on previous page) illustrates the technical change assumptions that have been made regarding the usage of commodities. For example, it is assumed that the usage of the electricity black commodity (*EleBlk*) will increase by 1.7 percent. That is, to achieve a given level of output an industry must increase its usage of this commodity by 1.7 percent with no change in the level of any other inputs.

Basecase Shocks

Table 6.5 provides a list of the shocked exogenous variables in the basecase and the values of those variables.

Table 6.5

SHOCKED EXOGENOUS VARIABLES IN THE BASECASE –PERCENTAGE CHANGE

Shocked Variables	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Import Vol Index	6.2	10.0	8.3	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Nat Acc Real Invest Exp	0.4	9.1	6.5	5.8	1.6	-1.8	3.0	3.0	3.0	3.0
Real GDP	3.0	3.6	3.8	3.7	2.8	2.2	3.0	3.0	3.0	3.0
Aggregate Employment	1.5	2.0	1.9	1.8	1.0	0.6	1.5	1.5	1.5	1.5
Labour Supply	1.5	2.0	1.9	1.8	1.0	0.6	1.5	1.5	1.5	1.5
Number of Households	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
CPI	3.5	2.0	2.0	3.2	3.4	1.9	1.5	1.5	1.5	1.5
Terms of Trade	1.0	3.0	3.5	-1.0	-2.2	0.9	0.0	0.0	0.0	0.0
Export Vol Index	7.0	5.5	6.6	5.2	4.8	4.8	5.0	5.0	5.0	5.0
Foreign Currency Import Prices	2.2	3.9	-3.6	2.7	5.0	2.5	2.5	2.5	2.5	2.5
Agg Real Govt Demands	1.8	2.0	1.9	2.8	2.7	2.5	2.5	2.5	2.5	2.5
Qty of Tourism Exports	6.6	7.3	6.2	6.6	6.6	6.6	6.6	6.6	6.6	6.6
Real GSP SA	2.5	3.2	3.3	2.9	1.8	1.2	*	*	*	*
Real GSP TAS	1.9	3.1	3.0	2.8	1.7	0.8	*	*	*	*
Australian population	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Real world GDP	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Public sector investment	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Population over 65	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

* Variable not shocked

Table 6.6 (shown on next page) illustrates the assumptions made about changes in foreign currency import prices. The variable shocked is defined over each of the commodities used in the MONASH-Electricity model. In many instances a different shock value has been allocated to each commodity. In the case of the electricity sector, the value of the shock for each of the individual generators is assumed to be identical to that of the original electricity industry (*I84Electricity*) found in the database. This treatment of the shock values for the electricity sector remains consistent throughout the closure.

Assumptions for Exports, Production and Capital Expenditure

Forecasts for exports, production and capital expenditure are provided by ABARE. Table 6.5 shows ABARE forecasts for the variable representing the export volume index. ABARE predicts export growth to be high in the years 2001 and 2003, with lower growth prospects for the remaining years of the simulation.

Basecase Projections for Industry Output

Table 6.7 shows average annual growth rates for the sectors in the MONASH-Electricity model as forecast in the basecase. The sector facing the strongest growth prospects is *Finance and Insurance*. This reflects assumptions regarding changes in technology as shown on Tables 6.2 and 6.4. Such technological changes will strengthen the intermediate usage of these service commodities. The *Ownership of Dwellings* sector also experiences strong growth. The worst performing sector is *Personal Services*. A decrease in household preferences assist in explaining the sector's poor economic outlook.

Table 6.6

FOREIGN CURRENCY IMPORT PRICE ASSUMPTIONS - PERCENTAGE CHANGE

COMMODITY	Foreign Currency Import Price %	COMMODITY	%	COMMODITY	%
C1Wool	-4.47	C46PulpPaper	-0.08	C86aaafFlin	0.83
C2Sheep	-2.15	C47BagsBoxes	-0.57	C86aabEleBlk	0.83
C3Wheat	-4.77	C48Sanitary	-0.53	C86aacEleGas	0.83
C4Barley	-5.65	C49NewsBooks	-0.28	C86aadEleHyd	0.83
C5OthGrains	-2.63	C50CommPrint	0.05	C86aaeEleOth	0.83
C6MeatCattle	-0.90	C51Fertilisr	-4.21	C86bElectTrn	0.83
C7MilkCattle	-0.89	C52BasicChem	-1.84	C86cElectDist	0.83
C8OthExport	-1.17	C53Paints	1.71	C87Gas	1.53
C9ImportComp	-1.17	C54Pharmacy	0.83	C88Water	2.10
C10Poultry	1.88	C55Soaps	-0.64	C89Resident	2.24
C11AgServ	-0.06	C56Cosmetics	1.79	C90OthBuild	2.36
C12Forestry	6.66	C57Explosive	1.57	C91Wholesale	4.00
C13Fishing	0.49	C58Petrol	0.01	C92RetailTrd	3.97
C14IronOre	1.91	C59Glass	-0.15	C93MechRep	4.94
C15NFerrous	2.26	C60ClayProd	-0.15	C94OthRepair	3.77
C16BlkCoal	-1.47	C61Cement	-0.19	C95RoadTrans	2.65
C17aOil	-0.05	C62Readymix	5.64	C96RailTrans	-2.61
C17bGas	-0.05	C63Pipes	-0.15	C97WaterTran	1.72
C17cBrCoal	-0.05	C64Plaster	-0.82	C98AirTransp	1.08
C18OthMin	-0.08	C65IronSteel	1.54	C99TransServ	1.19
C19MinServ	-0.88	C66aNFerrous	-0.85	C100Communic	-2.78
C20Meat	0.09	C66bAlum	-0.85	C101Banking	1.19
C21Dairy	2.93	C67Structurl	2.69	C102NonBank	1.19
C22FrtVeg	-1.09	C68SheetMetl	2.17	C103Investm	1.19
C23OilFat	0.11	C69Wire	1.85	C104Insurnce	3.56
C24Flour	1.23	C70MotorVeh	0.00	C105OthFinan	3.11
C25Bakery	-3.79	C71Ships	2.70	C106Dwelling	1.19
C26Confect	-5.45	C72Trains	2.70	C107PubAdmin	1.19
C27Sea_Sugar	-0.96	C73Aircraft	0.72	C108Defence	1.19
C28SoftDr	-0.79	C74SciEquip	0.09	C109Health	1.19
C29Beer	-1.15	C75Electron	-4.80	C110Educate	2.89
C30OthDrink	-0.58	C76HousAppl	0.71	C111Welfare	1.19
C31Tobacco	-2.54	C77ElectEq	-0.46	C112Entrtain	1.19
C32Ginning	-1.83	C78AgMach	1.31	C113Hotels	1.19
C33Synthetic	-0.11	C79ConMach	1.43	C114PerServ	1.19
C34CottonYa	-0.20	C80ManuMach	0.85	C115Other	-0.40
C35WoolYarn	-0.11	C81Leather	-0.18		
C36TextileF	-0.11	C82Rubber	1.18		
C37Carpets	-0.25	C83Plastic	-0.48		
C38Canvas	-0.25	C84Signs	0.00		
C39Knitting	-0.33	C85SportEq	-0.01		
C40Clothing	-0.55	C86aaaEleBr	0.83		
C41Footwear	-1.30	C86aaaaEdis	0.83		
C42Sawmill	9.44	C86aaabEBrix	0.83		
C43Panels	2.01	C86aaacHaz	0.83		
C44Fittings	1.63	C86aaadLoyY	0.83		
C45Furniture	0.38	C86aaaeYall	0.83		

Table 6.7

AVERAGE ANNUAL SECTOR GROWTH RATES EXPRESSED AS CUMULATIVE PERCENTAGE ANNUAL CHANGES

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AFF	Agriculture, forestry, fishing	0.8	1.4	2.0	2.8	4.7	6.4	8.7	11.3	13.8	16.6
Min	Mining	0.1	0.4	2.4	4.3	7.2	9.8	13.3	17.1	21.0	25.1
Man	Manufacturing	-1.3	-2.2	-2.4	-2.0	1.2	3.4	7.8	12.8	17.7	23.4
EGW	Electricity, gas and water	-1.2	-1.2	-1.2	-0.4	1.4	2.7	5.1	7.4	10.0	12.6
Con	Construction	-0.6	-0.6	-0.6	-0.2	0.7	1.4	2.5	3.7	5.0	6.3
WhT	Wholesale Trade	0.3	1.9	4.7	7.1	9.4	11.2	14.3	17.8	21.2	25.1
ReT	Retail trade	0.3	1.0	1.9	2.4	2.3	2.2	2.4	2.6	2.9	3.2
MOR	Mechanical and other repairs	-3.0	-5.8	-5.7	-5.8	-4.7	-4.1	-2.4	-0.7	1.0	2.9
TS	Transport and storage	0.2	1.1	2.4	3.8	6.1	8.0	10.9	14.1	17.2	20.8
Com	Communication	3.5	7.6	7.6	7.9	8.9	9.3	10.9	12.5	14.4	16.2
Fin	Finance and insurance	4.3	9.7	10.4	11.2	13.3	14.8	17.5	20.7	23.4	27.0
OBS	Other business services	1.4	3.3	4.7	6.3	9.1	10.6	14.2	17.9	21.8	25.9
Dwe	Ownership of Dwellings	3.2	6.6	10.1	13.7	17.9	22.3	26.3	30.4	34.6	39.0
PAD	Public administration and defence	1.7	3.7	5.8	8.7	11.8	14.6	17.6	20.7	23.9	27.2
HW	Health and welfare	0.4	0.9	1.4	2.6	4.1	5.3	6.9	8.5	10.1	11.8
EDU	Education and libraries	2.7	5.2	6.7	8.8	11.4	13.7	16.4	19.1	21.9	24.8
Ent	Entertainment and leisure	0.9	1.7	1.1	0.8	1.0	0.9	1.5	2.1	2.7	3.4
ReH	Restaurants and Hotels	-1.7	-2.8	-2.6	-1.8	-0.6	0.5	2.1	3.8	5.7	7.6
PS	Personal services	-1.8	-3.6	-4.4	-4.7	-4.9	-5.3	-5.3	-5.3	-5.2	-5.1
NCI	Non competing Imports	1.9	3.8	5.9	8.8	11.8	14.7	17.7	20.8	23.9	27.2

ABARE's forecast for an increase in the export volume stimulates activity in the *Agriculture, Forestry and Fishing* sector. The *Transport and Storage* sector also benefits from the higher export volume as it supplies many export-orientated industries with support services.

Included in Table 6.7 is the outlook for the *Electricity, Gas and Water* sector prior to greenhouse policy. In the short-run the sector is predicted to experience negative growth, significantly lower than the growth in real GDP over the same period. This tends to reflect assumptions about electricity-saving technical change that form part of the forecasting closure. Such industry trends were discussed in Section 4.2.3 of Chapter four. After 2005 the sector's economic prospects improve with reasonable growth through to the end of the simulation period in 2010.

Results for the individual electricity generators can be found in Table 6.8. As the electricity distribution industry contracts in the basecase, so too does the activity level of the electricity generating industries. The growth prospects for the three base generators in the electricity market, namely electricity brown (*EleBr*), electricity black (*EleBlk*) and electricity gas (*EleGas*), improve over the period of the simulation. At the same time the generators who supply to the peak electricity market, namely electricity hydro (*EleHyd*) and electricity other (*EleOth*), experience a decline in their growth prospects.[111]

Table 6.8

BASECASE RESULTS FOR ELECTRICITY GENERATION AND NON-FERROUS METAL INDUSTRIES EXPRESSED AS CUMULATIVE PERCENTAGE ANNUAL CHANGES

INDUSTRY		**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Electricity	EleBr	-0.7	-0.4	-0.2	0.8	2.9	4.5	7.2	9.9	13.0	16.1
	Edis	-0.8	-0.4	-0.2	0.8	2.9	4.5	7.2	9.8	12.9	15.9
	EBrix	-0.4	0.2	0.7	2.1	4.6	6.7	10.0	13.4	17.2	21.0
	Haz	-0.8	-0.4	-0.2	0.8	2.9	4.5	7.2	9.8	12.9	15.9
	LoyY	-0.8	-0.4	-0.2	0.8	2.9	4.5	7.2	9.8	12.9	15.9
	Yall	-0.8	-0.4	-0.2	0.8	2.9	4.5	7.2	9.8	12.9	15.9
	Flin	-0.8	-0.4	-0.2	0.8	2.9	4.5	7.2	9.8	12.9	15.9
	EleBlk	-0.7	-1.9	-1.9	-1.3	0.4	1.4	3.4	5.2	7.3	9.2
	EleGas	-2.1	0.1	1.0	3.1	6.5	9.6	14.0	18.7	24.0	29.4
	EleHyd	-2.9	-4.0	-5.5	-6.4	-6.5	-7.3	-7.3	-7.5	-7.7	-8.1
	EleOth	-2.9	-4.0	-5.5	-6.4	-6.5	-7.3	-7.3	-7.5	-7.7	-8.1
	ElectTrn	-0.9	-1.5	-1.5	-0.8	0.9	2.1	4.2	6.3	8.7	10.9
	ElectDist	-1.1	-2.0	-2.0	-1.2	0.5	1.7	3.8	5.9	8.3	10.5
Non-ferrous metals	NFerrous	0.9	2.4	3.3	4.0	7.2	9.2	13.1	17.3	21.3	25.8
	Alum	0.6	3.8	6.4	8.3	11.3	13.7	17.2	21.0	24.7	28.7

[111] In future simulations the growth outlooks in the basecase simulation could be altered to include growth forecasts from industry specialists such as the ESAA. Whilst the fossil-fuel electricity generators are likely to experience output growth, the growth rate of the renewable energy sources is likely to be greater.

At the individual brown coal generator level, the forecast for Energy Brix (*Ebrix*) is stronger than that of the other generators. This reflects very slight differences in the treatment of this industry in the database. Important ratios such as labour to capital are identical for all of the brown coal electricity generators. Table 6.9 shows the slight variances in the shares. In particular, the share of *EBrix* is approximately 2 percent throughout most of the database but in the case of intermediate inputs, commodity taxes on intermediate usage and markups on intermediate usage, it represents 3 percent.[112]

Table 6.9

ELECTRICITY GENERATOR SHARES

	Share used in remaining database	**Intermediate Usage**	**Com. Taxes on Intermed.**	**Markups on Int. Usage of Dom. Com.**
Edis	0.14	0.14	0.14	0.14
EBrix	0.02	0.03	0.03	0.03
Haz	0.23	0.23	0.23	0.23
LoyY	0.29	0.29	0.29	0.29
Yall	0.21	0.21	0.21	0.21
Flin	0.10	0.10	0.10	0.10

Also included on Table 6.8 is the economic outlook for the non-ferrous metals sector. As will be explained in Section 6.6.1, the Australian non-ferrous metals and aluminium industries experience the greatest economic hardship in the face of greenhouse policy due to their dependence on electricity.

Basecase Projections for the La Trobe Valley

Table 6.10 shows the basecase projections for Gross Regional Product (GRP) for the statistical divisions of Gippsland and the La Trobe Valley. The last column in the table indicates that the

Gippsland region is expected to marginally improve its economic growth relative to the La Trobe Valley. This is due to the La Trobe Valley's high dependence on brown coal electricity generation, which is expected to experience slow growth. On the whole, in the absence of greenhouse policy, there is very little difference in the growth prospects for the neighbouring regions.

Table 6.10

BASECASE PROJECTIONS FOR GRP EXPRESSED AS CUMULATIVE PERCENTAGE ANNUAL CHANGES

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	AVE
Gippsland	0.24	1.37	2.55	3.92	5.99	7.31	10.10	12.86	16.02	19.04	1.76
La Trobe Valley	0.00	1.63	2.71	4.05	5.81	7.27	9.69	12.35	15.09	18.03	1.67

CO_2 Emissions in the Basecase

MONASH-Electricity incorporates detailed data on greenhouse gas emissions. Emissions are broken down according to the emitting agent (the number of industries in the model and the household sector) and the emitting activity (the fuel sources in the economy and the different components of the electricity sector).

Emissions from agriculture and land clearing are not included in the modelling analysis. Whilst data on emissions from agricultural sources are available, it is uncertain whether the sector will be privy to greenhouse policy. The administration costs associated with the measurement of agricultural emissions and enforcement of the policy would be significant. Data on emissions from land clearing are not considered to be conclusive and although recognised by the Kyoto Protocol, it is still uncertain whether land clearing will be included as part of a nation's emission accounting under the UNFCCC. [113]

[112] Whilst acknowledging this inconsistency, it is important to note that the treatment of intermediate inputs and its associated taxes and markups are consistent at 3 percent.
[113] The omission of agriculture and land clearing is addressed further in Chapter seven.

Tables 6.11 and 6.12 illustrate the greenhouse gas emission scenario faced by the Australian Government. Table 6.11 shows the official greenhouse gas emission levels for Australia as recorded by the National Greenhouse Gas Inventory (NGGI). The official targets exclude land clearing. Table 6.12 shows the official data alongside the emission projections as generated by the MONASH-Electricity model. In 1998 the official record of emissions, less activity[114], is almost identical to the emissions results from MONASH-Electricity. The final column of Table 6.12 illustrates the projected quantity of greenhouse gas emissions in the Australian economy after the greenhouse policy has been implemented.

TABLE 6.11

CO_2 EQUIVALENT EMISSIONS, MILLION TONNES – INCLUDES ACTIVITY

	1990 Official	**1993/94 Official**	**1998 Official**	**2010 Target**
Total emissions less land clearing	389	399	456	421
Land Clearing	103	84	64	60
Miscellaneous	-	-	-	50
Total	492	483	520	531

[114] Activity includes emissions from agriculture, other services and recognises forestry as a net carbon sink.

TABLE 6.12

CO_2 EQUIVALENT EMISSIONS, MILLION TONNES – EXCLUDES ACTIVITY

	1990 Official	1993/94 Official	1998 Official	1998 Monash-Electricity	2010 Target	2010 Monash-Electricity
Total emissions less land clearing	389	399	456	319	421	325
Less Activity	-	-122	-139	-	-122	-
Total	-	277	317	319	299	325

Source: NGGI 1998 Appendix Table 7, 1993 Summary 1.A.

Tables 6.13 – 6.16 are located at the end of this section. The MONASH-Electricity emissions matrix for 1998 is shown in Table 6.13. The columns relate to the CO_2 emitting fuels and the aggregate electricity generation sector. The rows correspond to the 128 industries and 1 household sector in the model. Fuel-burning emissions are modelled in direct correlation with fuel usage. Table 6.14 provides a breakdown of emissions pertaining to the electricity sector. The sum of emissions in Table 6.14 is equal to the sum of emissions in the 'Electricity Generators' column of Table 6.13.

Table 6.15 shows the percentage growth in basecase CO_2 emissions from fuel usage by industry, summed over source (domestic and imports). The level of growth in emissions is representative of the activity level of the industry and its consumption of CO_2 emitting fuels. The emission results should be viewed carefully as not all of the industries included in the table actually consume any of the emitting fuels.[115] For instance, emissions from the brown coal industry (*EleBr*) are predicted to increase even though the industry does not use the fuels as intermediate inputs into its generation practices. Small increases in emissions are found in commodities whose activity level is predicted to fall after the imposition of greenhouse policy. A case in point is the hydro electricity industry (*EleHyd*) which uses the taxed fuel petrol (*C58Petrol*) as an intermediate input.[116]

Table 6.16 shows the industry basecase projections of greenhouse gas emissions at the end of the simulation period in 2009. Industries who experience growth in their activity levels during the simulation period, and who rely on energy as an intermediate input, have increased their CO_2 emissions accordingly.

The Australian economy is predicted to experience considerable growth in its aggregate greenhouse gas emissions between 2000 and 2009. According to the basecase forecast from MONASH-Electricity, total emissions are expected to rise by 12.5 percent in the absence of greenhouse policy action. Table 6.17 illustrates changes in the level of greenhouse gas emissions over the simulation period.

TABLE 6.17

CO_2 BASECASE EMISSIONS

Energy Source	**2000 Basecase**	**2009 Basecase**	**% change**
BlkCoal	41961	49455	18
Gas	34887	40069	15
Petrol	109066	122397	12
Electricity	132673	146192	10
Total Emissions	318586	358113	12.5

[115] The reason for the inconsistency is attributed to tiny numbers recorded in the database to avoid the equations dividing by zero. The results are expressed as percentage changes.
[116] Table 6.15 excludes emissions from the electricity generators.

Specific Shocks in the Policy Closure

Changes to both the database and the equation system allow a greenhouse tax to be placed on those sectors of the economy who are considered to be emission intensive. Rather than introducing a blanket tax on the fuel sources, three separate taxes can be used to capture the economic impact of greenhouse policy. A tax is placed on the intermediate usage of black coal, gas and petrol – minus sales of black coal to *EleBlk* and sales of gas to *EleGas*. A second tax is placed on CO_2 emissions from electricity produced by *EleBlk, EleGas, EleHyd* and *EleOth*. The final tax is imposed on the CO_2 emissions from electricity produced by the brown coal generators. In each instance the tax is imposed at the rate of $50 per tonne of CO_2 emitted into the atmosphere.

In addition to the policy shocks, the closure also includes supply side constraints on the output growth in the hydro electricity (*EleHyd*) and renewable electricity (*EleOth*) industries. As will be explained later in this chapter, a greenhouse tax will encourage substitution toward these sources of electricity. However in the short-run at least, hydro electricity dams cannot be physically constructed. The construction of the dams on the Snowy River in the States of NSW and VIC took many years and resources. Even with advanced technology, dam construction remains a time consuming infrastructure project. A mentioned in Chapter five, in Australia the construction of dams is also politically unpopular. Strong lobby groups exist to protect Australia's waterways from dam construction. It is unrealistic therefore to allow the hydro electricity industry to benefit from the greenhouse policy with the implicit assumption that the supply of hydro electricity is elastic.

To avoid this situation, the output for *EleHyd* is exogenised and the all factor augmenting technical change variable is endogenized. This has the effect of constraining supply. The impact will be a significant increase in the price of *EleHyd*.

To soften this severe constraint, the activity variable for *EleHyd* is shocked in the policy simulation at 3 percent growth in the first year and 1 percent for each year thereafter. As identified in Chapter four, there is excess capacity of hydro electricity in the Australian market. The shock to allow growth in *EleHyd* does not represent the construction of new plant, but rather an increase in generation at the existing power stations. Rather than supplying solely into the peak electricity market, the introduction of greenhouse policy may encourage the use of hydro electricity in the base generating periods. Market forces will encourage increased supply.

The renewable electricity industry (*EleOth*) is another that benefits from the greenhouse policy. As was outlined in Chapter three, the Australian Government is encouraging investment in the area of renewable energy. As will be explained later in this chapter, the introduction of greenhouse policy will stimulate growth in this industry as it does not incur the burden of the greenhouse tax.

Whilst it is important to allow this industry to grow, it is also important to restrict its growth rate. The industry is expected to grow strongly but in the short-run its growth is limited to output from known technologies. The existing renewable energy technologies such as wind power electricity generation are not well established in Australia. Wind turbines currently exist near Canberra, Newcastle, in remote parts of WA and on King Island and Flinders Island in Bass Strait. The combined electricity generation capacity from wind does not even equate to 0.01 of a percent of Australia's total electricity generation (ESAA, 2000). Thus, whilst this industry is expected to grow strongly over the next decade, it is unlikely to threaten the generation output from the other fuel sources such as brown and black coal.

Similarly to the treatment of the hydro electricity industry in the closure, the supply of renewable energy is constrained. Industry investment in the closure is exogenised and shocked at 10 percent in the first year. In subsequent years the growth in industry investment is shocked at 5 percent.

Table 6.13

1998 BASECASE MONASH GENERATED DATA: Emissions, CO_2 equivalent, kT

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I1Pastoral	0	0	0	211	0	211
I2WheatSheep	0	3	0	2321	0	2323
I3HighRain	0	2	0	581	0	582
I4NthBeef	0	0	0	244	0	244
I5MilkCattle	0	14	0	362	0	376
I6OthExport	0	18	0	446	0	464
I7ImportComp	0	22	0	532	0	555
I8Poultry	0	71	0	8	0	78
I9AgServ	0	0	0	188	0	188
I10Forestry	0	50	0	883	0	934
I11Fishing	0	0	0	1127	0	1127
I12IronOre	425	43	0	226	0	694
I13NFerrous	409	213	0	1079	0	1701
I14BlkCoal	11866	88	0	501	0	12455
I15aOil	135	1391	0	24	0	1550
I15bGas	93	950	0	17	0	1060
I15cBrCoal	28	285	0	5	0	318
I16OthMin	79	43	0	462	0	584
I17MinServ	0	20	0	233	0	254
I18Meat	611	141	0	248	0	1001
I19Dairy	671	103	0	118	0	891
I20FrtVeg	321	67	0	107	0	495
I21OilFat	46	5	0	9	0	60
I22Flour	201	41	0	24	0	265
I23Bakery	84	46	0	119	0	249
I24Confect	22	6	0	17	0	44
I25Sea_Sugar	333	117	0	231	0	681
I26SoftDr	40	21	0	129	0	190
I27Beer	128	22	0	24	0	174
I28OthDrink	52	23	0	40	0	115
I29Tobacco	28	3	0	4	0	35
I30Ginning	34	4	0	10	0	48
I31Synthetic	51	8	0	4	0	63
I32CottonYa	69	8	0	4	0	82
I33WoolYarn	0	0	0	8	0	8
I34TextileF	69	20	0	9	0	98
I35Carpets	9	2	0	7	0	18
I36Canvas	1	0	0	13	0	14
I37Knitting	8	2	0	5	0	14
I38Clothing	10	1	0	32	0	43
I39Footwear	0	0	0	4	0	5
I40Sawmill	68	12	0	138	0	218
I41Panels	185	27	0	64	0	276
I42Fittings	19	7	0	81	0	107
I43Furniture	10	9	0	62	0	81
I44PulpPaper	1107	119	0	122	0	1347
I45BagsBoxes	32	13	0	47	0	93
I46Sanitary	294	31	0	27	0	352

Table 6.13 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I47NewsBooks	4	5	0	149	0	158
I48CommPrint	28	20	0	193	0	240
I49Fertilisr	36	151	0	23	0	210
I50BasicChem	2007	1197	0	949	0	4153
I51Paints	17	4	0	71	0	92
I52Pharmacy	11	4	0	53	0	68
I53Soaps	26	5	0	42	0	73
I54Cosmetics	4	9	0	16	0	28
I55Explosive	52	14	0	104	0	171
I56Petrol	317	0	0	13323	0	13640
I57Glass	84	109	0	51	0	244
I58ClayProd	288	165	0	63	0	516
I59Cement	794	1116	0	146	0	2056
I60Readymix	11	9	0	105	0	125
I61Pipes	77	38	0	83	0	197
I62Plaster	173	35	0	31	0	238
I63IronSteel	5862	1580	0	464	0	7906
I64aNFerrous	4504	485	0	3054	0	8042
I64bAlum	5741	618	0	3907	0	10266
I65Structurl	79	57	0	104	0	240
I66SheetMetl	38	138	0	72	0	249
I67Wire	106	115	0	113	0	334
I68MotorVeh	159	127	0	58	0	343
I69Ships	38	14	0	21	0	73
I70Trains	27	14	0	11	0	51
I71Aircraft	4	4	0	15	0	23
I72SciEquip	3	3	0	15	0	22
I73Electron	27	4	0	45	0	76
I74HousAppl	52	16	0	12	0	80
I75ElectEq	29	38	0	69	0	136
I76AgMach	27	24	0	8	0	59
I77ConMach	13	6	0	9	0	28
I78ManuMach	87	57	0	101	0	244
I79Leather	19	2	0	9	0	30
I80Rubber	35	12	0	31	0	79
I81Plastic	38	20	0	95	0	153
I82Signs	2	2	0	12	0	17
I83SportEq	416	56	0	14	0	485
I84aaaEleBr	0	0	0	0	0	0
I84aaaaEdis	0	0	0	62	7391	7453
I84aaabEBrix	0	0	0	11	1595	1606
I84aaacHaz	0	0	0	100	13813	13912
I84aaadLoyY	0	0	0	125	14901	15025
I84aaaeYall	0	0	0	90	11746	11836
I84aaafFlin	0	0	0	44	4801	4845
I84aabEleBlk	0	0	0	934	74251	75185
I84aacEleGas	0	0	0	58	4175	4233
I84aadEleHyd	0	0	0	136	0	136
I84aaeEleOth	0	0	0	12	0	12
I84bElectTrn	0	0	0	102	0	102
I84cElectDist	0	0	0	999	0	999
I85Gas	65	18727	0	83	0	18875

Table 6.13 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I86Water	27	0	0	784	0	811
I87Resident	0	186	0	1359	0	1545
I88OthBuild	125	126	0	2028	0	2279
I89Wholesale	237	93	0	4206	0	4536
I90RetailTrd	1270	467	0	2408	0	4145
I91MechRep	0	0	0	38	0	38
I92OthRepair	0	0	0	572	0	572
I93RoadTrans	0	199	0	5831	0	6030
I94RailTrans	0	363	0	2811	0	3174
I95WaterTran	242	12	0	1690	0	1943
I96AirTransp	0	0	0	7733	0	7733
I97TransServ	0	0	0	198	0	198
I98Communic	0	808	0	1120	0	1928
I99Banking	0	396	0	322	0	718
I100NonBank	0	0	0	72	0	72
I101Investm	0	55	0	79	0	134
I102Insurnce	0	0	0	85	0	85
I103OthFinan	0	0	0	4407	0	4407
I104Dwelling	0	0	0	136	0	136
I105PubAdmin	277	301	0	399	0	977
I106Defence	98	819	0	1463	0	2379
I107Health	466	342	0	567	0	1375
I108Educate	40	173	0	18	0	230
I109Welfare	10	1049	0	3730	0	4788
I110Entrtain	93	130	0	538	0	761
I111Hotels	9	270	0	179	0	458
I112PerServ	20	32	0	770	0	822
I113Other	0	0	0	0	0	0
Household	208	0	0	27976	0	28184
Total	41961	34887	0	109066	132673	318586

Sources: Fry (1997), NGGI (1996, 1998)

Table 6.14

1998 MONASH GENERATED DATA: Emissions, CO_2 equivalent, kT

INDUSTRY	EleBlk	EleGas	Edis	Ebrix	Haz	LoyY	Yall	Flin
I1Pastoral	0	0	0	0	0	0	0	0
I2WheatSheep	0	0	0	0	0	0	0	0
I3HighRain	0	0	0	0	0	0	0	0
I4NthBeef	0	0	0	0	0	0	0	0
I5MilkCattle	0	0	0	0	0	0	0	0
I6OthExport	0	0	0	0	0	0	0	0
I7ImportComp	0	0	0	0	0	0	0	0
I8Poultry	0	0	0	0	0	0	0	0
I9AgServ	0	0	0	0	0	0	0	0
I10Forestry	0	0	0	0	0	0	0	0
I11Fishing	0	0	0	0	0	0	0	0
I12IronOre	0	0	0	0	0	0	0	0
I13NFerrous	0	0	0	0	0	0	0	0
I14BlkCoal	0	0	0	0	0	0	0	0
I15aOil	0	0	0	0	0	0	0	0
I15bGas	0	0	0	0	0	0	0	0
I15cBrCoal	0	0	0	0	0	0	0	0
I16OthMin	0	0	0	0	0	0	0	0
I17MinServ	0	0	0	0	0	0	0	0
I18Meat	0	0	0	0	0	0	0	0
I19Dairy	0	0	0	0	0	0	0	0
I20FrtVeg	0	0	0	0	0	0	0	0
I21OilFat	0	0	0	0	0	0	0	0
I22Flour	0	0	0	0	0	0	0	0
I23Bakery	0	0	0	0	0	0	0	0
I24Confect	0	0	0	0	0	0	0	0
I25Sea_Sugar	0	0	0	0	0	0	0	0
I26SoftDr	0	0	0	0	0	0	0	0
I27Beer	0	0	0	0	0	0	0	0
I28OthDrink	0	0	0	0	0	0	0	0
I29Tobacco	0	0	0	0	0	0	0	0
I30Ginning	0	0	0	0	0	0	0	0
I31Synthetic	0	0	0	0	0	0	0	0
I32CottonYa	0	0	0	0	0	0	0	0
I33WoolYarn	0	0	0	0	0	0	0	0
I34TextileF	0	0	0	0	0	0	0	0
I35Carpets	0	0	0	0	0	0	0	0
I36Canvas	0	0	0	0	0	0	0	0
I37Knitting	0	0	0	0	0	0	0	0
I38Clothing	0	0	0	0	0	0	0	0
I39Footwear	0	0	0	0	0	0	0	0
I40Sawmill	0	0	0	0	0	0	0	0
I41Panels	0	0	0	0	0	0	0	0
I42Fittings	0	0	0	0	0	0	0	0
I43Furniture	0	0	0	0	0	0	0	0
I44PulpPaper	0	0	0	0	0	0	0	0
I45BagsBoxes	0	0	0	0	0	0	0	0
I46Sanitary	0	0	0	0	0	0	0	0
I47NewsBooks	0	0	0	0	0	0	0	0

Table 6.14 Continued

INDUSTRY	EleBlk	EleGas	Edis	Ebrix	Haz	LoyY	Yall	Flin
I48CommPrint	0	0	0	0	0	0	0	0
I49Fertilisr	0	0	0	0	0	0	0	0
I50BasicChem	0	0	0	0	0	0	0	0
I51Paints	0	0	0	0	0	0	0	0
I52Pharmacy	0	0	0	0	0	0	0	0
I53Soaps	0	0	0	0	0	0	0	0
I54Cosmetics	0	0	0	0	0	0	0	0
I55Explosive	0	0	0	0	0	0	0	0
I56Petrol	0	0	0	0	0	0	0	0
I57Glass	0	0	0	0	0	0	0	0
I58ClayProd	0	0	0	0	0	0	0	0
I59Cement	0	0	0	0	0	0	0	0
I60Readymix	0	0	0	0	0	0	0	0
I61Pipes	0	0	0	0	0	0	0	0
I62Plaster	0	0	0	0	0	0	0	0
I63IronSteel	0	0	0	0	0	0	0	0
I64aNFerrous	0	0	0	0	0	0	0	0
I64bAlum	0	0	0	0	0	0	0	0
I65Structurl	0	0	0	0	0	0	0	0
I66SheetMetl	0	0	0	0	0	0	0	0
I67Wire	0	0	0	0	0	0	0	0
I68MotorVeh	0	0	0	0	0	0	0	0
I69Ships	0	0	0	0	0	0	0	0
I70Trains	0	0	0	0	0	0	0	0
I71Aircraft	0	0	0	0	0	0	0	0
I72SciEquip	0	0	0	0	0	0	0	0
I73Electron	0	0	0	0	0	0	0	0
I74HousAppl	0	0	0	0	0	0	0	0
I75ElectEq	0	0	0	0	0	0	0	0
I76AgMach	0	0	0	0	0	0	0	0
I77ConMach	0	0	0	0	0	0	0	0
I78ManuMach	0	0	0	0	0	0	0	0
I79Leather	0	0	0	0	0	0	0	0
I80Rubber	0	0	0	0	0	0	0	0
I81Plastic	0	0	0	0	0	0	0	0
I82Signs	0	0	0	0	0	0	0	0
I83SportEq	0	0	0	0	0	0	0	0
I84aaaEleBr	0	0	0	0	0	0	0	0
I84aaaaEdis	0	0	7391	0	0	0	0	0
I84aaabEBrix	0	0	0	1595	0	0	0	0
I84aaacHaz	0	0	0	0	13813	0	0	0
I84aaadLoyY	0	0	0	0	0	14901	0	0
I84aaaeYall	0	0	0	0	0	0	11746	0
I84aaafFlin	0	0	0	0	0	0	0	4801
I84aabEleBlk	74251	0	0	0	0	0	0	0
I84aacEleGas	0	4175	0	0	0	0	0	0
I84aadEleHyd	0	0	0	0	0	0	0	0
I84aaeEleOth	0	0	0	0	0	0	0	0
I84bElectTrn	0	0	0	0	0	0	0	0
I84cElectDist	0	0	0	0	0	0	0	0
I85Gas	0	0	0	0	0	0	0	0
I86Water	0	0	0	0	0	0	0	0

Table 6.14 Continued

INDUSTRY	EleBlk	EleGas	Edis	Ebrix	Haz	LoyY	Yall	Flin
I87Resident	0	0	0	0	0	0	0	0
I88OthBuild	0	0	0	0	0	0	0	0
I89Wholesale	0	0	0	0	0	0	0	0
I90RetailTrd	0	0	0	0	0	0	0	0
I91MechRep	0	0	0	0	0	0	0	0
I92OthRepair	0	0	0	0	0	0	0	0
I93RoadTrans	0	0	0	0	0	0	0	0
I94RailTrans	0	0	0	0	0	0	0	0
I95WaterTran	0	0	0	0	0	0	0	0
I96AirTransp	0	0	0	0	0	0	0	0
I97TransServ	0	0	0	0	0	0	0	0
I98Communic	0	0	0	0	0	0	0	0
I99Banking	0	0	0	0	0	0	0	0
I100NonBank	0	0	0	0	0	0	0	0
I101Investm	0	0	0	0	0	0	0	0
I102Insurnce	0	0	0	0	0	0	0	0
I103OthFinan	0	0	0	0	0	0	0	0
I104Dwelling	0	0	0	0	0	0	0	0
I105PubAdmin	0	0	0	0	0	0	0	0
I106Defence	0	0	0	0	0	0	0	0
I107Health	0	0	0	0	0	0	0	0
I108Educate	0	0	0	0	0	0	0	0
I109Welfare	0	0	0	0	0	0	0	0
I110Entrtain	0	0	0	0	0	0	0	0
I111Hotels	0	0	0	0	0	0	0	0
I112PerServ	0	0	0	0	0	0	0	0
I113Other	0	0	0	0	0	0	0	0
Household	0	0	0	0	0	0	0	0
Total	74251	4175	7391	1595	13813	14901	11746	4801

Sources: Fry (1997), NGGI (1996, 1998)

Table 6.15

BASECASE EMISSIONS FROM FUEL USAGE BY INDUSTRY - CUMULATIVE PERCENTAGE ANNUAL CHANGES SUMMED OVER SOURCE

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I1Pastoral	-2.3	-4.1	-3.9	-3.6	-3.8	-3.7	-3.9	-4.1	-4.4	-4.7
I2WheatSheep	0.1	0.9	2.5	3.3	3.5	4.1	4.4	5.0	5.5	6.2
I3HighRain	-1.6	-2.5	-0.8	0.8	2.4	4.3	6.0	7.9	9.8	11.9
I4NthBeef	-0.9	-1.5	-0.6	0.3	1.0	1.9	2.8	3.8	4.8	6.1
I5MilkCattle	3.3	5.9	9.1	12.0	15.6	19.5	23.8	28.5	33.3	38.7
I6OthExport	0.6	-0.1	2.3	4.1	8.5	12.9	18.6	24.9	31.2	38.2
I7ImportComp	1.1	1.2	2.5	3.7	6.7	9.8	13.7	17.9	22.1	26.8
I8Poultry	3.5	8.8	10.2	12.0	14.1	16.1	18.3	20.5	22.7	24.9
I9AgServ	2.2	4.0	7.3	10.2	13.4	16.8	20.3	24.0	27.6	31.6
I10Forestry	0.4	1.0	3.4	6.7	11.6	15.7	21.7	28.0	35.2	42.4
I11Fishing	-0.8	-1.8	-1.5	-1.8	-0.3	1.0	2.9	4.8	6.6	8.6
I12IronOre	0.6	0.4	4.4	7.0	11.3	14.6	17.7	21.7	24.9	29.4
I13NFerrous	-3.8	-6.8	-4.0	-1.7	1.1	3.8	6.9	10.2	13.2	16.6
I14BlkCoal	-1.3	-1.3	3.2	6.4	9.2	12.1	15.0	17.9	21.0	24.0
I15aOil	-1.2	-1.7	-1.6	-0.8	2.7	5.5	9.9	14.5	19.1	24.1
I15bGas	2.1	2.7	3.2	4.1	5.7	6.9	8.9	11.0	13.2	15.5
I15cBrCoal	-0.1	2.4	3.7	5.6	8.4	10.8	14.2	17.7	21.4	25.1
I16OthMin	4.8	9.0	15.8	21.4	28.0	33.2	41.9	50.6	59.9	69.5
I17MinServ	-6.1	-11.2	-9.2	-7.5	-5.1	-2.7	0.2	3.4	6.5	9.9
I18Meat	2.2	3.9	4.8	6.1	7.6	9.0	10.6	12.3	14.0	15.9
I19Dairy	2.1	1.6	5.4	8.7	13.3	17.8	23.3	29.1	34.9	41.3
I20FrtVeg	1.7	0.9	1.4	1.3	4.5	7.3	11.4	15.9	20.1	24.9
I21OilFat	-5.4	-12.8	-13.0	-13.1	-9.5	-6.2	-0.7	5.4	11.6	18.5
I22Flour	3.7	4.7	9.0	12.9	18.8	24.3	31.3	38.7	46.3	54.4
I23Bakery	-1.4	-3.4	-1.6	-0.2	2.0	4.0	6.4	8.8	11.1	13.6
I24Confect	-3.2	-8.2	-8.7	-9.7	-7.2	-5.1	-1.6	2.4	6.3	10.8
I25Sea_Sugar	-1.6	-2.7	-1.3	-0.8	1.8	4.2	7.4	10.7	13.9	17.4
I26SoftDr	1.4	2.3	3.2	4.0	5.4	6.6	8.2	9.9	11.6	13.3
I27Beer	-4.6	-10.3	-9.8	-9.3	-8.4	-7.6	-6.4	-5.2	-3.9	-2.6
I28OthDrink	-0.6	-1.9	-2.8	-2.8	0.3	3.0	7.3	12.1	16.9	22.3
I29Tobacco	-4.5	-10.0	-9.2	-8.5	-6.7	-5.3	-3.3	-1.1	0.9	3.2
I30Ginning	0.8	-2.3	-2.2	-2.4	-1.5	-0.8	0.3	1.5	2.7	4.1
I31Synthetic	-6.8	-13.6	-19.7	-22.7	-20.0	-18.4	-14.6	-9.9	-4.9	1.3
I32CottonYa	-4.7	-10.6	-15.4	-17.6	-14.4	-12.5	-8.5	-3.7	1.0	6.7
I33WoolYarn	-5.8	-12.2	-14.8	-16.7	-13.7	-11.5	-7.3	-2.4	2.1	7.6
I34TextileF	-4.0	-9.1	-10.3	-10.9	-8.0	-5.9	-2.2	1.9	5.8	10.3
I35Carpets	-6.4	-13.2	-14.2	-15.3	-13.5	-12.4	-9.6	-6.3	-3.2	0.5
I36Canvas	-2.6	-5.8	-7.2	-8.4	-5.2	-2.6	2.0	7.2	12.2	18.0
I37Knitting	-5.5	-12.5	-14.4	-16.2	-12.9	-10.3	-5.8	-0.7	4.0	9.7
I38Clothing	-3.4	-7.6	-9.6	-11.2	-8.5	-6.4	-2.7	1.3	4.9	9.3
I39Footwear	-6.1	-11.9	-17.4	-20.9	-18.8	-17.6	-14.5	-10.8	-7.3	-2.9
I40Sawmill	-2.9	-6.1	-4.1	1.3	10.4	16.3	27.5	40.2	53.9	69.1
I41Panels	-0.4	-1.8	-1.1	0.7	5.4	7.2	13.0	19.1	25.3	31.9
I42Fittings	-0.8	0.0	1.4	6.7	11.2	9.5	13.8	17.7	22.4	26.3
I43Furniture	-2.2	-4.2	-5.9	-7.6	-6.5	-5.8	-3.6	-1.0	1.2	4.0
I44PulpPaper	-5.7	-12.2	-14.0	-15.4	-12.2	-9.6	-4.7	1.1	7.0	13.6
I45BagsBoxes	-1.6	-3.3	-2.4	-1.5	1.3	3.3	6.8	10.6	14.3	18.4
I46Sanitary	-3.0	-7.5	-7.8	-8.2	-5.5	-3.4	0.1	4.1	7.8	12.0
I47NewsBooks	-3.6	-7.2	-7.1	-7.0	-4.8	-3.0	-0.1	3.1	6.2	9.6

Table 6.15 Continued

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I48CommPrint	0.4	0.8	0.9	1.3	3.9	5.8	9.1	12.8	16.3	20.2
I49Fertilisr	-9.3	-17.8	-20.7	-23.4	-21.0	-19.3	-15.8	-11.8	-8.3	-3.9
I50BasicChem	-3.7	-8.0	-10.2	-11.5	-7.8	-5.0	0.3	6.5	13.1	20.4
I51Paints	-0.8	-0.5	1.3	4.4	8.9	10.7	15.9	21.4	27.1	33.1
I52Pharmacy	-1.0	-3.6	-5.5	-7.0	-3.5	-0.5	4.4	9.8	15.0	21.2
I53Soaps	-4.9	-10.8	-10.9	-11.2	-8.9	-6.9	-3.9	-0.5	2.7	6.3
I54Cosmetics	-3.8	-8.5	-9.6	-10.6	-7.3	-4.4	0.1	5.1	9.7	15.1
I55Explosive	0.6	0.1	-0.3	0.0	4.9	8.9	15.2	22.3	29.5	37.6
I56Petrol	-1.3	-2.7	-1.0	0.2	2.8	4.9	8.4	12.1	15.8	19.9
I57Glass	-2.5	-5.1	-5.2	-5.0	-1.4	1.0	5.8	11.1	16.3	22.1
I58ClayProd	-3.2	-6.2	-6.5	-3.0	2.4	2.0	7.3	13.0	18.7	25.1
I59Cement	-3.3	-2.7	0.3	5.1	9.0	8.1	12.5	16.5	21.4	25.5
I60Readymix	0.4	5.9	11.2	18.8	22.2	18.9	23.0	25.9	30.4	33.3
I61Pipes	-0.3	4.4	9.6	16.3	19.5	17.2	21.4	24.7	29.6	32.7
I62Plaster	0.8	1.7	3.1	7.0	12.2	12.2	17.9	23.7	29.8	36.2
I63IronSteel	-2.5	-6.3	-5.9	-6.0	-1.5	1.4	7.5	14.3	20.7	28.3
I64aNFerrous	0.6	1.4	3.3	4.5	8.2	10.7	15.1	19.9	24.4	29.7
I64bAlum	0.3	2.8	6.3	8.9	12.4	15.3	19.3	23.7	27.9	32.5
I65Structurl	1.5	9.7	17.4	22.7	25.3	26.3	30.9	35.6	40.7	45.6
I66SheetMetl	1.2	2.9	8.2	12.9	18.9	23.9	31.5	39.7	47.8	56.7
I67Wire	-1.3	-1.5	-1.4	-0.9	4.2	7.5	14.5	22.1	29.6	38.2
I68MotorVeh	-6.1	-10.2	-11.6	-12.2	-9.6	-7.8	-4.1	0.7	4.3	9.6
I69Ships	-1.0	-2.9	0.6	2.8	7.8	12.9	19.4	27.0	33.8	42.4
I70Trains	-12.4	-20.4	-18.4	-17.1	-15.0	-12.7	-10.0	-6.6	-3.7	0.5
I71Aircraft	-0.4	-1.7	0.3	1.9	7.3	12.9	20.3	29.0	36.9	47.1
I72SciEquip	0.1	-2.6	-1.4	-1.3	3.5	8.0	14.7	22.2	29.2	37.5
I73Electron	2.8	5.3	4.4	2.9	6.6	9.7	15.5	22.0	28.4	35.7
I74HousAppl	-5.3	-11.2	-12.2	-12.4	-8.9	-7.3	-3.0	2.3	6.6	12.5
I75ElectEq	-5.3	-9.3	-8.6	-8.6	-4.2	-0.8	5.6	12.9	19.7	27.9
I76AgMach	-17.1	-22.4	-19.9	-17.7	-13.3	-7.8	-1.4	7.3	15.3	26.8
I77ConMach	-9.9	-17.0	-13.3	-10.7	-5.2	-0.5	7.1	16.1	24.1	34.4
I78ManuMach	-2.3	-2.3	0.7	1.4	6.5	11.2	19.2	29.1	37.1	48.5
I79Leather	5.5	7.3	14.3	20.7	29.9	39.0	50.2	62.3	74.7	88.3
I80Rubber	-4.3	-9.7	-11.7	-13.5	-9.7	-6.8	-1.5	4.5	10.2	17.2
I81Plastic	-4.0	-8.2	-10.0	-11.1	-7.6	-5.3	-0.5	5.1	10.3	16.7
I82Signs	-4.7	-9.1	-10.2	-11.2	-8.7	-6.9	-3.6	0.3	3.7	8.0
I83SportEq	-3.0	-8.8	-7.9	-7.0	-1.7	3.0	9.7	17.1	24.5	32.9
I84aaaEleBr	2.6	11.0	22.7	35.8	34.5	34.3	30.8	26.3	23.8	19.3
I84aaaaEdis	1.8	5.4	7.4	9.2	11.6	14.0	17.1	20.5	24.1	28.0
I84aaabEBrix	2.1	6.0	8.2	10.5	13.4	16.2	20.0	24.1	28.5	33.3
I84aaacHaz	1.8	5.4	7.4	9.2	11.6	14.0	17.1	20.5	24.1	28.0
I84aaadLoyY	1.8	5.4	7.4	9.2	11.6	14.0	17.1	20.5	24.1	28.0
I84aaaeYall	1.8	5.4	7.4	9.2	11.6	14.0	17.1	20.5	24.1	28.0
I84aaafFlin	1.8	5.4	7.4	9.2	11.6	14.0	17.1	20.5	24.1	28.0
I84aabEleBlk	2.4	5.4	7.1	8.6	10.6	12.3	14.8	17.4	19.9	22.7
I84aacEleGas	0.8	5.8	8.4	11.2	14.8	18.6	23.5	29.0	34.8	41.2
I84aadEleHyd	0.0	2.5	2.9	2.9	3.1	3.0	3.3	3.7	3.9	4.2
I84aaeEleOth	0.0	2.5	2.9	2.9	3.1	3.0	3.3	3.7	3.9	4.2
I84bElectTrn	3.2	6.7	9.7	11.9	14.5	16.8	19.7	23.0	26.2	29.8
I84cElectDist	1.5	3.7	6.2	8.3	10.7	12.8	15.6	18.6	21.6	25.0
I85Gas	-2.9	-2.9	-3.0	-2.4	-0.5	0.7	3.1	5.5	8.1	10.8
I86Water	3.4	6.9	13.7	19.4	24.3	29.0	32.6	37.5	41.4	47.2
I87Resident	3.3	8.7	11.6	24.7	31.7	25.5	29.6	33.8	38.0	42.2

Table 6.15 Continued

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I88OthBuild	-1.9	4.7	11.6	14.4	14.2	13.3	16.8	18.4	23.1	24.4
I89Wholesale	0.5	2.2	6.3	9.2	11.4	13.4	16.4	19.9	23.1	27.0
I90RetailTrd	-0.6	-1.0	0.7	1.7	1.7	1.7	1.9	2.0	2.3	2.6
I91MechRep	-4.1	-8.0	-6.9	-6.2	-5.8	-5.7	-5.0	-4.3	-3.5	-2.7
I92OthRepair	-4.2	-8.1	-7.5	-7.5	-5.9	-4.7	-2.4	0.2	2.7	5.5
I93RoadTrans	2.0	4.9	8.3	11.2	13.6	15.0	18.0	21.0	24.4	27.7
I94RailTrans	0.1	0.5	3.4	5.5	7.7	9.6	12.2	14.7	17.7	20.3
I95WaterTran	-2.5	-3.8	-1.5	0.1	2.8	5.2	8.3	11.6	14.9	18.3
I96AirTransp	0.0	0.4	-0.1	0.5	3.4	6.4	10.5	15.2	20.0	25.5
I97TransServ	2.2	4.8	8.6	11.3	13.7	16.2	19.4	22.8	26.3	30.2
I98Communic	1.9	4.9	5.9	6.9	8.3	9.2	11.1	13.0	15.1	17.3
I99Banking	3.8	9.3	11.0	13.0	15.3	17.1	19.7	22.6	25.4	28.6
I100NonBank	4.2	9.0	11.7	12.4	15.7	15.9	20.9	20.9	28.3	26.0
I101Investm	5.7	11.6	12.6	14.0	16.5	18.5	21.7	25.6	28.9	33.3
I102Insurnce	2.4	3.8	3.1	1.5	2.7	3.6	5.8	8.5	10.9	13.8
I103OthFinan	1.1	2.6	4.9	7.0	9.7	11.3	14.8	18.5	22.4	26.5
I104Dwelling	1.0	2.0	4.0	5.9	7.6	9.5	11.0	12.4	14.0	15.4
I105PubAdmin	0.4	1.0	3.5	6.6	9.6	12.3	15.2	18.2	21.3	24.5
I106Defence	0.4	1.7	4.4	8.1	11.4	14.6	17.8	21.1	24.5	28.0
I107Health	-1.0	-2.2	-1.6	-0.5	0.6	1.4	2.4	3.3	4.3	5.3
I108Educate	2.0	4.8	7.3	10.2	13.4	16.3	19.5	22.6	25.9	29.1
I109Welfare	0.1	0.8	2.6	4.9	6.9	8.8	10.8	12.9	15.0	17.2
I110Entrtain	-0.7	-1.3	-1.3	-1.3	-1.0	-0.9	-0.4	0.2	0.9	1.5
I111Hotels	-2.1	-2.6	-1.5	0.0	1.7	3.3	5.3	7.3	9.6	12.0
I112PerServ	-1.9	-3.6	-3.9	-4.0	-4.3	-4.8	-4.9	-5.0	-5.1	-5.1
I113Other	-0.6	-0.8	1.7	4.9	8.2	11.3	14.5	17.8	21.2	24.7
Household	-3.2	-6.3	-6.1	-6.3	-7.0	-7.6	-8.3	-8.9	-9.4	-10.0

Table 6.16

2009 BASECASE MONASH GENERATED DATA: Emissions, CO_2 equivalent, kT

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I1Pastoral	0	0	0	201	0	202
I2WheatSheep	0	3	0	2448	0	2451
I3HighRain	0	2	0	638	0	639
I4NthBeef	0	0	0	256	0	256
I5MilkCattle	0	18	0	483	0	501
I6OthExport	0	24	0	584	0	609
I7ImportComp	0	28	0	649	0	677
I8Poultry	0	87	0	9	0	96
I9AgServ	0	0	0	239	0	239
I10Forestry	0	71	0	1192	0	1263
I11Fishing	0	0	0	1202	0	1202
I12IronOre	515	56	0	295	0	866
I13NFerrous	445	249	0	1232	0	1926
I14BlkCoal	14257	121	0	688	0	15066
I15aOil	149	1671	0	27	0	1847
I15bGas	97	1086	0	17	0	1200
I15cBrCoal	32	348	0	6	0	386
I16OthMin	118	70	0	746	0	933
I17MinServ	0	22	0	248	0	270
I18Meat	681	170	0	291	0	1141
I19Dairy	890	147	0	166	0	1202
I20FrtVeg	378	85	0	131	0	594
I21OilFat	50	6	0	10	0	67
I22Flour	289	64	0	36	0	388
I23Bakery	90	53	0	133	0	276
I24Confect	22	6	0	18	0	47
I25Sea_Sugar	368	140	0	267	0	775
I26SoftDr	43	24	0	145	0	212
I27Beer	121	22	0	24	0	167
I28OthDrink	59	28	0	48	0	135
I29Tobacco	28	3	0	4	0	35
I30Ginning	34	4	0	11	0	49
I31Synthetic	48	8	0	4	0	60
I32CottonYa	69	9	0	5	0	83
I33WoolYarn	0	0	0	8	0	8
I34TextileF	71	22	0	10	0	103
I35Carpets	8	2	0	7	0	17
I36Canvas	1	1	0	14	0	16
I37Knitting	8	2	0	6	0	15
I38Clothing	11	1	0	33	0	45
I39Footwear	0	0	0	3	0	4
I40Sawmill	99	20	0	217	0	336
I41Panels	228	36	0	82	0	346
I42Fittings	23	9	0	100	0	132
I43Furniture	10	9	0	63	0	82
I44PulpPaper	1170	135	0	137	0	1442
I45BagsBoxes	36	16	0	55	0	106
I46Sanitary	313	36	0	30	0	379
I47NewsBooks	4	6	0	158	0	168

Table 6.16 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I48CommPrint	31	24	0	224	0	279
I49Fertilisr	31	141	0	21	0	193
I50BasicChem	2192	1411	0	1094	0	4696
I51Paints	21	5	0	91	0	117
I52Pharmacy	13	5	0	61	0	78
I53Soaps	25	5	0	44	0	75
I54Cosmetics	4	10	0	17	0	31
I55Explosive	65	19	0	137	0	221
I56Petrol	351	0	0	15448	0	15799
I57Glass	93	131	0	60	0	284
I58ClayProd	331	205	0	77	0	613
I59Cement	920	1396	0	181	0	2497
I60Readymix	14	12	0	138	0	164
I61Pipes	96	51	0	109	0	256
I62Plaster	220	48	0	42	0	309
I63IronSteel	6949	2019	0	578	0	9545
I64aNFerrous	5432	629	0	3947	0	10009
I64bAlum	7118	825	0	5186	0	13129
I65Structurl	107	83	0	148	0	338
I66SheetMetl	54	208	0	106	0	367
I67Wire	132	154	0	147	0	433
I68MotorVeh	160	138	0	60	0	358
I69Ships	50	19	0	28	0	97
I70Trains	25	14	0	10	0	50
I71Aircraft	5	6	0	20	0	31
I72SciEquip	4	4	0	20	0	28
I73Electron	34	5	0	58	0	98
I74HousAppl	55	17	0	13	0	85
I75ElectEq	33	47	0	82	0	163
I76AgMach	30	28	0	9	0	68
I77ConMach	16	7	0	11	0	34
I78ManuMach	115	81	0	139	0	335
I79Leather	32	4	0	16	0	52
I80Rubber	38	14	0	35	0	87
I81Plastic	41	22	0	106	0	169
I82Signs	2	2	0	13	0	17
I83SportEq	512	74	0	18	0	604
I84aaaEleBr	0	0	0	0	0	0
I84aaaaEdis	0	0	0	77	8347	8425
I84aaabEBrix	0	0	0	14	1870	1883
I84aaacHaz	0	0	0	124	15599	15723
I84aaadLoyY	0	0	0	155	16828	16983
I84aaaeYall	0	0	0	112	13265	13378
I84aaafFlin	0	0	0	54	5422	5476
I84aabEleBlk	0	0	0	1121	79683	80804
I84aacEleGas	0	0	0	78	5177	5255
I84aadEleHyd	0	0	0	141	0	141
I84aaeEleOth	0	0	0	13	0	13
I84bElectTrn	0	0	0	128	0	128
I84cElectDist	0	0	0	1215	0	1215
I85Gas	66	20253	0	91	0	20409
I86Water	33	0	0	1113	0	1147

Table 6.16 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I87Resident	0	264	0	1869	0	2133
I88OthBuild	149	161	0	2495	0	2805
I89Wholesale	280	118	0	5187	0	5585
I90RetailTrd	1261	500	0	2480	0	4241
I91MechRep	0	0	0	37	0	37
I92OthRepair	0	0	0	587	0	587
I93RoadTrans	0	253	0	7247	0	7500
I94RailTrans	0	439	0	3296	0	3734
I95WaterTran	265	14	0	1954	0	2232
I96AirTransp	0	0	0	9280	0	9280
I97TransServ	0	0	0	250	0	250
I98Communic	0	953	0	1265	0	2218
I99Banking	0	507	0	393	0	900
I100NonBank	0	0	0	92	0	92
I101Investm	0	74	0	99	0	173
I102Insurnce	0	0	0	94	0	94
I103OthFinan	0	0	0	5393	0	5393
I104Dwelling	0	0	0	155	0	155
I105PubAdmin	324	379	0	482	0	1185
I106Defence	117	1056	0	1790	0	2963
I107Health	472	373	0	590	0	1434
I108Educate	47	221	0	22	0	290
I109Welfare	11	1253	0	4243	0	5506
I110Entrtain	90	137	0	540	0	767
I111Hotels	9	301	0	192	0	502
I112PerServ	19	32	0	730	0	780
I113Other	0	0	0	0	0	0
Household	199	0	0	25329	0	25528
Total	49455	40069	0	122397	146192	358113

6.5 SIMULATION

The shock is representative of greenhouse policy associated with the introduction of trading emission permits or a CO_2 tax. As mentioned in Section 6.4, the simulation is conducted as a threefold shock upon the CO_2 emitting sectors of the Australian economy. The first shock involves an increase in the power of the tax on users of the CO_2 emitting fuels, black coal (*BlkCoal*), gas (*Gas*) and petrol (*Petrol*).[117] The remaining shocks are upon the electricity generating sectors of the economy. Specifically, the shock involves an increase in the power of the tax on users of electricity produced by CO_2 emitting generators (*EleBlk, EleGas, EleHyd, EleOth*). The final shock is an increase in the power of the tax on the brown coal electricity industry's (*EleBr*) use of the CO_2 emitting commodities (*Edis, EBrix, Haz, LoyY, Yall, Flin*).

The simulation introduces a uniform $50 per tonne CO_2 tax which increases the power of taxes applying to intermediate sales of the CO_2 emitting fuels and sales of the electricity commodity. The imposition of the tax increases the price of the fuel and electricity commodities. Industries reliant on these commodities as intermediate inputs will experience a rise in their operating costs.

An industry has the limited capacity to substitute away from the usage of these fuels. As explained in Chapter five however, MONASH-Electricity incorporates extensive substitution possibilities for the electricity sector. Given the homogenous nature of electricity, consumers are unaware of its source and have no preference for a particular generator. Accordingly, a large elasticity of substitution has been used to allow consumers to choose between suppliers, based on the price of the commodity.

[117] For the purpose of description the shock will be referred to as a greenhouse fuel tax.

6.5.1 GRANDFATHERING RESULTS

Overview

The Greenhouse Fuel Tax (GFT) restricts the growth of the energy sectors in the economy such as electricity generation. The indirect result is that electricity intensive industries such as non-ferrous metals, experience an increase in their costs of production and consequently become less competitive, particularly on the international market.

Initially the large tax on usage of CO_2 emitting fuels absorbs the real return that was previously available to labour and capital. In the first year of the simulation, capital is fixed and the consumer's real wage rate (*W*) is sticky.

The key to the simulation results is that the tax imposes a wedge between the price of expenditure (the CPI[118]) and the price of the product (the GDP deflator at factor cost). With the after-tax real wage rate from the employee's point of view sticky in the short-run ($^{W}/_{CPI}$), the ratio of the real wage rate to the GDP deflator ($^{W}/_{PGDP}$) increases. The ratio ($^{W}/_{PGDP}$) is the real cost of labour from the producer's point of view. Hence, initially the nominal wage rises relative to the factor cost GDP deflator. The imposition of the tax increases the real cost of labour and hence suppresses the real return on capital. Because capital becomes cheaper relative to labour, producers attempt to substitute toward the cheaper input. However, the fixed capital stock forces producers to reduce the amount of labour they use, causing aggregate employment to fall.

After the first year, the real wage rate responds to conditions in the labour market. Because employment has fallen relative to base, the real wage rate also declines. This allows employment to move back toward base. The reduction in the real return on labour now absorbs some of the loss associated with the greenhouse tax and the relative price of capital begins to rise. This encourages the capital stock to rise periodically at the industry level.

[118] Consumer Price Index

As outlined in Section 6.4, the closure constrains investment in the renewable electricity generation industry to prevent its rapid growth. Along with its counterparts in the electricity sector, this industry is very capital intensive. The electricity industries are responsible for a greater share of capital relative to their share of investment. On aggregate the collapse in investment in the electricity industries causes investment to fall.

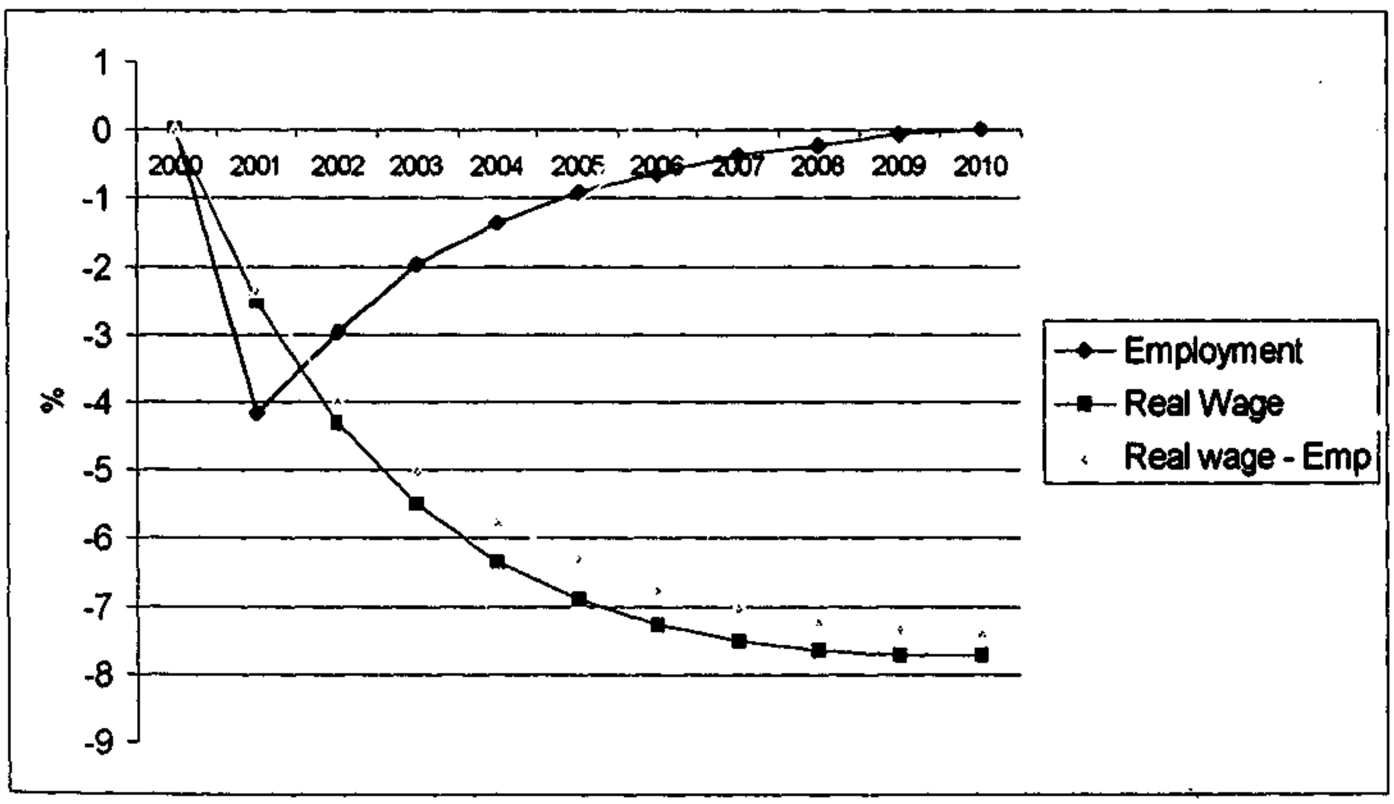
The results for factor inputs are discussed in more detail in the following sub-sections.

i Employment results are a reflection of the areas of the economy which are being stimulated.

Chart 1-GF shows the deviation-from-base path of employment.

Chart 1-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR EMPLOYMENT AND THE REAL WAGE



The economy's capital stock is fixed in the first year. In order to lower output, industries will be forced to reduce their usage of labour. Even those industries which are deemed to be capital intensive will attempt to reduce the amount of labour they use in their production process. To reduce output, an industry will demand less intermediate inputs and primary factors. The only primary factor that can be reduced in the short-run is labour.

In 2002 employment increases toward control as the wage-adjustment mechanism in the MONASH-Electricity model alleviates the impact of the GFT shock. In the closure it is assumed that employees respond to real after-tax wage rates. According to the labour-market specification in MONASH-Electricity, if a deviation shock moves employment below its basecase value, real wage rates gradually decrease to eliminate the initial employment response. The wage-adjustment mechanism is operational in Chart 1-GF. As employment falls, employees accept a reduction in their wage to encourage employment back toward control. Hence, the fall in aggregate employment is followed by a fall in the real wage.

The wage-adjustment mechanism usually returns employment to control after a period of five years. The results for this simulation indicate that employment does not return to its basecase level until 2010, a period of ten years. A contributing element to this slow recovery is the factor intensity of the expanding and contracting industries in the economy. Chart 7-GF shows the percentage-deviation-from-base output results for those industries who contract. Some of the industries in this group such as health (*I107Health*) are labour-intensive. Industries reduce their demand for factor inputs as their activity levels fall. A large proportion of labour-intensive industries following a similar path will hold aggregate employment below control for prolonged periods (see Appendix 6-A).

After the first year, the result for employment is further affected by the increase in aggregate investment. Point *v* below outlines the path for aggregate investment. In the MONASH-Electricity model there exists price-induced substitution between primary factors. Investment is considered to be relatively labour intensive due to the high representation of the construction industries. The commodities residential (*C89Resident*) and other buildings (*C90OthBuild*) represent a combined total of 79 percent of domestic investment. Both of these industries are very labour intensive with capital to labour ratios of 0.27 and 0.08 respectively. The reduction in aggregate investment leads to a contraction in the output of other buildings, and constrains aggregate employment.

ii The Capital Stock steadily decreases

As the real wage rate declines, producers will attempt to substitute labour for capital. One might expect a reduction in the capital stock as capital formation is discouraged by the relatively cheaper cost of labour. This situation however does not eventuate in the short run as the wage rate is not relatively lower than the price of capital after it has been deflated by the factor price index. In fact, the reverse has occurred with the price of capital falling relative to the price of labour.

The justification for the fall in the price of capital is based on what happens to the price of GDP at the macro level. The explanation starts with an analysis of the price of GDP from the expenditure side. As the CPI is the numeraire, the price of private consumption goods does not change. Rather, the price of GDP responds to the reduction in the price of government goods. The price of commodities sold to the Government decrease in response to the introduction of greenhouse policy. As shown on Appendix 6-B, commodities sold to the Government are mainly public sector services such as health and education. These commodities tend to be relatively labour intensive and do not use notable quantities of energy related commodities as intermediate inputs. The falling real wage leads to a small reduction in the price of goods consumed by the Government, and hence to an increase in the ratio of the CPI to the price of expenditure generally.

The impact on the price of GDP is very small due to the negligible percentage changes in the price of the remaining components of the expenditure side of GDP, including the terms of trade. There is a very slight change in both the price of GDP and the price of Gross National Expenditure (GNE). The difference between the two variables is attributed to indirect taxes.

With the price of GDP from the expenditure side explained, the next step is to analyse it from the income side of the economy. The price of GDP from the income side can be explained as the share of labour times the price of labour, plus the share of capital times the price of capital, plus the share of taxes times the increase in ad valorem tax rates.

As mentioned above, in the first year it is assumed that real wages are sticky. Although the wage-adjustment mechanism allows the real wage to fall, it takes some time for this adaptation to occur.

Taxes represent approximately 5 percent of GDP in the model before the imposition of greenhouse policy. Whilst this is a relatively small share, taxes are very important factor in greenhouse policy analysis. In the simulations described in this chapter, taxes absorb a higher portion of the price of GDP than previously.

Given that it has been determined from the expenditure side that the price of GDP changes only slightly, and it is assumed that the price of labour does not change due to sticky wages, the movement in the taxes must be absorbed by a corresponding movement in the price of capital. The increase in taxes, coupled with the stable price of GDP, forces the price of capital down.

To summarise, the price of GDP does not initially change in response to the policy shock. The economy has experienced a large increase in indirect taxes. Wages are sticky in the short-run and do not adjust in a downward direction. The economy consequently experiences a fall in its aggregate profit as the price of capital declines.

The analogy can be drawn at the industry level. Greenhouse policy is introduced and industries are taxed very heavily for their intermediate usage of the fuel and electricity commodities. The wage rate is sticky and employees refuse to accept a reduction in their earnings to offset the impact of the tax. The shareholders have no alternative but to accept a reduction in profits. Thus, the return on capital falls. Investment at the industry level declines and in the short-run industries use less capital than they otherwise would.[119]

The impact of the shock from the supply side of the capital market is a reduction in the capital stock. The reduction in the rental price of capital increases the capital to labour ratio. With the rate of return on capital lowered, owners of capital will reduce the amount they supply. At the industry level, the capital stock for most industries falls as they respond to the reduced rates of return.

In the long-run, the industry rates of return begin to rise in response to the capital shortage. Industries reply by increasing investment and consequently the path of the capital stock flattens out.

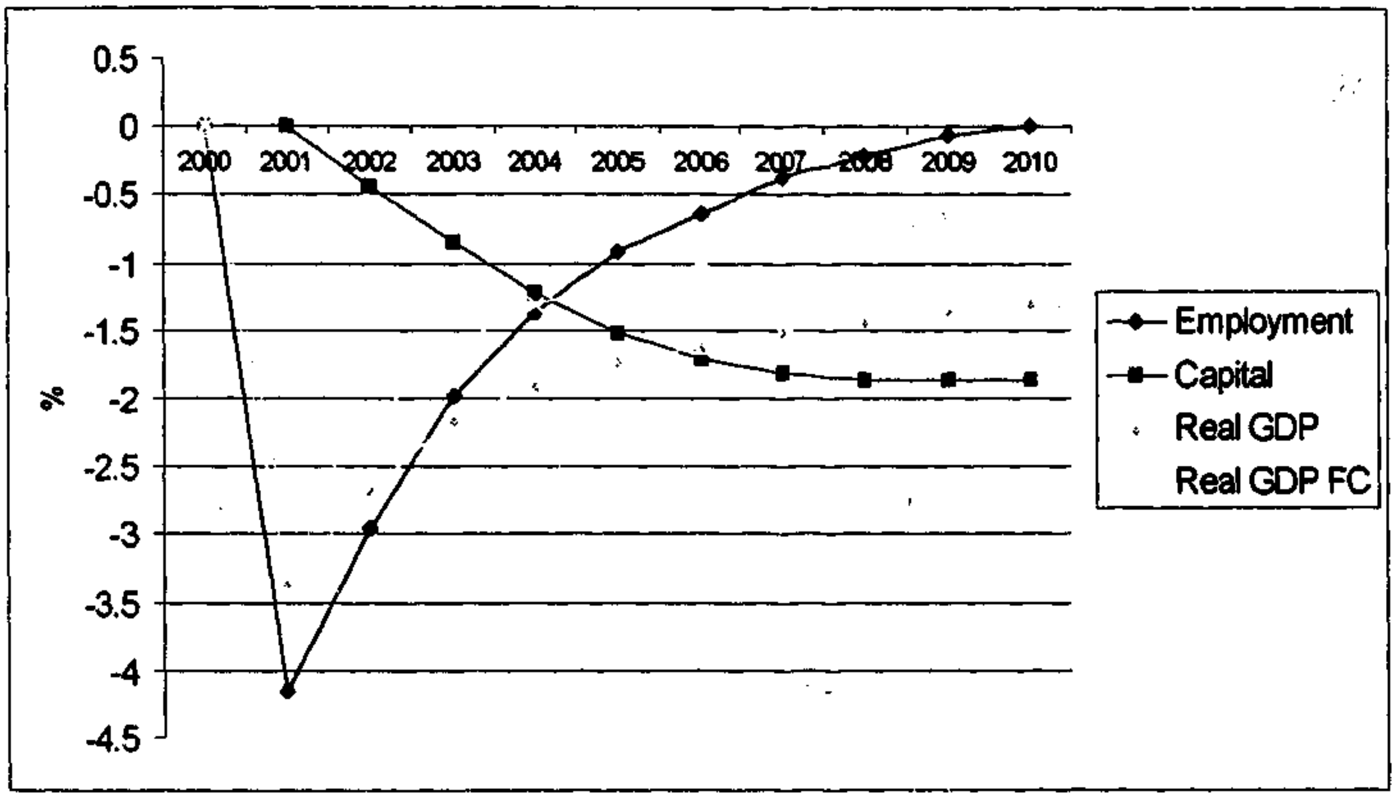
iii Results for GDP are driven initially by employment

Chart 2-GF shows the deviation-from-base paths for real GDP, aggregate employment and the aggregate capital stock. In the first year, the path of real GDP moves down in a similar manner to employment because the capital stock is fixed. As mentioned in point *i* above, the industries being damaged are predominantly capital intensive, but in the first year if industries want to contract they are forced to use less labour.

[119] This is offset by the fall in the relative price of capital which encourages its use. The rental price of capital at the industry level for those industries who collapse has fallen dramatically.

Chart 2-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR EMPLOYMENT, CAPITAL AND REAL GDP



The path for real GDP continues to follow the path of employment. As the wage-adjustment mechanism encourages the aggregate level of employment to rise, real GDP follows a similar pattern. As discussed in point *i* above, the real wage continues to decline throughout the period of the simulation. Producers respond to the lowering of the real wage by substituting labour for capital. Hence, in the long-run the capital stock continues to decline relative to base. Eventually employment returns to base, with capital and real GDP in long-run decline.

In 2004 the path of both real GDP at market prices and real GDP at factor cost lie below the path of both employment and the capital stock. This is attributable in part to the treatment of productivity growth at the industry level in the basecase. Industries who are assumed to experience strong productivity growth in the basecase are damaged by the imposition of the greenhouse policy. In particular, the collapse of the non-ferrous sector results in the economy experiencing less technical progress and consequently suppresses growth in real GDP.

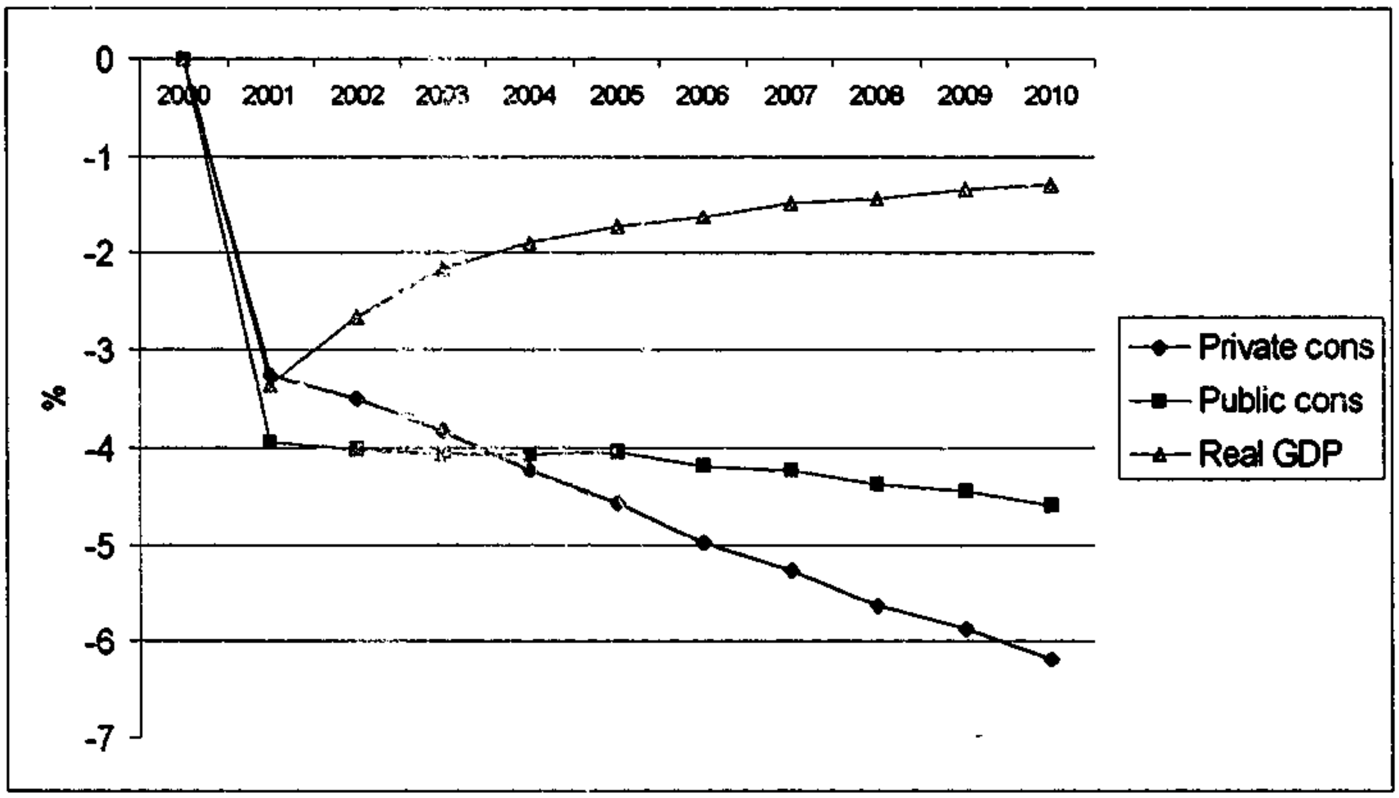
The change in aggregate employment is driving the change in real aggregate value added. The result for GDP at factor cost can be verified by summing the share weighted average of the percentage change in real employment, aggregate capital, other costs and cost savings from technical change. Other cost tickets allow for costs not explicitly identified in MONASH-Electricity, such as the costs of holding inventory. The quantity of other cost tickets used by an industry is proportional to the industry's activity level. As the aggregate industry activity level in the economy declines, demand for other costs also declines.

iv Consumption and Government Expenditure Results determined by the Closure

As shown on Chart 3-GF, both private consumption and public consumption show decreases in their deviation-from-base paths.

Chart 3-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR PRIVATE AND PUBLIC CONSUMPTION



The simulation is based on the notion that the Australian Government imposes a carbon tax upon those sectors of the economy who consume CO_2 emitting commodities. The revenue collected from the GFT is then returned to the owners of the firms under the assumption that the emission permits are grandfathered free of charge.

As discussed earlier, the closure for the grandfathering simulation is modified so that the consumption function is switched off and nominal total household consumption is set equal to the sum of the CPI and real household consumption. Hence, nominal and real household consumption are identical. By exogenizing the average propensity to consume, nominal total household consumption is allowed to respond to changes in household disposable income.

As shown on Chart 3-GF, the percentage change in private consumption expenditure moves in line with the percentage change in real GDP in the first year of the policy shock. However, the paths after 2002 diverge as private consumption follows the path of household disposable income. Household disposable income responds to changes in GDP as well as benefit payments and deductions for taxation. There is a reduction in the percentage change for the net interest payments made by the Government, grant payments, the age benefit and the health benefit. Offsetting this is a large percentage change in the unemployment benefit in response to the reduction in aggregate employment in the first year.

The net effect of the imposition of the GFT and the grandfathering of the tax revenue is a reduction in household disposable income. The grandfathering of the tax increases household disposable income but it is offset by the significant payments made by the owners of the firms (households) to the Government for the GFT. Households respond by reducing their private consumption.

As mentioned previously, in accordance with the grandfathering methodology, the tax collected by the Government is returned to the household sector of the economy. The tax refund is equivalent in the first year of the policy shock to 6 percent of total household consumption from both domestic and imported sources. The difference between the 6 percent and the fall in real GDP supports the result of a 3 percent decrease in private consumption.[120]

Government expenditure has been tied to real GNE. Whilst the closure encourages public consumption to respond to real GNE, the Government moves toward a current account surplus (CAS). The CAS arises as the Government collects the taxation revenue and returns only 80 percent of it to the household sector of the economy. The remaining revenue improves the Government's current account position.

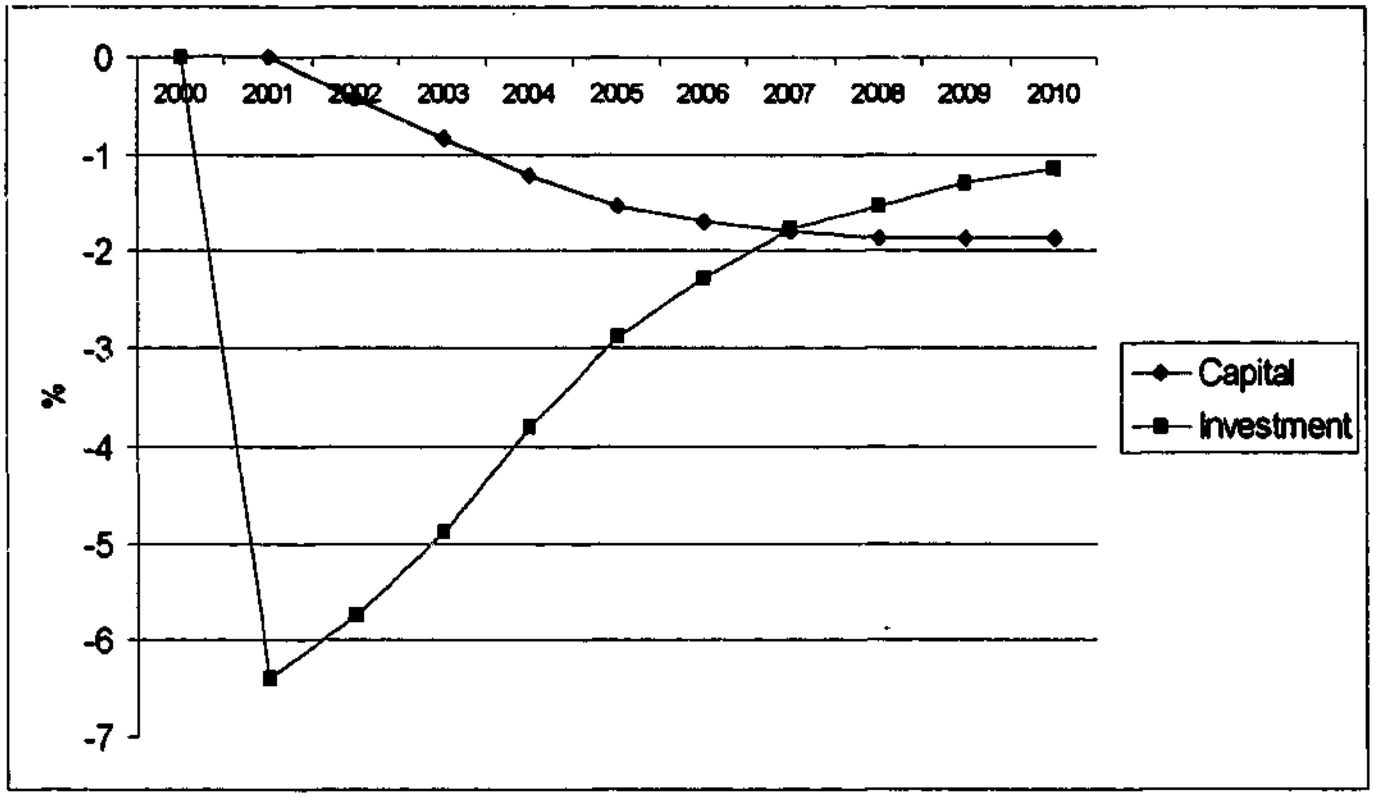
Investment is the other key influence on GNE

Chart 4-GF shows the percentage deviation from base paths for investment and the capital stock. In the short-run investment falls.

[120] The difference between the result for the value of Real GDP (equivalent to 9 percent) and the 6 percent tax refund.

Chart 4-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR CAPITAL AND INVESTMENT



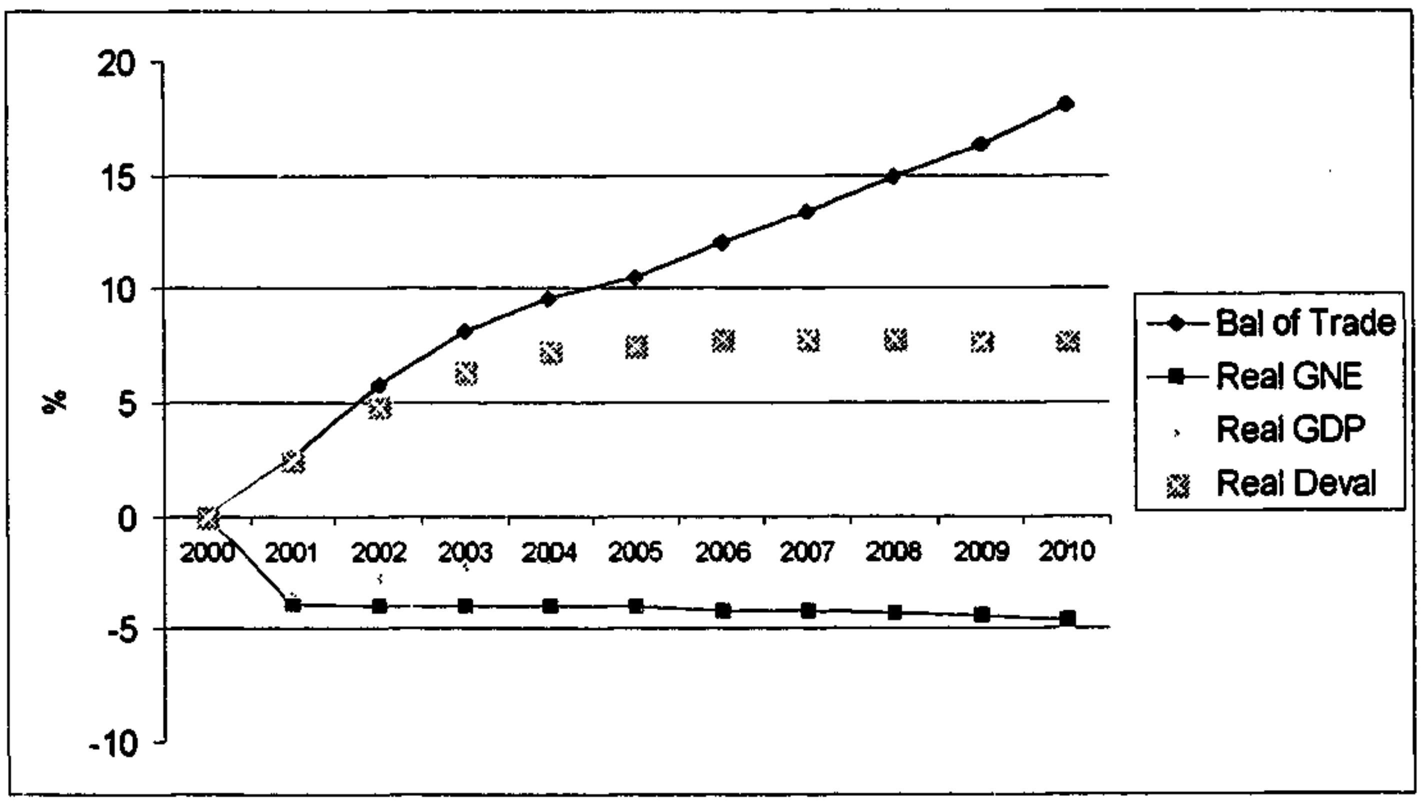
The path of investment at the industry level influences the result for aggregate investment. Aggregate investment is determined by the rate of return at the industry level. As discussed in point *ii* above, the expected rate of return for most industries has fallen following the imposition of greenhouse policy. The fall in the price of capital creation is attributable in part to the reduction in the real wage as investment is labour intensive. After the first year the price of investment increases, decreasing rates of return and discouraging investment. This helps to explain why the path of aggregate investment after the first year rises quickly at first, before its growth slows.

The fall in investment causes real GNE to decline relative to real GDP. The difference between real GNE and real GDP is the balance of trade. The contraction in investment lowers demand for imports, leading to an increase in the balance of trade. This in effect leads to an improvement in the result for real GDP which is not replicated in the calculation of real GNE as it excludes consideration of movements in export and import volumes.

Of importance to the macroeconomic story is that the closure is set up so that movements in the balance of trade reconcile model-determined movements in GNE with GDP. The results shown on Chart 5-GF indicate that the model driven percentage changes in GDP and GNE are different as GDP falls relatively further from base. Accordingly, the balance of trade moves toward surplus, depicted as a rise in the Balance of Trade (BT) to GDP ratio. The main mechanism for generating a shift toward surplus in the trade account is the real depreciation of the currency. Chart 5-GF shows the real depreciation in the Australian dollar which stimulates export activity and restricts imports.

Chart 5-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR REAL GDP, REAL GNE, BALANCE OF TRADE/GDP RATIO AND REAL DEVALUATION



The model reconciles the difference between GNE and GDP by depreciating the Australian currency to prevent aggregate exports from falling even further. In the absence of the depreciation, the balance of trade would have incurred a more exaggerated deficit than that presently found in the results.

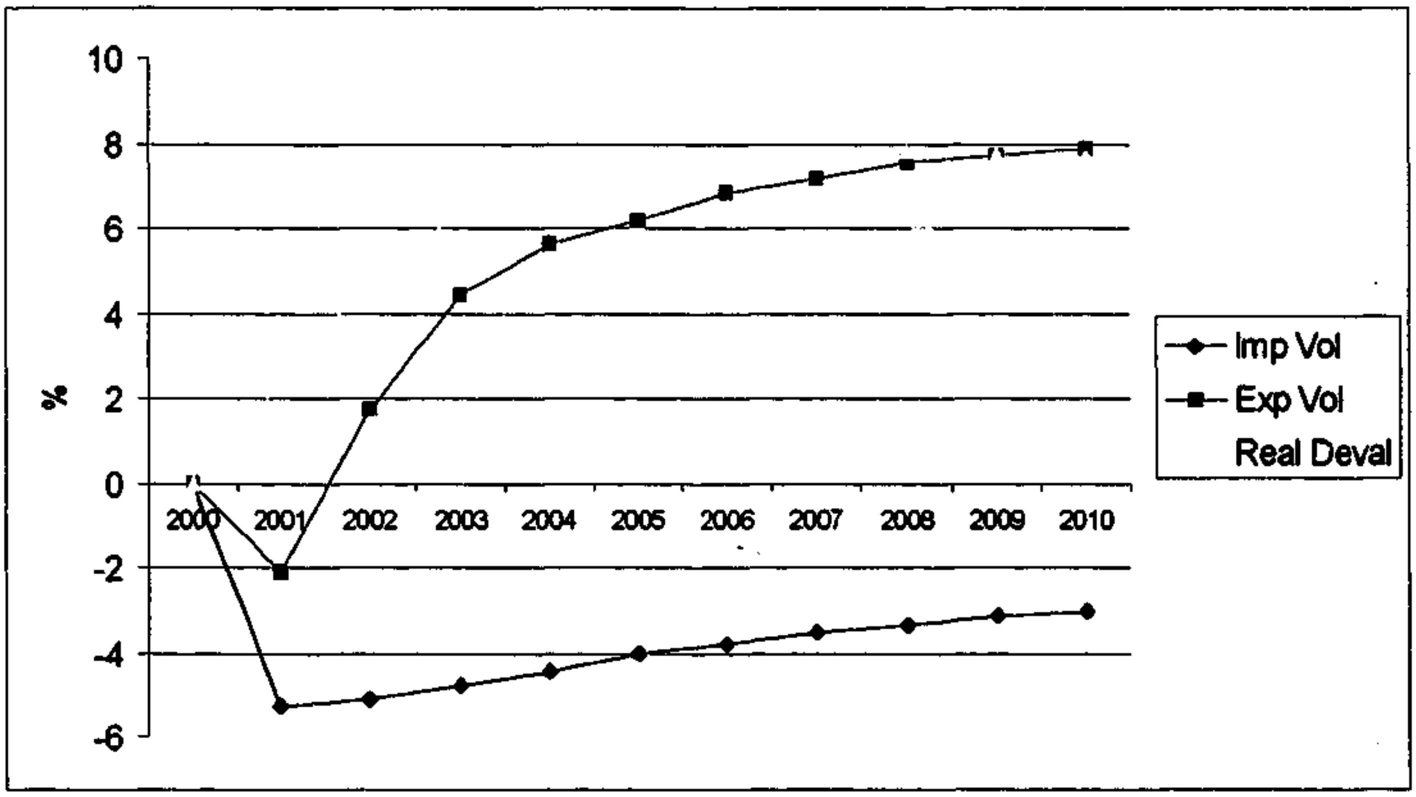
The trade results, as shown on Chart 6-GF, indicate that both imports and exports decline in the first period of the simulation. The reduction in imports can be mainly attributed to the price effect of the depreciation in the Australian dollar and the activity effect of the lower demand for import use in production.[121] The reduction in exports is due to the activity effect of a lower demand for exports, which offsets the stimulus arising from the real depreciation. A significant portion of Australia's exports are energy intensive and are therefore heavily affected by the imposition of a greenhouse policy. The collapse of the non-ferrous sector both domestically and on the international market will have a negative impact upon the result for aggregate exports.

The weakness in investment may also cause a decline in demand for imports. Imports are used highly for investment purposes. Contraction in the investment sector will lead to less imported inputs used.

[121] The commodities most commonly imported into Australia for use as intermediate inputs are science equipment (*C74SciEquip*), electronics (*C75Electron*) and construction machinery (*C79ConMach*). (Appendix 6-C) In the majority of instances, these commodities are purchased by industries who experience a decline in their activity levels following greenhouse policy. Policy effected industries reduce their output and in doing so reduce the level of domestic and imported commodities they use as intermediate inputs.

Chart 6-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR IMPORTS, EXPORTS AND REAL DEVALUATION OF THE CURRENCY



vii Gains and Losses for Industry Sectors are Consistent with the Macroeconomic Results

There are both direct and indirect impacts of the GFT upon industries. The industry results depend upon whether:

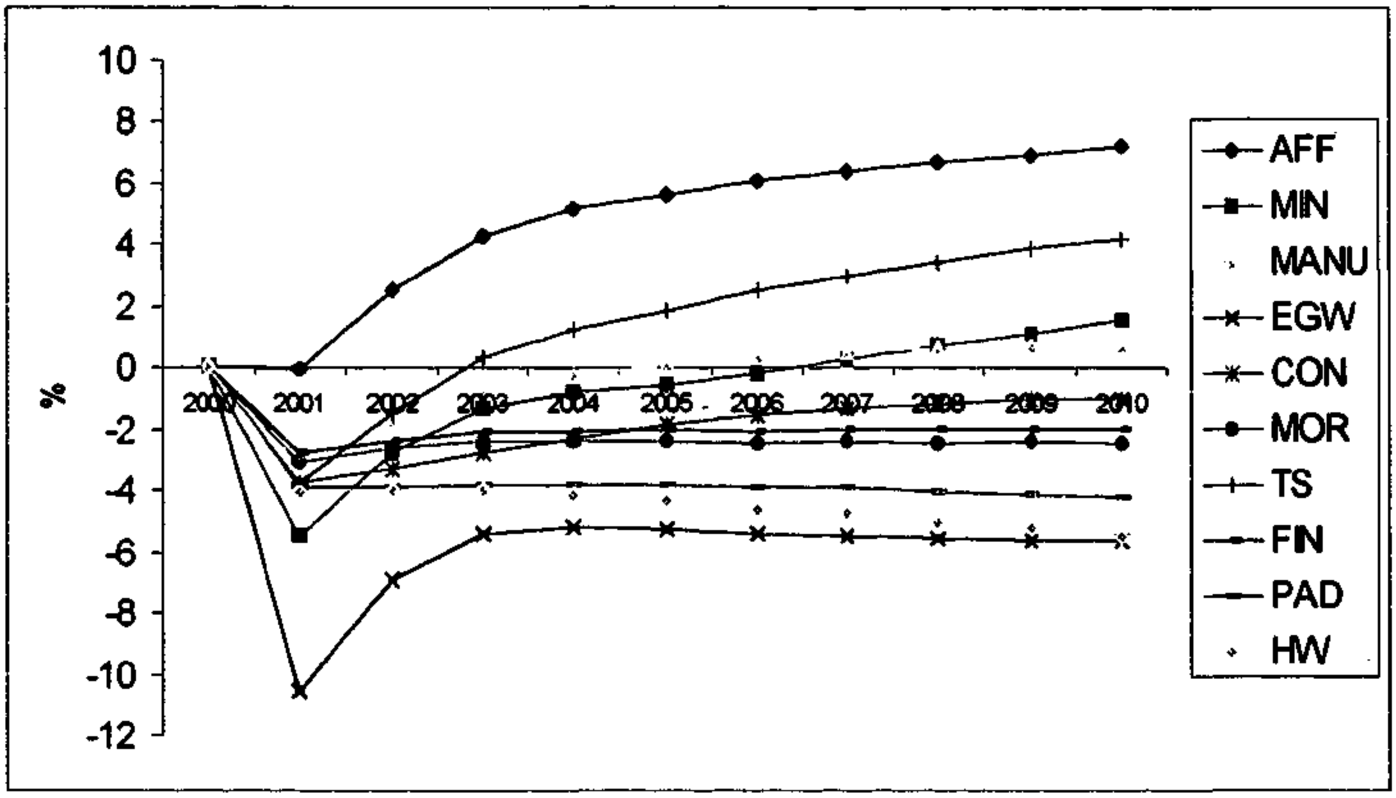
- CO_2 emitting fuels, or electricity, are an important part of an industry's costs; and
- the industry is price sensitive.

Domestic industries who compete on the international market are price sensitive. The demand for exports and imports will respond to the changes in relative prices caused by the depreciation of the Australian dollar. Those industries which sell to the household sector will also be price sensitive as households can substitute between domestic goods.[122]

Chart 7-GF shows the percentage deviation-from-base paths for the industry sectors of the Australian economy.

Chart 7-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR INDUSTRY SECTORS



Industry sectors who fair well after the policy shock are the export orientated sectors such as *Agriculture, Forestry, Fishing and Hunting* (AFF). Many of the industries in this group are classified as traditional exporters who benefit from the depreciation of the currency. Chart 7-GF also shows an expansion in the *Transport and Storage* (TS) sector. This sector expands as many of its industries provide transport services to the export industries.

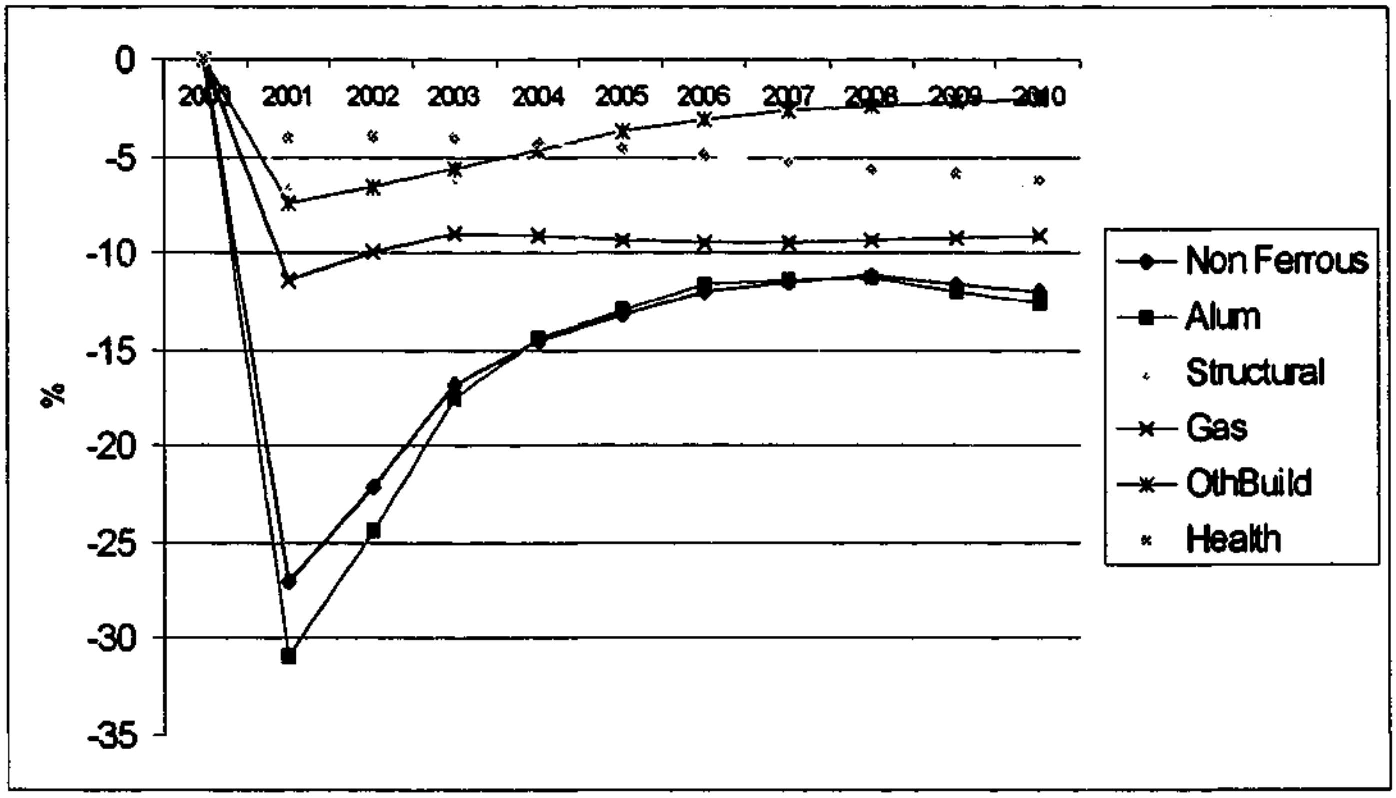
As expected, the industry sector to perform most poorly is *Electricity, Gas and Water* (EGW). As will be explained in point *viii* below, some industries within the electricity sector such as *EleGas* increased their output but on the whole most suffered as greenhouse policy increased their costs and made them less attractive to other sectors within the economy.

[122] Household substitution between commodities is however constrained by a low substitution elasticity.

Chart 8-GF shows the deviation-from-base paths for those industries who reduce their output levels after the GFT.

Chart 8-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR INDUSTRIES WHO CONTRACT FOLLOWING THE CO_2 TAX



The two stand out losers in the aftermath of the greenhouse policy shock are the non-ferrous metals industries *NFerrous* and *Alum*. The reason for such a notable collapse is twofold. The industries suffer directly as the price of intermediate fuel usage increases. The tax on usage of the petrol commodity (*C58Petrol*) will impact upon the non-ferrous metal industries as it represents an important part of industry costs – 13 percent of *NFerrous* and 12 percent of *Alum*. (Appendix 6-D) The indirect effect is the rise in the price of electricity. The refining of non-ferrous metals is very electricity intensive and consequently an increase in the cost of electricity has contracted the activity levels of these industries (Dixon, Parmenter and Rimmer 1999). The sector will however benefit from the devaluation of the currency as its exports become more attractive on the international market. The non-ferrous metal industries export a high share of their commodity output.

Additional losers include the retail gas (*I85Gas*) and structural (*I65Structural*) industries.

The retail gas industry suffers as the CO_2 emission tax is levied on its main intermediate input, natural gas (*Gas*). A significant share of retail gas is consumed by the non-ferrous metal sector as an intermediate input. Almost 8 percent of output is sold to *NFerrous* and 10 percent to *Alum*. As discussed above, both of these industries collapse following the imposition of greenhouse policy, and both subsequently reduce their demand for intermediate inputs. In addition, over 30 percent of industry output is sold to the household sector of the economy which reduces its consumption expenditure. As the retail gas commodity is not exported, the industry does not benefit from the depreciation of the currency.

The structural industry represents an important part of investment. The industry sells 14 percent of its output to the residential sector (*I87Resident*) and 55 percent to other building (*I88OthBuild*). The industry activity level for the residential sector remains virtually unchanged due to the fact that the model's closure ties down the use of capital in the dwellings industry (*I104Dwellings*). As the dwelling industry uses only capital as its primary factor input, and as the capital stock for this industry is exogenously shocked at zero, its output remains unchanged. As the residential sector sells almost all of its output to dwellings, there is no change in demand for output from this industry. (Appendix 6-E) Hence, the result for the structural industry moves in line with output fluctuations in other buildings (*I88OthBuild*), which itself contracts in response to the fall in aggregate investment. Thus, the indirect link between the reduction in investment and the collapse of the structural industry has been established.

As outlined in the previous paragraph, other buildings (*I88OthBuild*) collapses due to its reliance on investment. As aggregate investment falls, demand for other building supplies follows suit.

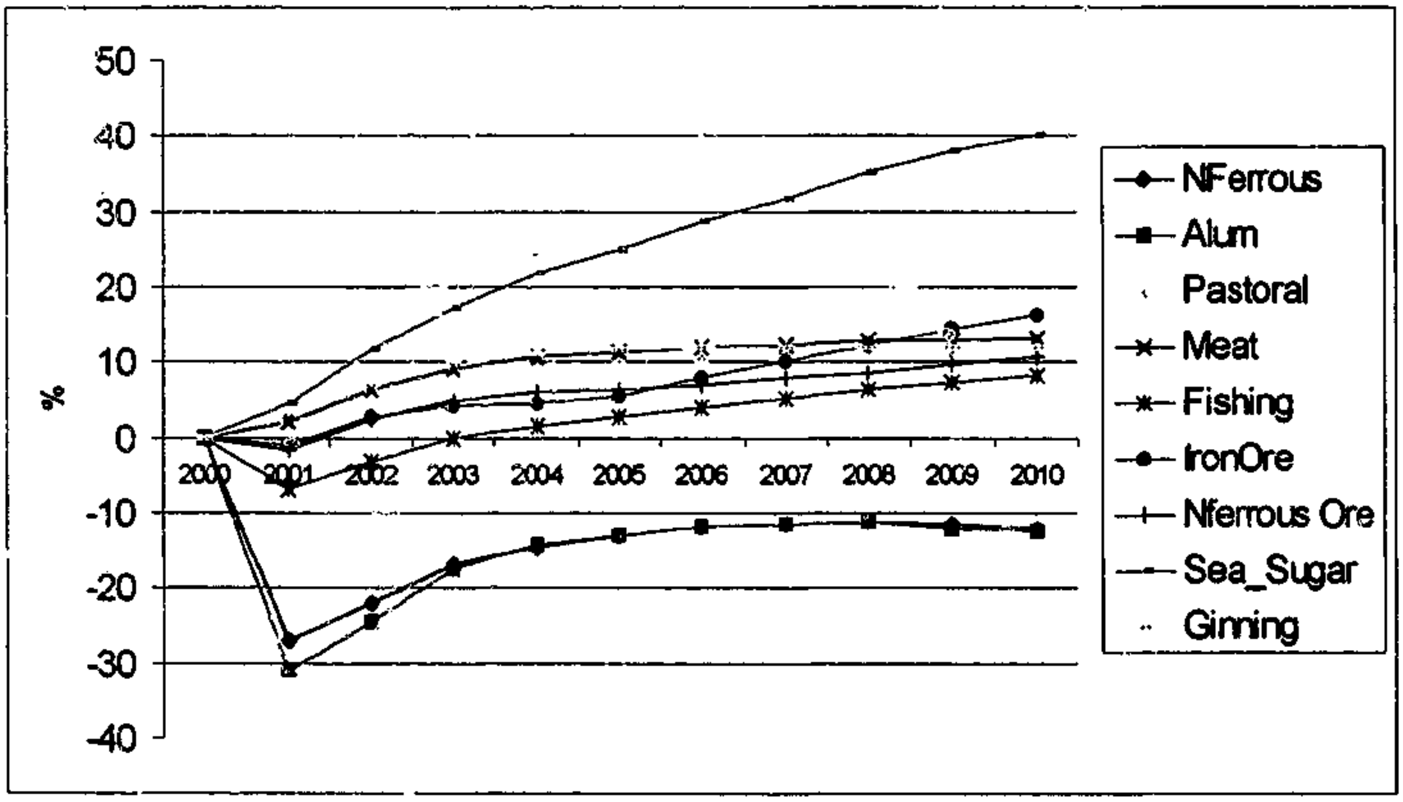
Industries such as health (*I107Health*) collapse following the reduction in private and public expenditure. Appendix 6-B outlines the results for those industries who represent a significant percentage of aggregate government demand. Appendix 6-G represents industries who sell a large percentage of their commodity output to the household sector.

ix Traditional Export Orientated Industries

Chart 9-GF shows the deviation-from-base paths for the traditional export orientated industries.

Chart 9-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR TRADITIONAL EXPORT ORIENTATED INDUSTRIES



Additional industry losers to those mentioned above include traditional export-orientated industries such as fishing (*I11Fishing*). These export-orientated industries suffer as the introduction of greenhouse policy increases their operating costs. In the case of the fishing industry, the petrol commodity (*C58Petrol*) represents 32 percent of its intermediate input costs. The increase in the cost of petrol will consequently have a significant bearing on this industry's activity level.

Aside from the non-ferrous metals sector, the remaining traditional export orientated industries expand their output despite the introduction of greenhouse policy. This response is attributed to the significant depreciation of the Australian dollar which encourages foreign markets to purchase Australian commodities. Industries in this category tend to face very elastic export demand curves. For instance, if the price of Australian iron ore (*C14IronOre*) decreases relative to the international price of iron ore, demand for this commodity will increase substantially.

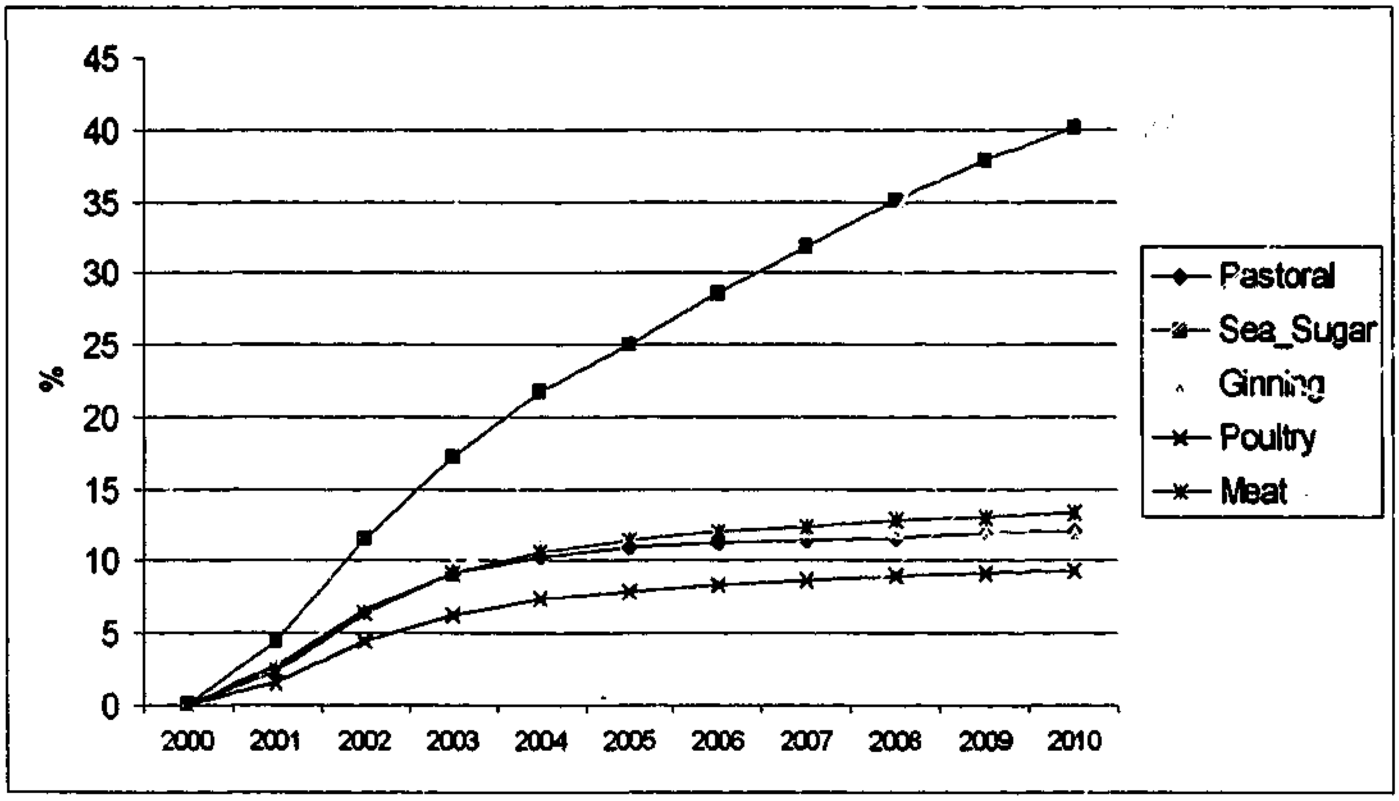
The differentiation between the results for the non-ferrous exported industries and the rest of the traditional exports is due to the reliance on energy as an intermediate input. Whilst all of the traditional export industries are associated with greenhouse intensive industries in some form, the degree of involvement varies significantly. For example, the sea and sugar industry (*I25Sea_Sugar*) is not nearly as reliant on energy as *Alum*. An outline of commodities purchased by the sea and sugar industry is provided in Appendix 6-H.

x Industry Winners

Chart 10-GF shows the deviation-from-base paths for those industries who expand their output levels after the GFT.

Chart 10-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR INDUSTRIES WHO EXPAND FOLLOWING THE CO_2 TAX



Industries who increase their output tend to use very little energy in their production process. The majority of industries who increase their industry activity are not exposed to a direct increase in their intermediate input costs when the price of fuel and electricity rises. (Appendix 6-I)

With the exception of the electricity generators, those industries who benefit from the introduction of greenhouse policy are traded internationally. The depreciation stimulates exports as they become relatively cheaper on the international market. Chart 5-GF shows the percentage deviation from base path for the real devaluation, which is similar to the output path of the expanding industries. The export orientated industries who expand include pastoral (*I1Pastoral*), northern beef (*I4NthBeef*), meat (*I18Meat*), sea and sugar (*I25Sea_Sugar*) and ginning (*I30Ginning*).

The Australian footwear industry (*I39Footwear*) improves its activity level because it competes directly with imported goods. Imports are now relatively more expensive due to the depreciation of the dollar. The footwear commodity (*C41Footwear*) is sold predominantly to the household sector of the economy as a final good. A very small amount is sold to other industries as an inter :ediate input.

The poultry industry (*I8Poultry*) is another industry who improves its outlook after the greenhouse policy is introduced. Almost all of the output of poultry (96 percent) is sold to the meat industry (*I8Meat*). As mentioned above, the meat industry improves its activity level as it benefits from the depreciation of the Australian dollar.

Whilst not shown on Chart 10-GF, an industry with a surprising increase in its activity level is non-ferrous ore (*I13Nferrous*)[123]. Although the industry benefits from the depreciation of the currency, its demand was expected to fall substantially given the collapse of the non-ferrous metals sector. A breakdown of the commodity sales of non-ferrous ore (*C15Nferrous*) reveals the answer. Over 76 percent of its output is sold overseas, with the remaining sales of 10 and 14 percent respectively made to the *NFerrous* and *Alum* industries. Hence, whilst almost all of its domestic sales are to the collapsing non-ferrous metals sector, the majority of its total sales are to foreign markets.

xi Fuels and Electricity

As shown in Chart 11-GF, of the fuel industries, brown coal (*I15cBrCoal*) experiences the greatest collapse. The brown coal industry is the most emission intensive of the fuels and its collapse is solely attributed to the introduction of the GFT. The result for the brown coal industry is dependent on the demand for its output by the brown coal electricity generators as these are the only industries who purchase its commodity. In turn, the result for the brown coal generators relies upon the activity levels of *EleBr*. As this industry experiences a decline in its activity level, it demands fewer intermediate inputs, the vast majority of which come from the brown coal generators.

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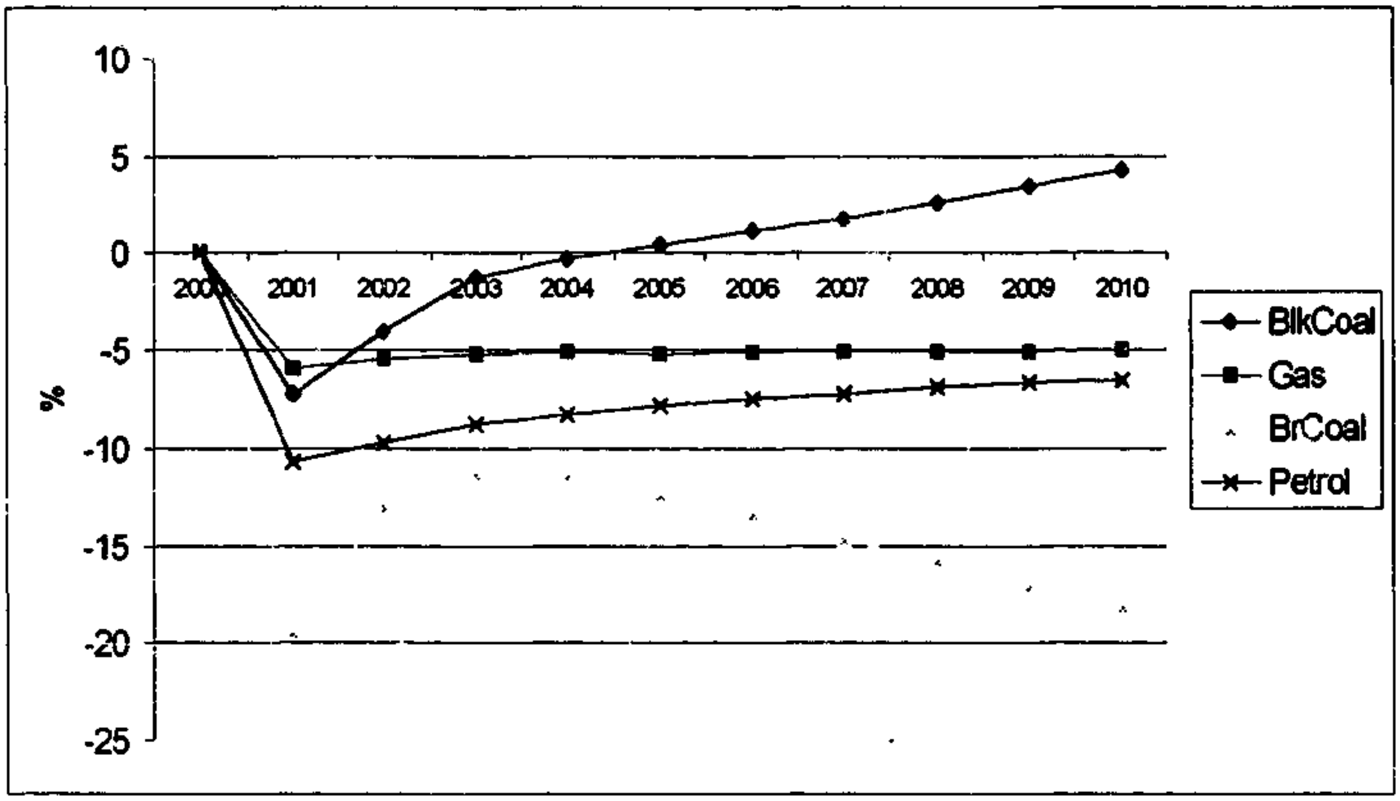
[123] The non-ferrous ores industry is distinguished from the non-ferrous metals industry in the model.

Chart 11-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR CO_2 FUEL INDUSTRIES



The result for the black coal industry (*I14BlkCoal*) is heavily influenced by the fact that it is a traditional exporter. Whilst some sales of black coal represent intermediate inputs to industry, a significantly large percentage is exported. There are two factors that determine the result for this industry.

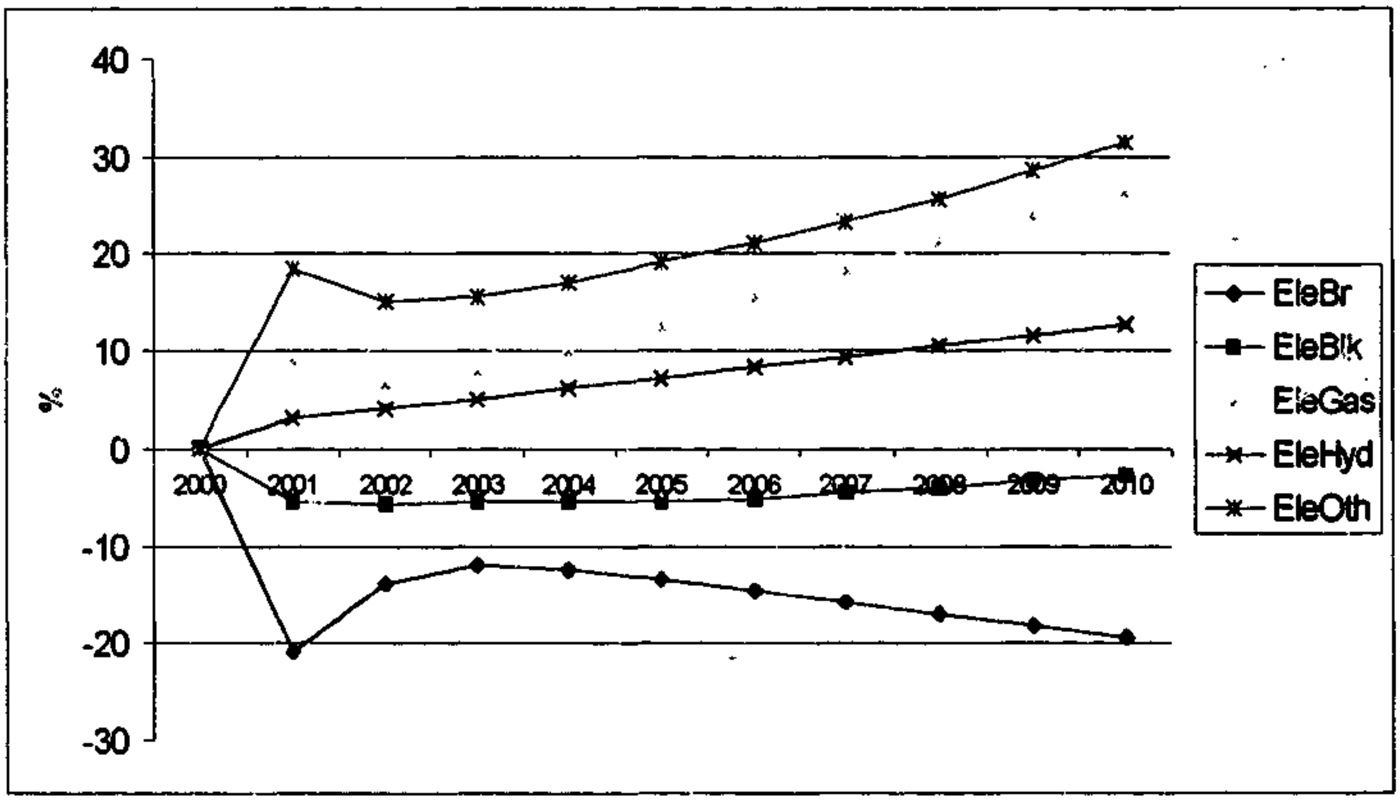
The first factor is that demand for black coal will fall as it is taxed directly under greenhouse policy. This is evidenced in the first year of the policy shock as the industry activity falls. As the price of black coal rises in response to greenhouse policy, industries reduce their usage of it as an intermediate input. Black coal is used as an intermediate input by *EleBlk*. The price of black coal to this industry will not rise directly with the introduction of greenhouse policy because as discussed earlier, it has been assumed that there are no emissions of CO_2 in the sales of *BlkCoal* to *EleBlk*. Despite this assumption, the demand for black coal will decline as *EleBlk* reduces its usage of intermediate inputs.

The second factor is the depreciation of the Australian currency which works to offset the negative impact of the previous influences. The depreciation makes black coal mined in Australia relatively cheaper on the world market, encouraging foreigners to substitute toward its consumption. The depreciation explains the upward path of the black coal industry after the initial impact of the policy shock. The other fuels such as gas and petrol are not exported from Australia, and therefore do not benefit directly from the depreciation. The output paths for these industries remain below base throughout the simulation period.

The percentage deviation from base paths for the electricity generation industries is shown on Chart 12-GF. Overall, the order of the collapsing industries is in line with the relative emission intensities of the fuels used in the generation process. The most emission intensive industry collapsed the greatest. Those generators who do not emit in the production process expand their output. Neither *EleHyd* or *EleOth* actually incur the impact of the tax as they are emission free generators. Demand for electricity generated by these sources increased as the electricity distribution industry substituted in favour of their output. The remaining generators experienced a shift of their supply curves to the left to reflect the new tax. This increased the price and reduced demand for these commodities.

Chart 12-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR CO_2 ELECTRICITY INDUSTRIES



After the first year of the policy shock, the path for *EleBr* increases toward base. At the same time the paths for the less emission intensive generators *EleGas* and *EleHyd* decrease toward base. It is believed that this occurs because of the additional substitution capacity available to *EleBr*[124]. The policy shock is introduced so that *EleBr* is not taxed directly, but indirectly via its use of electricity produced by the brown coal generators. The brown coal electricity industry has the capacity to substitute away from the emission intensive generators such as *EBrix* toward the 'cleaner' generators such as *LoyY*. This means that the relative price of *EleBr* may decrease slightly, encouraging substitution toward it. It is important to reiterate that the paths for the electricity generators remain in line with the relativity of their emission intensity.

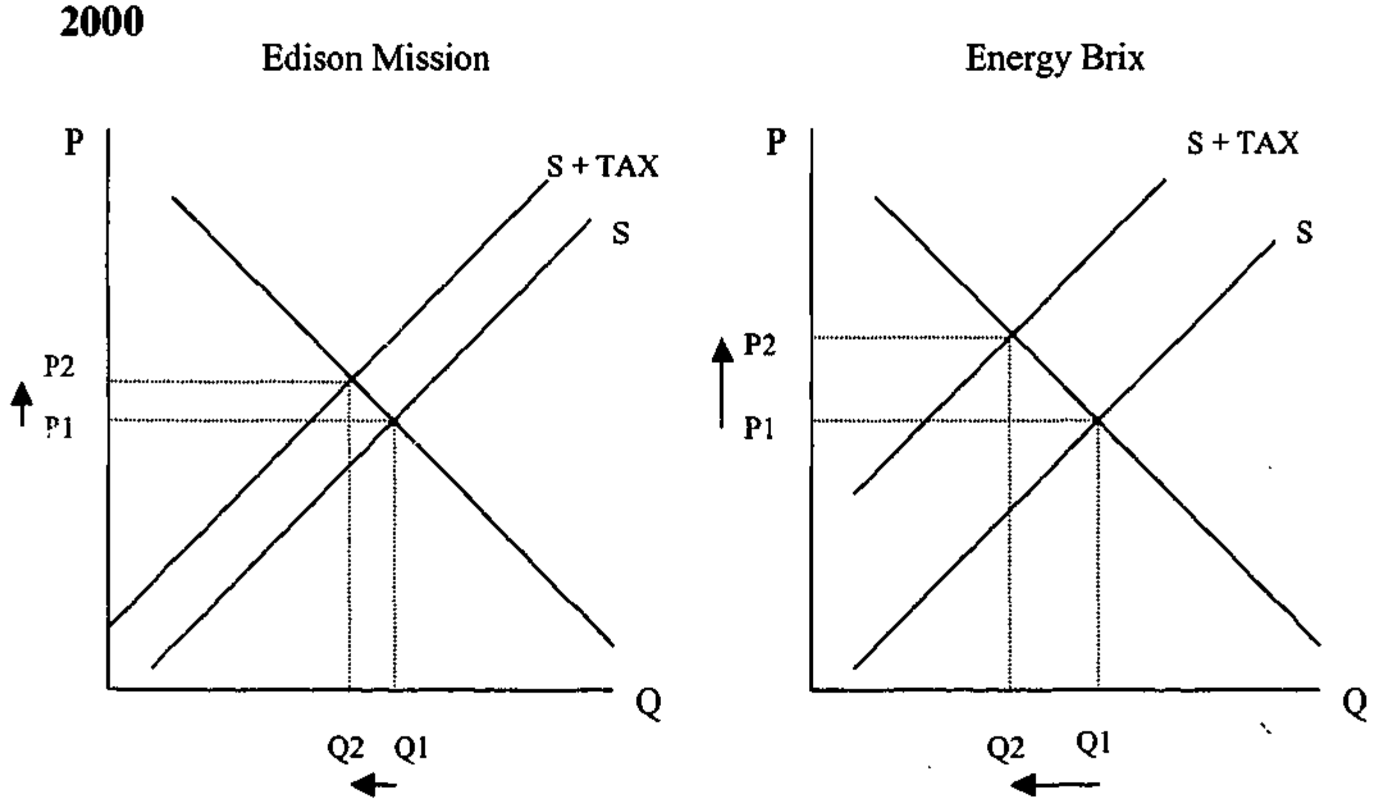
[124] Relative to the other electricity generators at this industry level such as *EleBlk*.

The impact of the GFT and the substitution between the generators can be explained with the use of the following diagrams. The diagrams refer to the most and least emission intensive of the generators located in the La Trobe Valley region. The generator with the highest CO_2 emission rate per MWh of electricity generated is *EBrix*, whilst *Edis* emits the lowest.

The analysis is based on the assumption that the generators face identical slopes in their demand and supply schedules. The brown coal generators are taxed directly on the basis of their CO_2 emission intensity. The tax is illustrated on Diagram 6-A as a shift of the supply curve to the left to depict the original supply plus the tax. The supply curve for *EBrix* shifts relatively further to the left due to the fact that the tax placed upon this industry is effectively higher.[125] After the adjustment to the new equilibrium, the price of *EBrix* is now relatively higher. This encourages *EleBr*, who is the only purchaser of the brown coal electricity, to substitute away from the use of electricity generated by *EBrix*. This is depicted in the industry activity result on Chart 13-GF.

Diagram 6-A

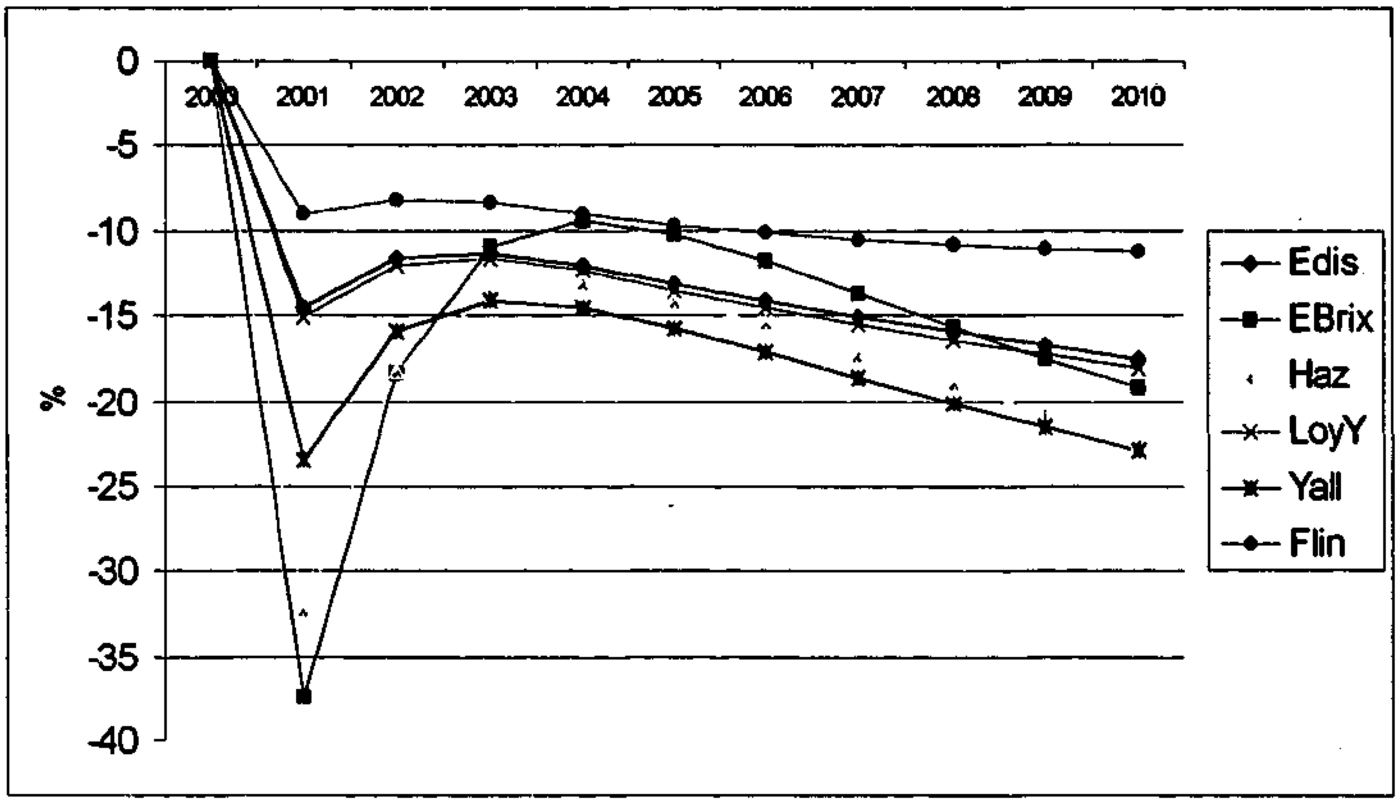
2000



[125] A uniform $50 tax per tonne of CO_2 is introduced, imposing a greater tax burden on the more emission intensive generators.

Chart 13-GF

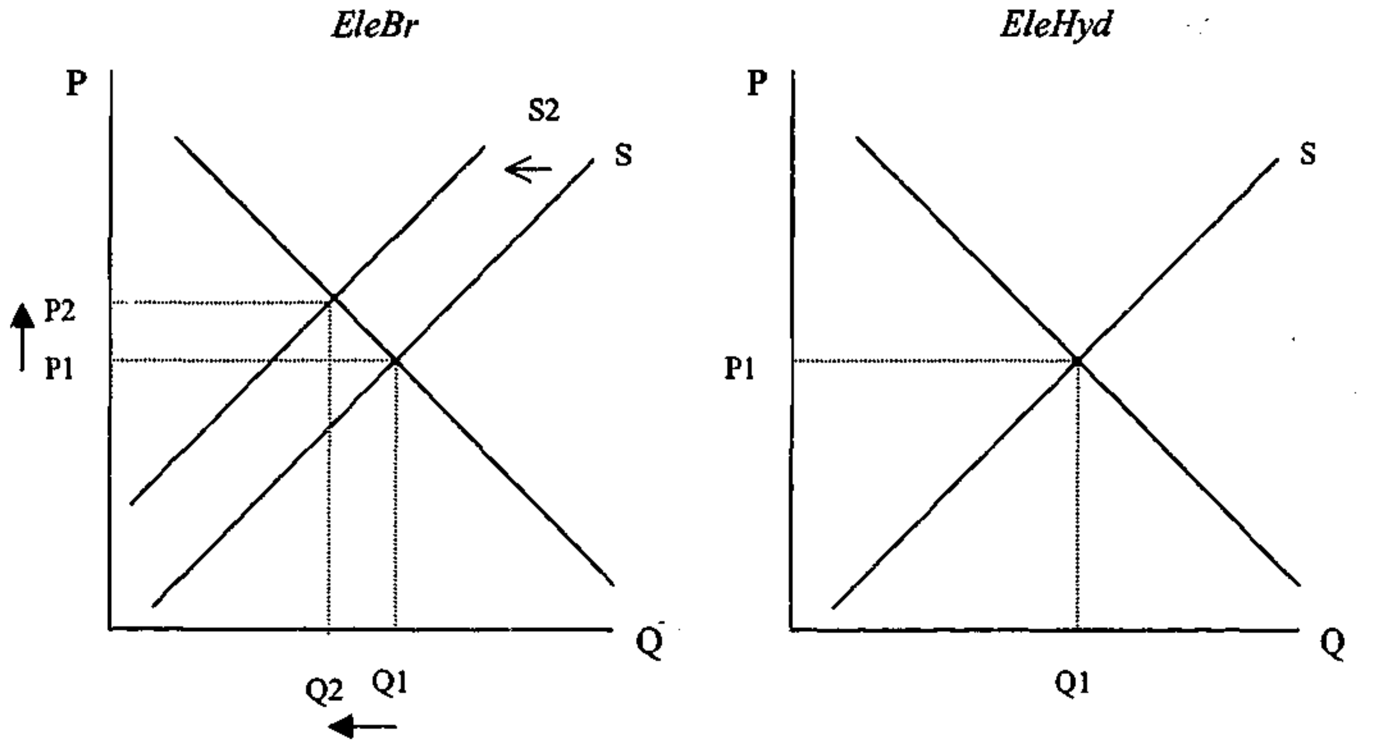
PERCENTAGE DEVIATION FROM BASE PATHS FOR BROWN COAL GENERATORS



The brown coal electricity industry *EleBr*, is not taxed directly as it does not produce any electricity of its own, but rather purchases it from the brown coal generators. The industry does however experience an increase in its operating costs as the price of the brown coal generated electricity rises in response to the imposition of the greenhouse policy. The higher costs are illustrated on Diagram 6-B as a shift of the industry's supply curve to the left. It is worth diagrammatically comparing the impact of the taxation upon *EleBr* and the hydro electricity generator *EleHyd* which does not emit any CO_2 during its generation. The price of electricity sourced from brown coal increases relative to the price of electricity from hydro. The electricity supply industry *ElectDist* who purchases all of the market's electricity is able to substitute toward the cheaper hydro electricity. This result is depicted in Chart 12-GF with the collapse of *EleBr* and the expansion of *EleHyd*.

Diagram 6-B

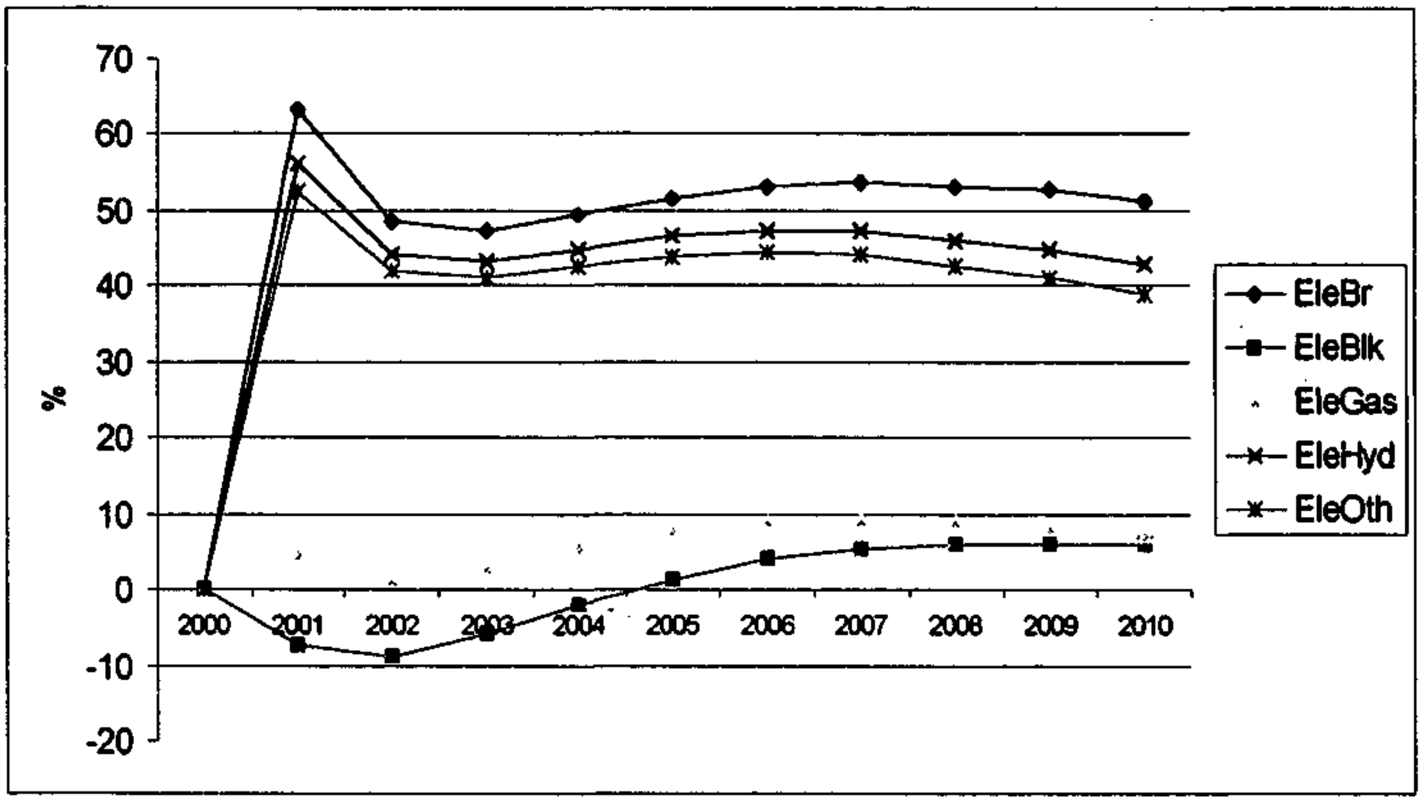
2001



As alluded to above, *EleBr* is able to substitute toward the more inexpensive brown coal generators. This option is not however open to the remaining CO_2 emitting generators such as *EleGas*. In the second year of the policy simulation the price of *EleBr* falls relative to the price of the other generators, as shown on Chart 14-GF. This fall in price is explained by the higher availability of substitution.

Chart 14-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR DOMESTIC PRICE OF ELECTRICITY INDUSTRIES



The impact of generator substitution can be shown on Diagram 6-C. Using the example of *EBrix* and *Edis* once again, *EleBr* will substitute away from the use of the CO_2 intensive emitters such as Energy Brix toward the cleaner generators such as Edison Mission. This is illustrated as a shift of the demand curve for *EBrix* to the left as the price of a substitute good is now relatively lower. At the same time, the demand curve for *Edis* will shift to the right. The outcome is a decrease in the price of *EBrix* and a relative increase in the price of *Edis*. The result for the percentage change in the price of domestic goods is shown on Chart 15-GF. In the second year of the policy simulation the relatively lower price of *EBrix* encourages *EleBr* to substitute toward it. This is shown on Chart 13-GF by the significant increase toward base of the industry.

Chart 15-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR DOMESTIC PRICE OF BROWN COAL GENERATORS

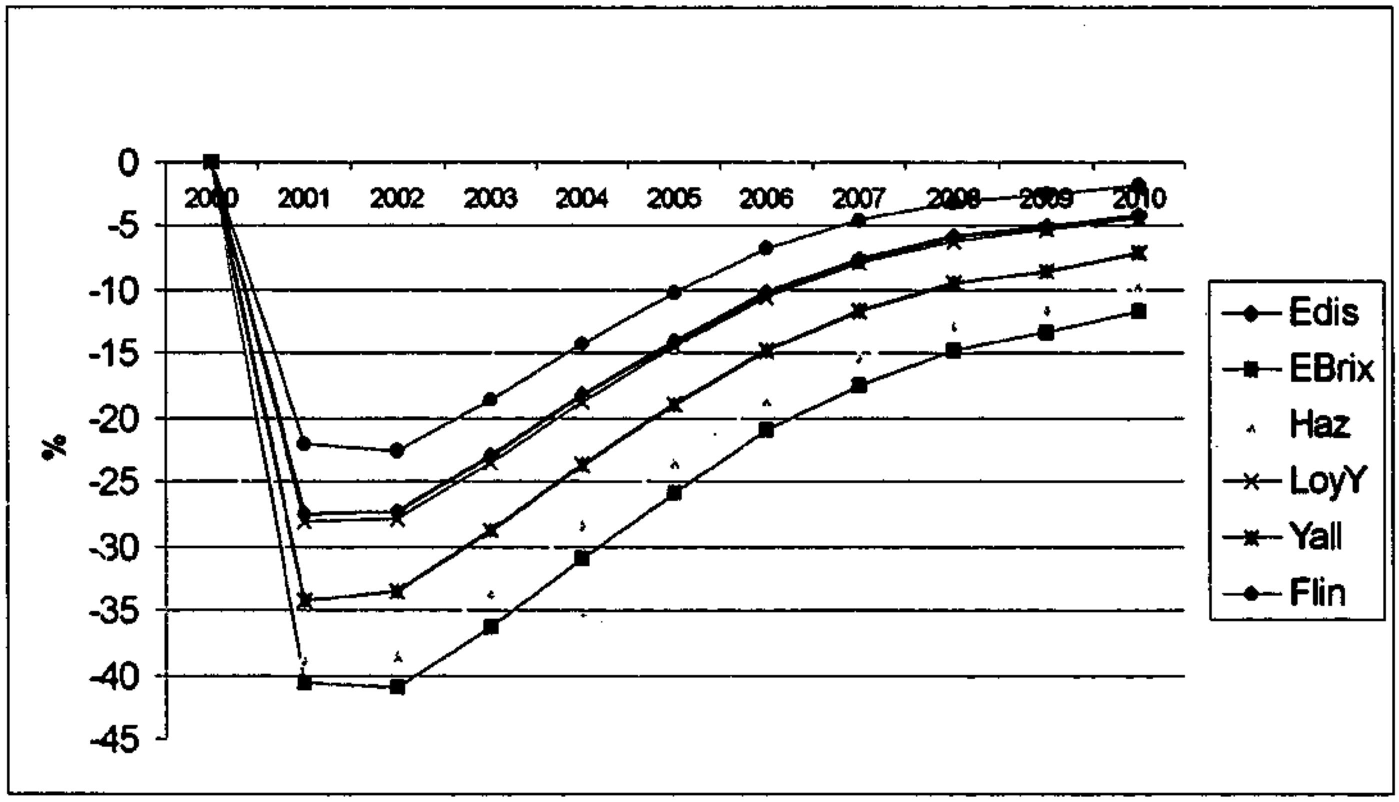
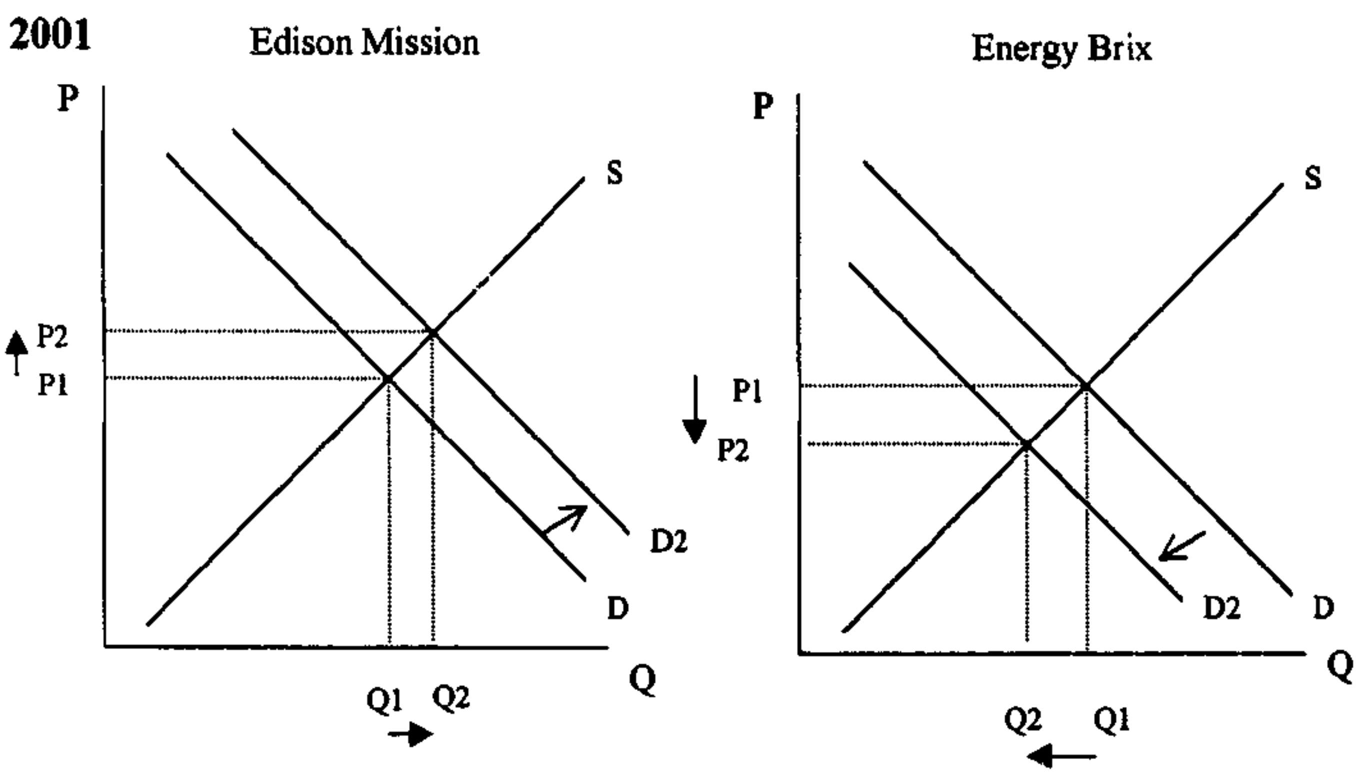


Diagram 6-C



The industries which gain most from an increase in the power of the GFT are *EleGas* and *EleOth*. Both of these industries sell electricity to *ElectDist* and compete directly with the other electricity generators such as *EleBr*. As explained in Chapter five, the MONASH model has been modified to incorporate substitution between the different electricity generators in the economy. The GFT impacts most heavily upon the coal fired electricity generators as they rely on brown or black coal as intermediate inputs. At the same time, the intermediate inputs of fuel used by the renewable electricity producers do not increase in price when a GFT is imposed. Overall *ElectDist* substitutes toward the cheaper and less CO_2 intensive electricity generators in response to the relatively higher price of coal-fired electricity.

The result for *EleOth* is affected by a supply constraint placed on its investment growth. As mentioned in Section 6.4, to avoid the situation where investment in renewable energy is unrealistically high, the closure was modified to constrain investment growth to 10 percent.

The result for *EleHyd* is also lower than it would be in the absence of supply constraints. The supply constraint was imposed to confine the output growth of the industry, ensuring that it could not expand nationally without consideration for the limitations associated with the development of additional generating plant. The construction of a hydro electricity dam is a long-term capital project spanning many years. The increased demand for electricity from this generation source cannot be met in the short-run as the physical capacity required to supply the electricity cease to exist.

Output from *EleHyd* was allowed to incur some expansion not associated with the construction of new capital projects. The generation capacity of hydro electricity is greatly underutilised in the Australian electricity market. Hydro electricity generators in the States of VIC and NSW are considered to only meet peak supply demands. In essence these plants are only utilised during periods of peak demand such as in extreme weather conditions. The imposition of the GFT encourages substitution toward this relatively cheaper source of electricity. The industry is allowed to grow in line with the surplus generation capacity that is not currently utilised for the base market.

xii Local vs National Commodities

National commodities are traded across state boundaries. Although not in the formal modelling, it is implicitly assumed that if demand for a national commodity in one state increases, it can be met by increased production in another state. For example, if demand for aluminium increased in SA, production in QLD could increase to satisfy this demand. The model allocates the same growth rate to the State's national commodities as the Australia wide growth rate.

Local commodities are those for which demand in the state is met by production in that state. Local commodities tend to be perishable goods or services which are not conducive to interstate transport. The model imposes market clearing in each state for local commodities. The growth rate of the local industry is dependent upon the growth rate in demand for the commodity by the state. An important feature of using the classification of local commodities is the introduction of multiplier effects. If the state has a number of high growth industries, local industries will experience strong growth.

There are differences in the classification of national and local commodities between states and statistical divisions. Agricultural services (*C11AgServ*), bakery (*C25Bakery*), soft drink (*C28SoftDr*), beer (*C29Beer*), wholesale (*C91Wholesale*) and hotels (*C113Hotels*) are all local commodities at the state level and national commodities at the statistical division level. The reason for the re-classification of these commodities is due to the fact that they are predominantly perishable or service based. For instance, whilst it is reasonable to assume that bread baked in Melbourne is transported and sold to many statistical divisions in the State of VIC, it is unlikely that the bread is sold in the State of QLD. Beside the product becoming stale, the transport costs would inevitably outweigh any price advantage Victorian producers had over interstate counterparts.

The state and statistical division results described in the following sections are influenced by the representation of national and local commodities. Those states who have an over-representation of low-growth energy related industries will find that their local industries will also have low-growth prospects.

Chart 16-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR GDP AND GSP

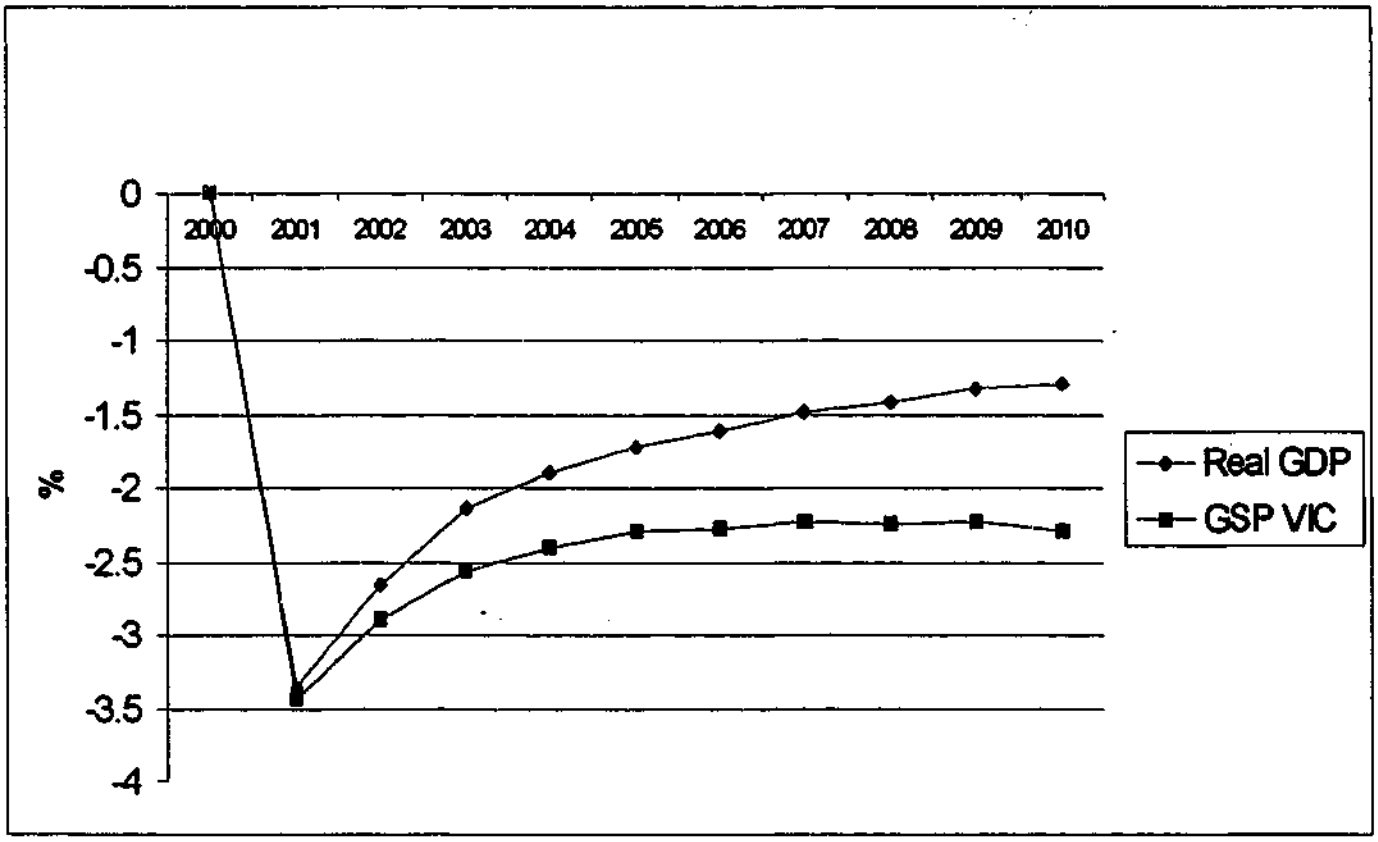
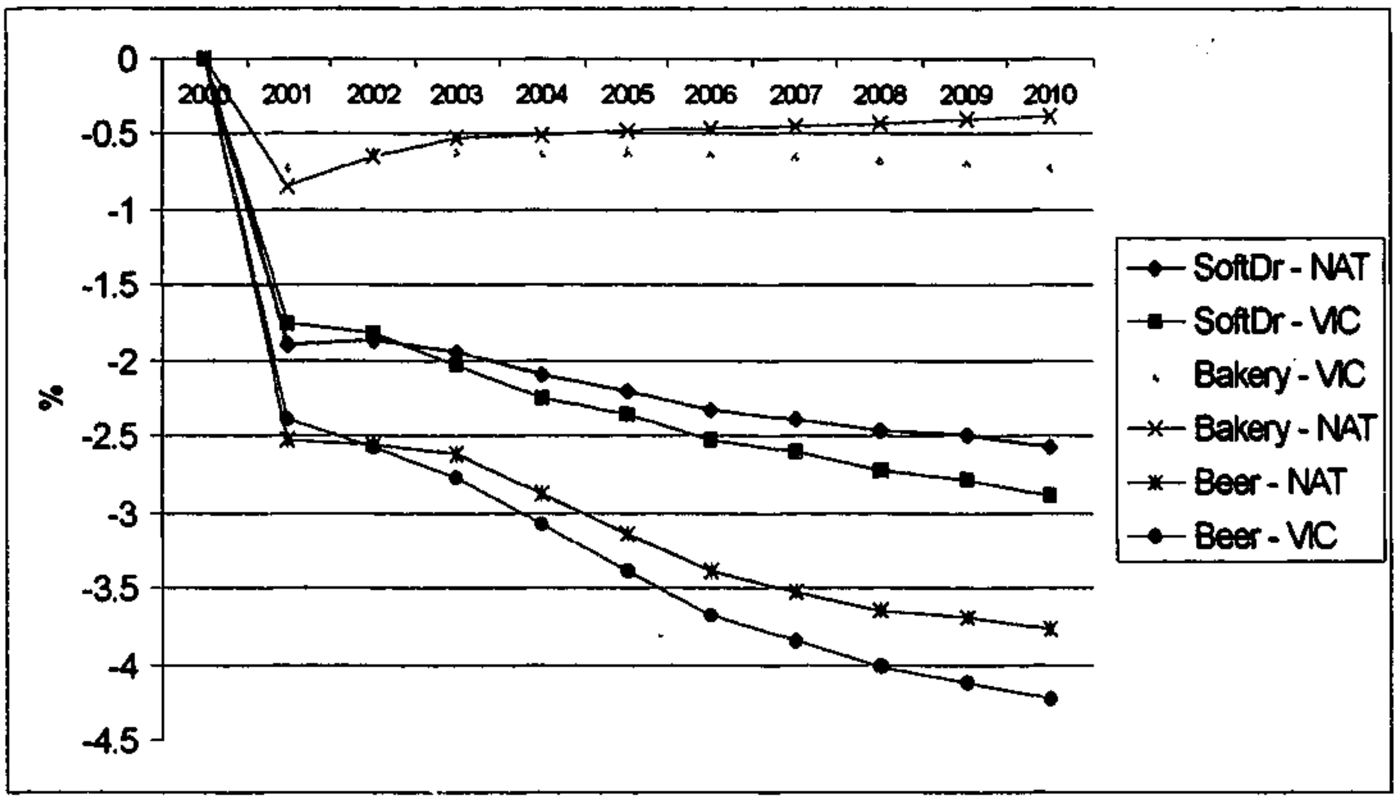


Chart 16-GF shows the percentage deviation from base paths for Australia's real GDP and real GSP for the State of Victoria. In the case of VIC, over the period of the simulation its growth is considerably lower than real GDP at the national level. The collapse of national industries such as *EleBr* will have multiplier effects on Victoria's local industries. Chart 17-GF illustrates the difference between some of the states local industries and their growth rate at the national level. In all cases Victoria's over-representation of low-growth industries in the simulation causes its local industries to experience the same pattern of negative or low growth.

Chart 17-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR NATIONAL AND VICTORIAN LOCAL COMMODITIES

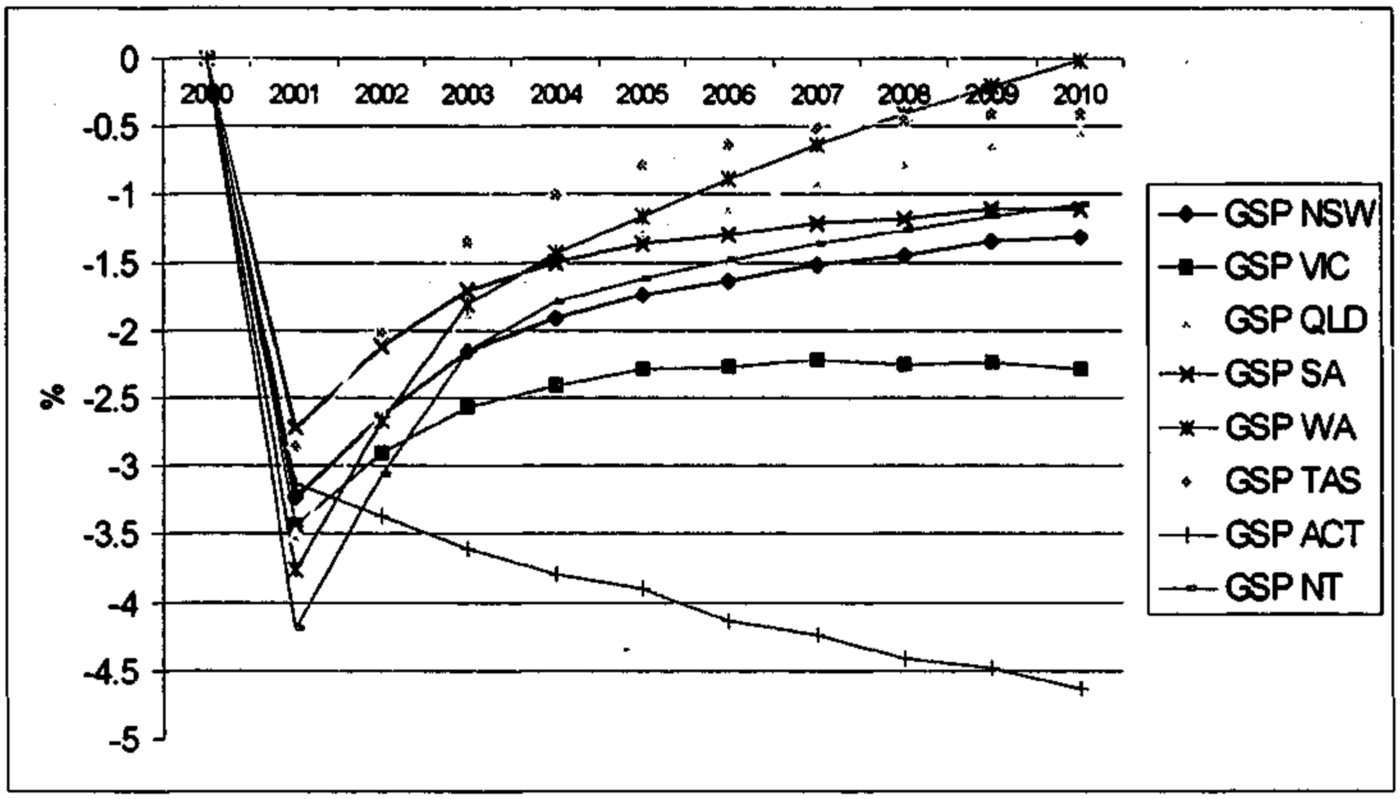


xiii Results for the States of Australia

Chart 18-GF shows the deviation-from-base paths of Gross State Product (GSP) for the States and Territories of Australia.

Chart 18-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR GROSS STATE PRODUCT



The tops-down MONASH-Electricity model of the Australian economy used in this simulation implicitly allows interstate trade of electricity. As demand and supply of electricity is equal nationally, the model assumes that the excess supply is met by exporting into states where electricity output has contracted more than demand. This of course is based on the assumption that electricity can flow readily across state boundaries. Unfortunately this is not entirely the case in the Australian NEM at present. As discussed above, the method used to address this inconsistency is to restrict the capital stock growth of these industries.

The states to perform poorly after the introduction of greenhouse policy are those who rely on the on the non-ferrous metal industries for a large share of their economic activity. The collapse of *NFerrous* and *Alum* at the national level has a significant economic impact upon those states who support these industries. The non-ferrous metal industries are found predominantly in WA and QLD, although part of the aluminium smelting industry operates in VIC. Appendix 6-J outlines the share of employment by industry for the States of Australia.

Immediately following the introduction of greenhouse policy, WA experiences a significant collapse in its GSP. A large percentage of the State's economic activity is found in the energy intensive and mining industries. As mentioned above, the two industries most impacted upon by the greenhouse policy are *NFerrous* and *Alum*. WA is one of the largest producers of both of these industries. Other leading industries found in WA also experience sharp declines in their activity levels, contributing to the fall in the State's economic activity. Almost all of Australia's iron ore (*I12IronOre*) production, 64 percent of non-ferrous ore (*I13Nferrous*) and over 50 percent of oil (*I15aOil*) and gas (*I15bGas*) output is sourced from the State of WA. The path for GSP returns toward base after the first year of the policy simulation. The depreciation of the Australian dollar stimulates export orientated products on the international market. WA produces many of these products and consequently experiences output stimulus.

The NT is unique in that it is a relatively small economy when compared to the other states. The NT is not a diverse economy, relying heavily on beef cattle and non-ferrous metals. Although the NT's share of the Australian non-ferrous metals industry is not large, this sector represents a significant share of the NT's economic activity. Consequently, the collapse of the non-ferrous metals sector at the national level, is large enough to cause a decline in GSP in the NT.

In a similar pattern to the GSP paths of the majority of states, after the initial policy shock the NT experiences an increase in its activity levels. A large part of this improvement is attributable to the NT's production of northern beef (*I4NthBeef*) which represents almost 40 percent of the Australian share of this agriculture industry. The northern beef industry benefits from the depreciation of the dollar as Australian beef is exported to overseas markets. In addition, the NT hosts a relatively large share of *EleOth* which expands following the imposition of the greenhouse policy. *EleOth* is however a relatively small industry in itself and its improved activity level is not enough to offset the decline in other areas of the region's economy.

The agricultural intensive States of QLD and NSW perform better than their western neighbours as the depreciation of the currency increases the demand for exports. Australia traditionally exports agricultural products such as wool and wheat, with a large percentage of these commodities produced in the States.

The economic prosperity of QLD in the long-run is dependent on its export orientated industry base. The State supports energy intensive industries which collapse in the short-run as the cost of energy increases. As can be seen in the first year of the policy simulation on Chart 18-GF, this is damaging to the GSP of the State. After the initial shock, the path of economic activity in the State improves as its export orientated industries such as pastoral (*I1Pastoral*) benefit from the significant depreciation of the Australian dollar.

NSW is the largest State in Australia based on population. From this fact alone NSW is expected to have the largest employment shares by industry for most of the industries included in the model. Of course, in some industries such as poultry (*I8Poultry*) and ginning (*I30Ginning*), NSW holds a higher share of employment than can be attributed to population. The reverse is also true of industries such as *Alum*.

The performance of the State of NSW is influenced by its electricity sector. The majority of electricity generated in the State is sourced from black coal electricity generation. *EleBlk* is considered to be emission intensive relative to alternate fuel sources such as gas and hydro. The simulation results support this as the industry suffers following the introduction of greenhouse policy. NSW does not however experience a fall in its GSP equal to that of VIC as the black coal industry performs relatively stronger than the brown coal industry. NSW further profits from its interest in *EleHyd* and *EleOth*, holding a 50 percent share of both industries. The State also boasts a 50 percent share in the water transportation industry (*I95WaterTran*) which contracts in the first year of the policy simulation but experiences strong growth thereafter.

VIC is the predominant producer of the agricultural output for the high rain (*I3HighRain*) and milk cattle (*I5MilkCattle*) industries, and is responsible for most of the output of brown coal

(*I15cBrCoal*). The Victorian economy suffers under the weight of the brown coal electricity industry which contracts following the introduction of greenhouse policy. Electricity generated using brown coal is the most emission intensive of the fuels and subsequently, consumers of electricity substitute away from its use when the greenhouse policy increases its relative price.

In addition to electricity, the State of VIC is also responsible for a high share of the employment in the structural and other building industries, both of whom collapse with the reduction in aggregate investment at the national level. Another dominant industry is retail gas (*I85Gas*) which is found in VIC to have a greater share than population would otherwise warrant. The gas is predominantly mined from the Gippsland Basin gas fields. The gas is distributed throughout the State and exported to other States such as NSW.

The implication of the policy shock for the State of SA is varied. On the one hand SA generates a large percentage of its electricity using natural gas as the fuel source. As natural gas emits relatively low levels of CO_2 in its production process it becomes a cheaper and more attractive source of electricity supply. This is reflected in the results by large percentage increases in the industry's output levels. At the same time the State does not produce any petrol and therefore avoids any detrimental implications associated with the collapse of this industry. On the other hand SA suffers from its reliance on brown coal electricity generation for the remaining electricity supply in the State. The collapse of this industry damages the GSP in SA.

Both VIC and SA boast a smaller share of the traditional export industries which improve their economic activity when the policy shock forces a depreciation of the currency. For instance, QLD and NSW both have a higher percentage of the share of the wheat sheep (*I2WheatSheep*) agricultural industry than VIC or SA. The expansion of this agricultural industry will therefore have a more positive impact upon the northern states.

Over the ten year period of the simulation, the ACT is the worst performer of the states. The ACT is heavily represented by the public sector, which is detrimentally affected by the decrease in public consumption. The largest industry representation in the ACT comes from public administration (*I105PubAdmin*) and defence (*I106Defence*), both of which are funded predominantly by the Commonwealth Government. In response to the policy shock, both industries contract their industry activity level.

A unique element of the ACT is that it does not produce any of its own electricity, but rather imports it from other states via the NEM. There are positive and negative elements to this fact. On the one hand the ACT does not suffer the same loss associated with the collapse of the fossil-fuel electricity generators. On the other hand it does not derive any benefit associated with the expansion of the less emission intensive electricity generators. The long-run path of GSP for the ACT differs from that of the remaining states given that it does not have a direct link to export markets. Whereas the other states experience an increase in their paths toward control, as the depreciation stimulates demand for exports, this is not the case for the ACT.

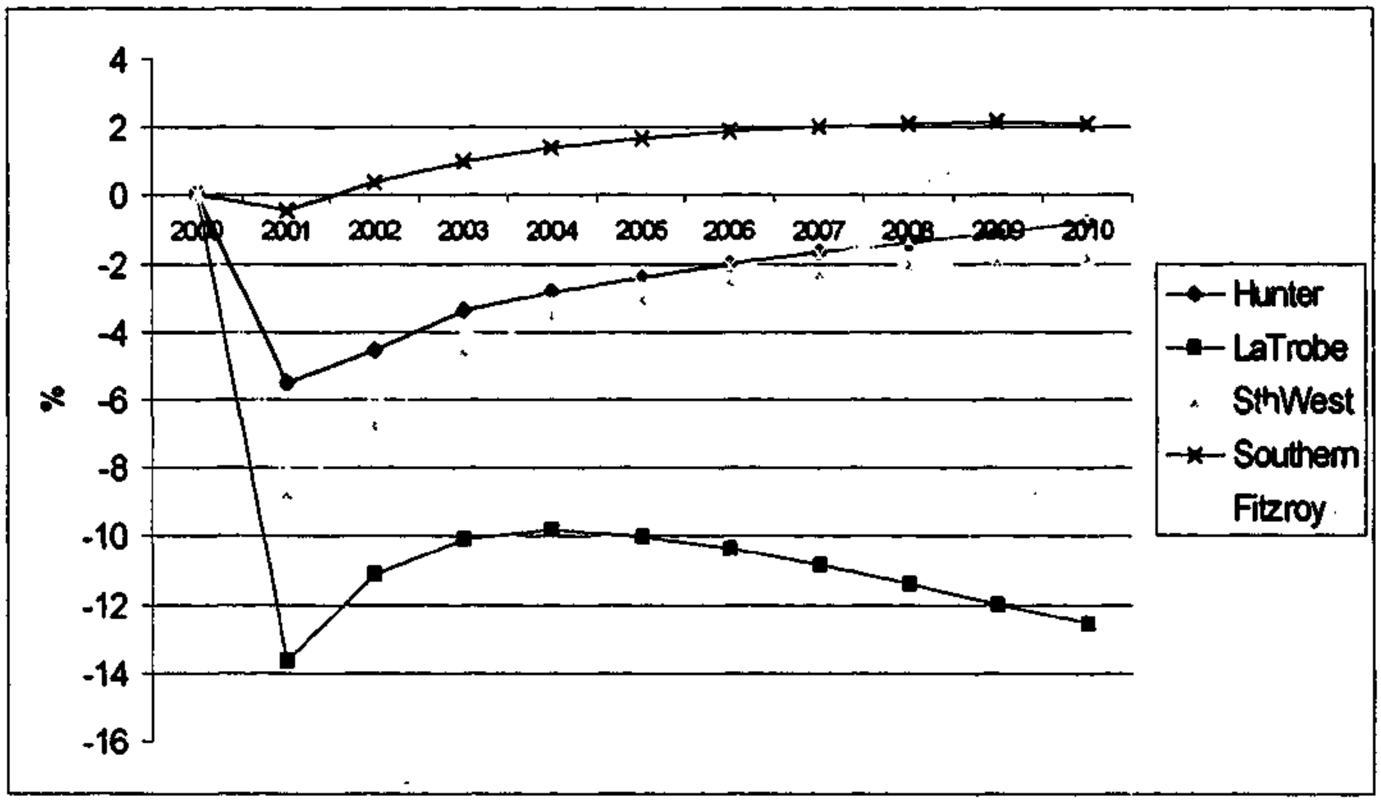
The State of TAS will benefit from the expansion of *EleHyd*. Almost all electricity in TAS is sourced from the hydroelectricity schemes developed by the State Government. As hydroelectricity does not emit CO_2 during the generation process, it will not be detrimentally impacted upon by the greenhouse policy. That is, the cost of electricity in the State of TAS will not increase. The State does however suffer initially from the collapse of other large industries such as forestry (*I10Forestry*), fishing (*I11Fishing*), pulp and paper (*I44PulpPaper*), cement (*I59Cement*), non-ferrous metals (*I64aNFerrous*) and water transportation (*I95WaterTran*). Many of these industries such as fishing, rely on fuels as an intermediate input. The greenhouse tax raises the relative price of fuel, reducing the activity level of these industries. The aggregate collapse of these industries forces the GSP for TAS to fall in the short-run.

xiv Results for the Statistical Divisions

Chart 19-GF shows the deviation-from-base paths of Gross Regional Product (GRP) for the statistical divisions whose industry base is of direct relevance to greenhouse policy.

Chart 19-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR GROSS REGIONAL PRODUCT



Statistical divisions in this group include the Hunter region in NSW which is responsible for most of that State's black coal electricity generation, and Australia's brown coal electricity generators from the Northern region of SA and the La Trobe Valley region of VIC. The sole statistical division in this group to benefit from the introduction of the greenhouse policy is also responsible for electricity generation. Unlike its counterparts, the Southern region in TAS produces electricity using hydro dams.[126]

Aside from the La Trobe Valley, the statistical divisions to experience the most severe downturn in GRP are South West in WA and the Fitzroy region of QLD. These regions are responsible for the majority of Australia's production of non-ferrous metal and aluminium. The collapse of these industries at the national level has led to the economic downturn of these regions.

[126] It is implicitly assumed that this electricity is exported to other regions in Australia.

Chart 20-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR STATISTICAL DIVSIONS WHO BENEFIT FROM GREENHOUSE POLICY

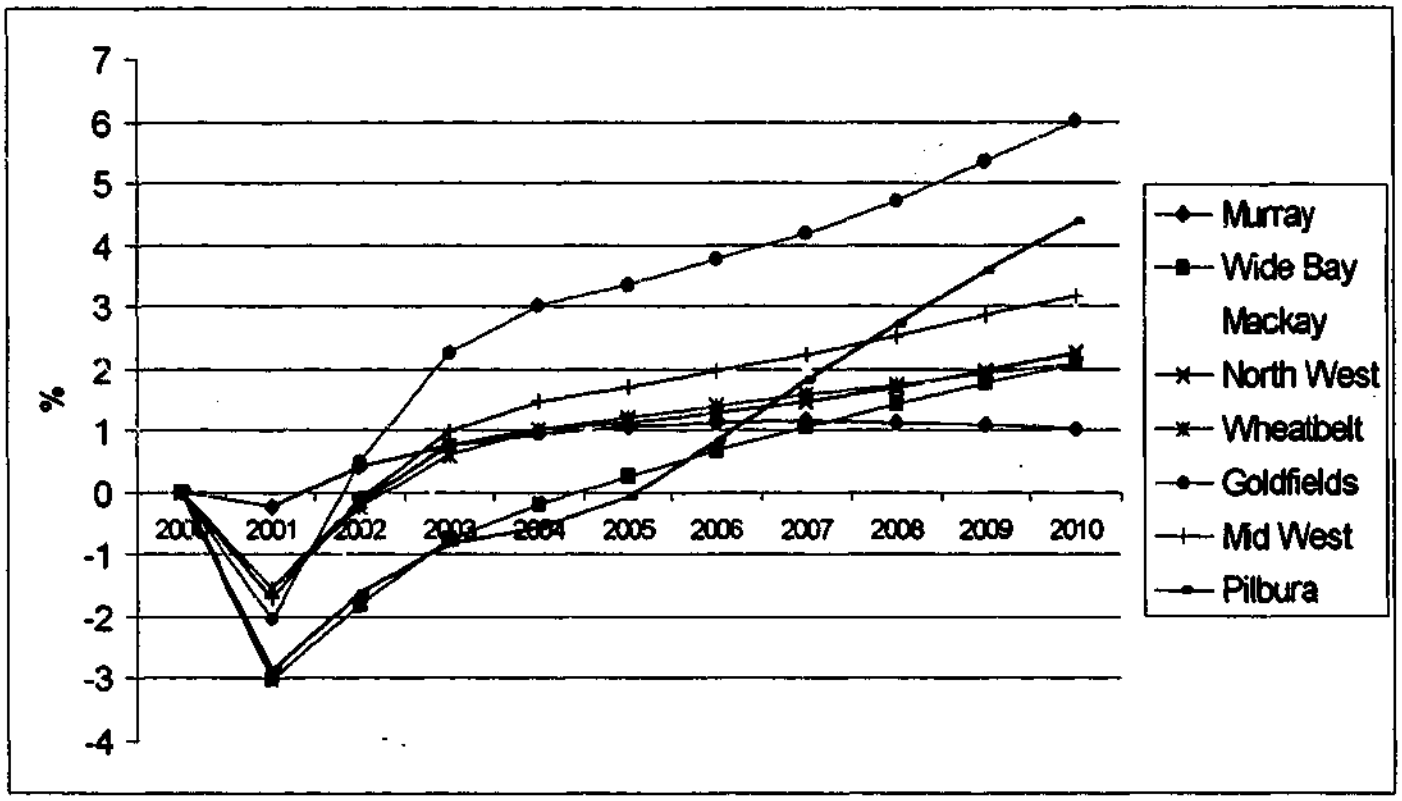


Chart 20-GF shows the deviation-from-base paths of GRP for those statistical divisions who benefit from the introduction of greenhouse policy. The expansion in SD11Murray is due in part to the favourable growth in renewable electricity generation. The Murray region supplies 36 percent of *EleHyd*'s total output and 28 percent of output in *EleOth*. The expansion of these national industries will have positive multiplier affects on the local commodities in the region.

The shape of the paths for most of the expanding statistical divisions indicate that they initially feel the impact of greenhouse policy but then recover, mainly due to the expansion in traditional export orientated industries following the depreciation of the currency. A brief pen-picture of the main industry activities found in each region is outlined below:

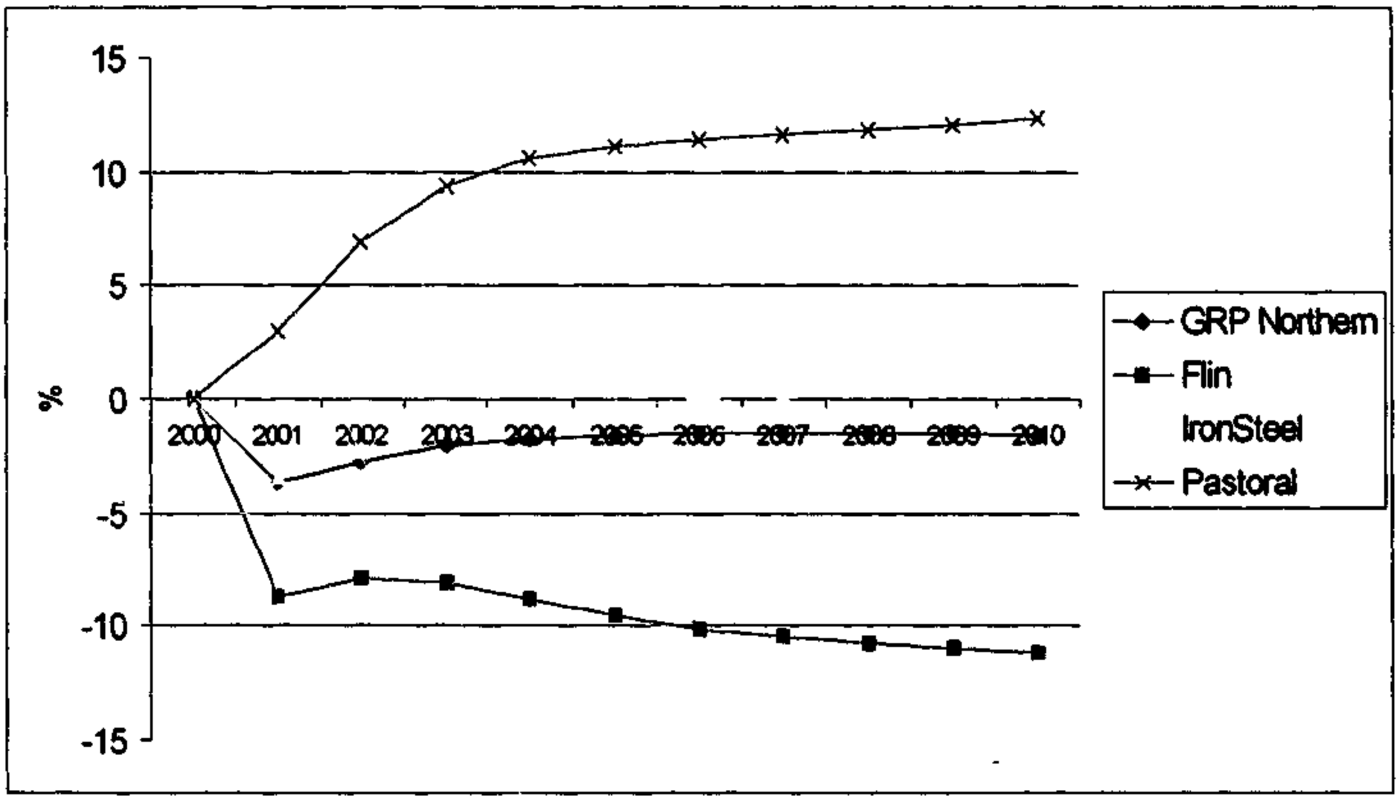
- The Wide Bay statistical division is responsible for 15 percent of total output of agriculture machinery (*I76AgMach*).

- The Mackay statistical division produces 5 percent of other exports (*I6OthExport*) and 7 percent of the sea and sugar industry (*I25Sea_Sugar*), both of whom perform well.
- The North West statistical division is located in QLD and is responsible for almost 24 percent of total output of northern beef (*I4NthBeef*), 18 percent of non-ferrous ores (*I13Nferrous*) and 8 percent of *EleOth*.
- The WA Wheatbelt statistical division produces 8 percent of the wheat and sheep industry's (*I2WheatSheep*) output and 10 percent of *EleGas*.
- The Goldfields statistical division produces 19 percent of non-ferrous ore (*I13Nferrous*) and 10 percent of mining services (*I17MinServ*).
- The Mid West statistical division produces 6 percent of pastoral (*I1Pastoral*), 2 percent of wheat and sheep (*I2WheatSheep*) and 5 percent of non-ferrous ore (*I13Nferrous*). Although geographically large, the Mid West region is not densely populated and it does not contribute to the production of other goods in any notable quantity. Thus, any movements in the activity levels of the above mentioned industries will dictate the path of GRP.
- The Pilbura statistical division is located in Northern WA and is responsible for 95 percent of Australia's iron ore production and 8 percent of *EleGas*. It further represents 43 percent of the output of *Oil* and *Gas*, both of whom collapse as the CO_2 tax raises their respective prices.

Another statistical division warranting discussion at this point is Northern which is located in SA (shown as SD 42 on Map 51). The nature of the database has created the situation where this region is geographically large and has a very diversified industry base to reflect its different climatic conditions. At the most southern point of the statistical division is the brown coal electricity generator *Flin*. Offsetting the collapse in *Flin* is the expansion of the pastoral sector (*I1Pastoral*) of which 19 percent of total output is sourced from Northern statistical division. The troubled iron and steel industry (*I63IronSteel*) sources 12 percent of its production from the region. It becomes evident from Chart 21-GF that GRP for this statistical division follows a similar path to that of its main industry iron steel. The path for GRP however lies below that of iron and steel as the collapse of *Flin* contributes to lower growth.

Chart 21-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR STATISTICAL DIVISION NORTHERN



xv Results for the La Trobe Valley

The main compositional difference between the Gippsland and La Trobe statistical divisions in the MONASH-Electricity model is the importance of the electricity industry. Relative to Gippsland, the La Trobe Valley has a higher percentage of its workforce employed in the electricity sector.

Chart 22-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR GSP AND GRP

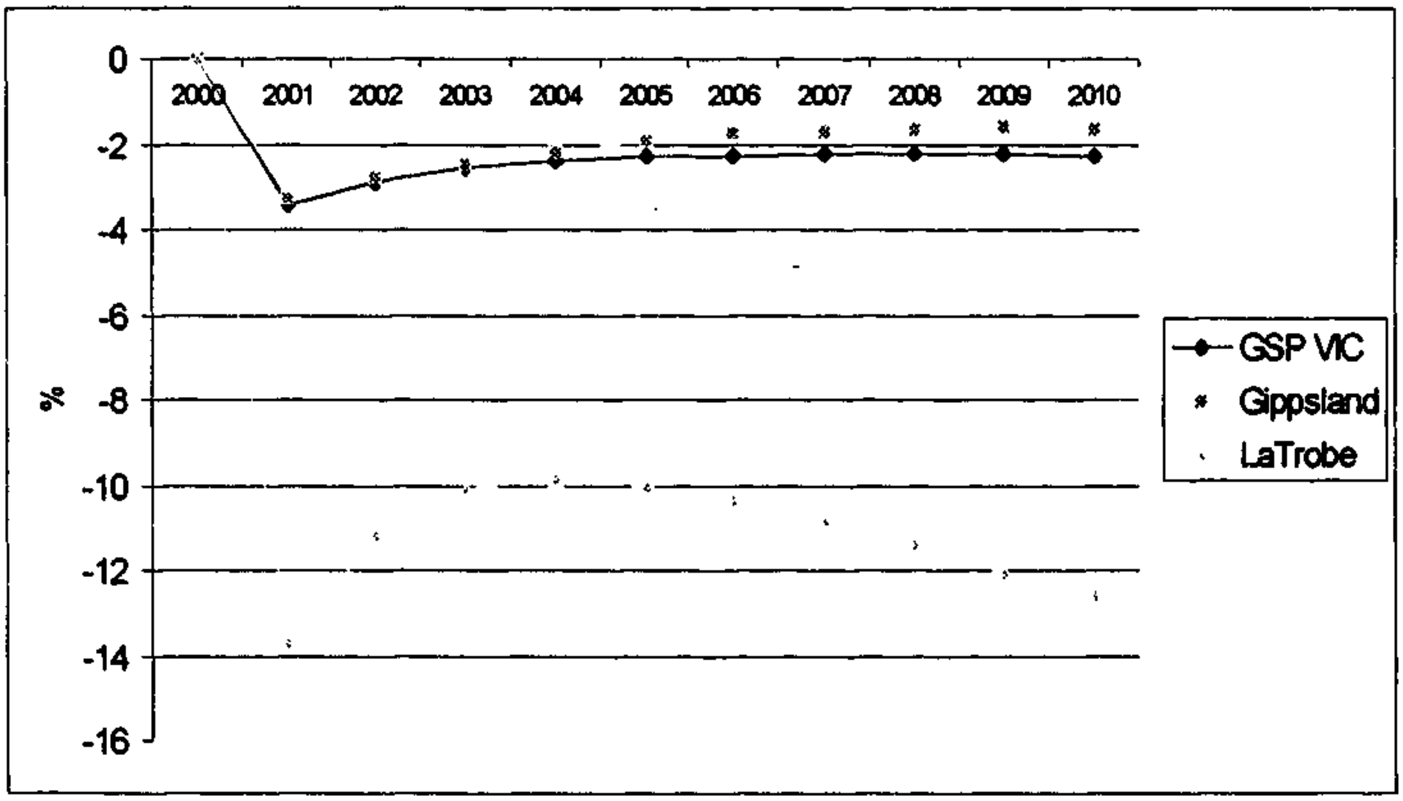


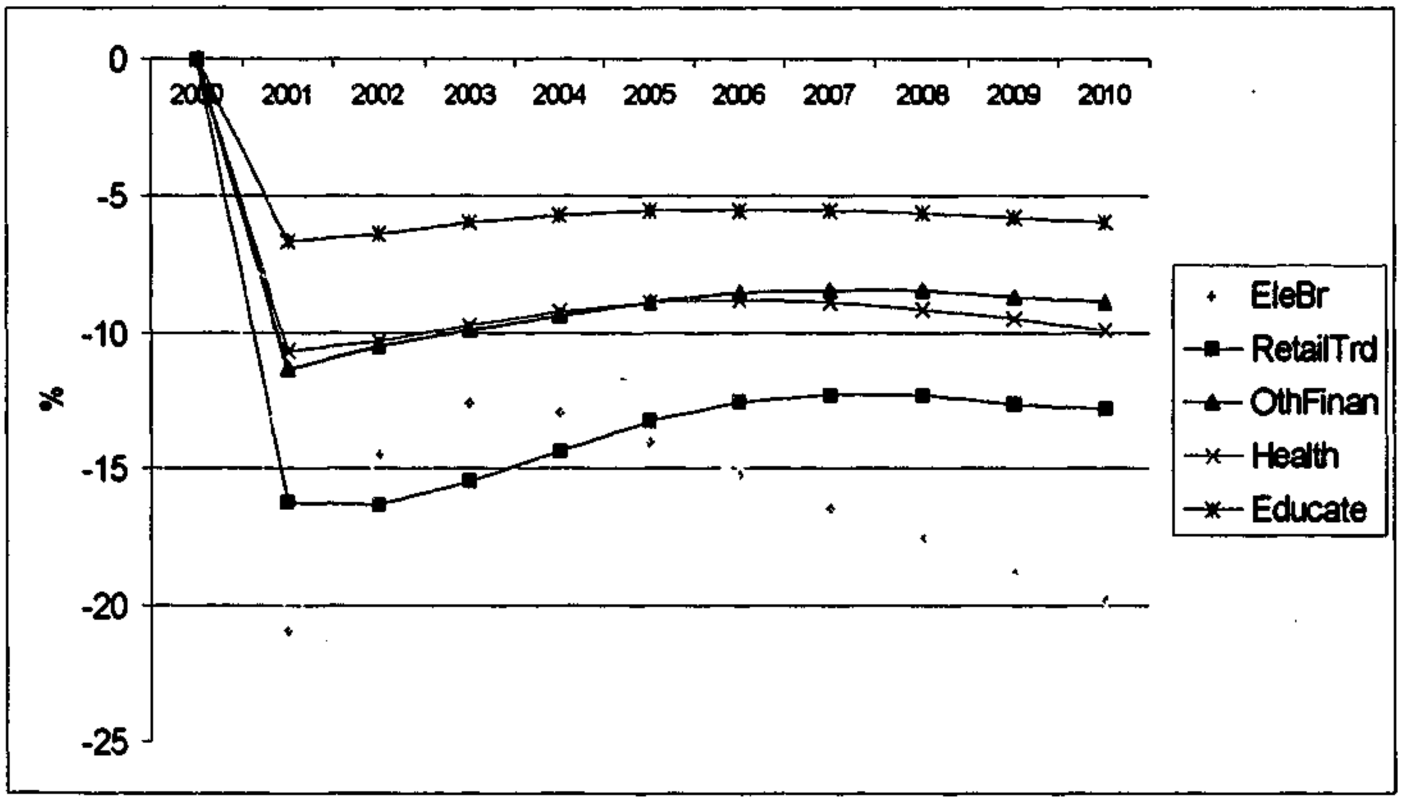
Chart 22-GF shows the deviation-from-base paths of GSP for Victoria, and GRP for Gippsland and the La Trobe Valley. The result for Gippsland shows a slight increase in deviation-from-base GRP whereas the result for La Trobe Valley fairs considerably worse.

The main industry base in the La Trobe Valley region experienced a negative reaction to greenhouse policy in its deviation-from-base output. (Appendix 6-J) Chart 23-GF shows the La Trobe Valley's main industries - retail trade (*I90Retail Trade*), other finance (*I103Other*

Finance), health (*I107Health*), and education (*I108Education*). Apart from the electricity sector, the rest of these industries were classified as *local-region* at the statistical division level. The path for GRP of the La Trobe Valley is aligned with the changes in the activity levels of *EleBr*.

Chart 23-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR LA TROBE VALLEY'S MAIN INDUSTRIES

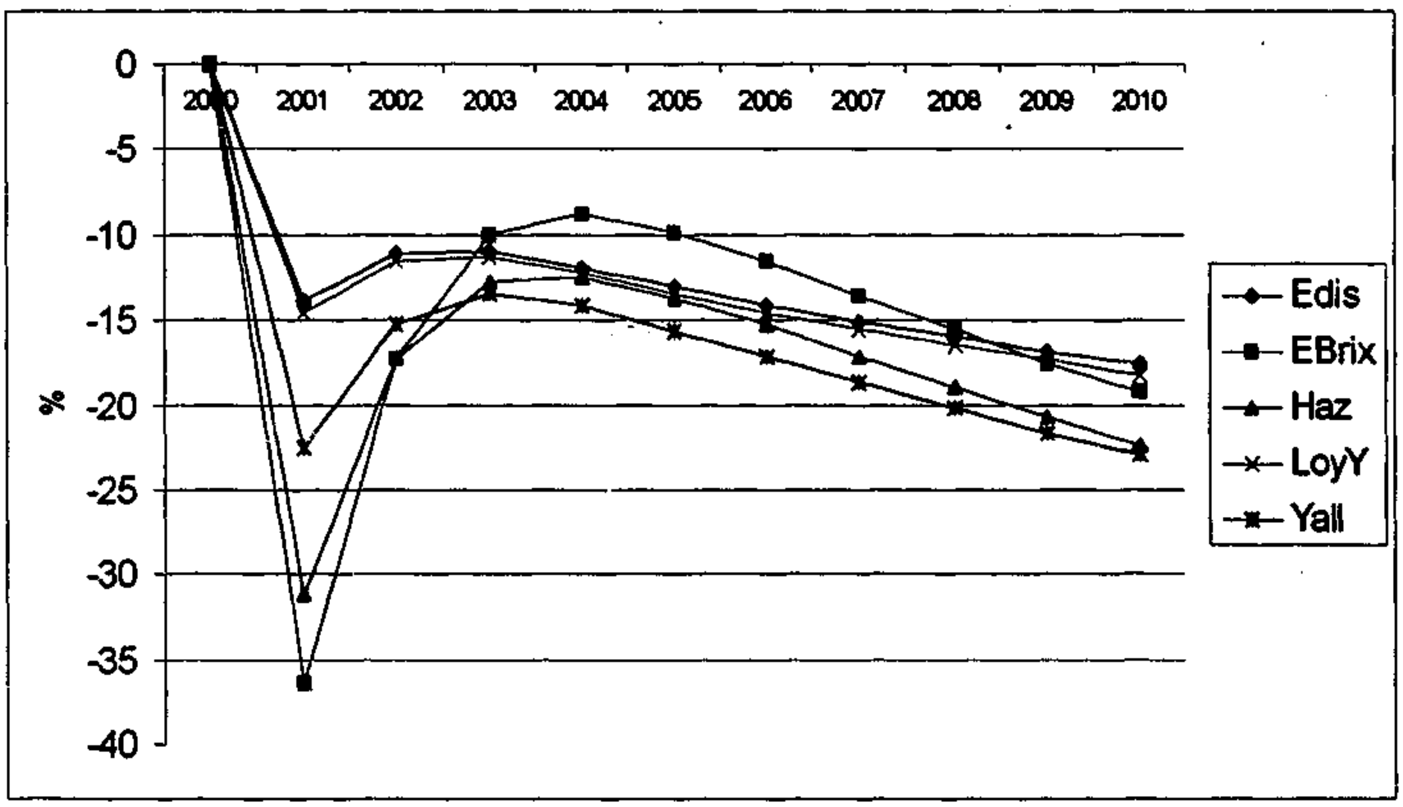


As anticipated, Chart 23-GF indicates that industry results at the statistical division level mirror those found at the macro and state level for national industries. The statistical division's *local-region* industries follows the pattern of what occurs to its main *national-region* industry.

Chart 24-GF shows percentage deviation from base paths for the brown coal electricity generators in the La Trobe Valley. Energy Brix contracts in the first year of the policy shock relative to the other generators due to its higher emission intensity. The brown coal generation plant is older than that of the other generators and uses outdated technology. Investment in the plant has lagged behind the newer electricity generators. At the same time, Energy Brix is the smallest of the generators located in the La Trobe Valley. Whilst it produces electricity, Energy Brix concentrates predominantly on the production of brown coal briquettes. The briquettes are used by industry and the household sector of the economy as a fuel source.[127]

Chart 24-GF

PERCENTAGE DEVIATION FROM BASE PATHS FOR LA TROBE VALLEY'S ELECTRICITY INDUSTRY



The four remaining brown coal generators are the main players in the industry. Emissions of CO_2 from Edison Mission and Loy Yang Power are almost identical given that the power stations were built sequentially over a relatively short period of time. As mentioned in Chapter four Edison Mission does not mine its own coal but rather purchases it from the fields of Loy Yang Power. Therefore the only difference in emission intensity per MWh of

[127] Briquettes are commonly used by households for heating.

electricity generated is due to slight differences in the technology used in the plant. Subsequently, the downward path taken by both of these companies is almost identical.

Compared to the newer power stations of Edison Mission and Loy Yang Power, Hazelwood Power and Yallourn Energy are considered to be CO_2 intensive emitters. Drawing on the discussion in Chapter four, the emissions from each of the power stations differ mainly due to the technology used in the plant and the brown coal source. The following emission intensities indicate the significant difference in the level of CO_2 released by the brown coal generators per MWh of electricity produced – Edison Mission 1.25 tCO_2/MWh; Energy Brix 1.50 tCO_2/MWh; Hazelwood Power 1.46 tCO_2/MWh; Loy Yang Power 1.26 tCO_2/MWh; and Yallourn Energy 1.37 tCO_2/MWh. The results of the simulation reflect the relativities of these emission levels.

Following the introduction of greenhouse policy, Hazelwood Power is predicted to experience a sharp reduction in its activity levels. The tax weighs heavily on the business, forcing it to lose market share. As discussed in Chapter four, prior to privatisation Hazelwood Power was scheduled to end its working life as an electricity generator at the start of this Century. The capital injection by private stakeholders has however extended the life of the plant for a further 30 years. Hazelwood Power is in a unique situation as although it faces a large increase in its costs following the introduction of greenhouse policy, it is arguably in the best position to abate. The technology used to generate electricity at Hazelwood Power is likely to benefit from minor upgrades. Whereas Loy Yang Power cannot upgrade its efficiency levels without significant cost to the business, the plant at Hazelwood Power will respond to relatively minor improvements (at a fraction of the cost). It should be stated however that any improvements will be marginal in terms of total emissions, and will not allow Hazelwood Power to achieve an emission intensity as low are the newer power stations.

Following Hazelwood Power, Yallourn Energy is the most emission intensive of the four main electricity generators operating in the La Trobe Valley. Like Hazelwood Power, the company is forecast to experience a severe contraction in its growth prospects as the CO_2 tax deems it uncompetitive.

Bearing the contraction of Hazelwood Power and Yallourn Energy in mind, it is highly unlikely in the short-run that either company will cease to generate electricity altogether. A more likely scenario is that part of their generation share will be replaced with generation capacity from the newer generators such as Loy Yang Power.

As mentioned previously, the generators are operating in a competitive market with significant excess generation capacity. Following the introduction of greenhouse policy, companies such as Loy Yang Power will be likely to lose some of their market position to interstate generators such as Delta Electricity who produce electricity in NSW using black coal. With a lower aggregate demand for electricity from brown coal generators, the existing generators will have extra capacity to increase their individual generation at the expense of their local competitors.

A reduction in overall brown coal electricity generation will have a negative impact upon the La Trobe Valley. As outlined in Chapter four, the electricity industry has been an important part of the region's industrial structure for many decades. The deregulation of the industry by the State Government resulted in a severe downturn in the region's economic activity. A similar industry contraction caused by greenhouse policy, will further damage the regional economy.

The short-run economic impact on the La Trobe Valley is likely to result in a reduction in aggregate electricity generation within the region, and consequently a downsizing of the labour force. The number of people directly employed in the electricity industry in the La Trobe Valley currently stands at approximately 4,000. It is not unreasonable to predict that the industry downturn, as outlined in the simulation results, will greatly reduce the number of people employed in the industry. Employees on contract could be the first to be stood down. The cost of the downturn will be felt by the generators, their employees and the local region. As was the case a decade ago, a contraction in the electricity industry will inevitably have multiplier effects throughout the regional economy.

To add to the problems of the region, the La Trobe Valley electricity industry has a history of industrial action dating back as far as its inception. Strong labour union groups have caused a number of generation plant shut-downs. As recently as last year, industrial action was taken by a union consortium over the employment conditions of workers. The result was a loss of electricity generation, costing the industry in excess of AUD$50 million dollars.

The conclusion drawn from the simulation results is that the imposition of a greenhouse policy will be detrimental to the La Trobe Valley region. The results indicate that the policy will not have the same negative ramifications for a region such as the rest of Gippsland which does not rely on electricity as an important part of its industrial base.

In the long-run the policy shock reduces total greenhouse gas emissions in the Australian economy by 18 percent relative to the basecase level. Table 6.18 (shown at the end of this section) illustrates the level of CO_2 emissions by industry in the Australian economy following the imposition of greenhouse policy with the permits grandfathered. Table 6.18 can be compared with Table 6.16 which shows the basecase projections for greenhouse gas emissions.

Table 6.19 below shows the differences between the greenhouse gas emissions at the beginning and end of the simulation after the policy shock. This table should be compared to Table 6.17. The level of CO_2 emissions in the Australian economy has remained virtually unchanged between the basecase (2000) and the policy (2009). The emissions from almost all of the energy sectors are stagnant. This means that the introduction of greenhouse policy, with the permits grandfathered, has maintained the existing level of CO_2 released by Australia into the earth's atmosphere.

Table 6.19

CO_2 EMISSIONS

	2000 Basecase	**2009 Policy**	**% change**
BlkCoal	41961	44283	0.05
Gas	34887	35095	0.005
Petrol	109066	112520	0.03
Electricity	132673	133293	0.004
Total Emissions	318586	325191	0.02

Table 6.20 shows the differences between the basecase and policy simulation results for CO_2 emissions by energy source at the end of the simulation period. This can be contrast from Table 6.19 which looked at the difference between the current level of emissions (2000 basecase) and the projected emission levels (2009 policy). Table 6.20 indicates that there is a 9 percent reduction in the basecase emissions following the introduction of greenhouse policy.

Table 6.20

CO_2 EMISSIONS

	2009 Basecase	**2009 Policy**	**% diff**
BlkCoal	49455	44283	-10.5
Gas	40069	35095	-12.5
Petrol	122397	112520	-8
Electricity	146192	133293	-9
Total Emissions	358113	325191	-9

Table 6.21 (shown at the end of this section) illustrates the percentage change in fuel usage by industry, summed over source. The largest reduction in emissions is made by the non-ferrous metals sector.

The following series of charts demonstrate the emission reductions which have been achieved as a direct result of the Australian Government implementing greenhouse policy. Unlike the charts presented earlier, these charts are not expressed in percentage change format.

Chart 25-GF

CHANGE IN CO_2 EMISSIONS FROM BLACK COAL BETWEEN BASECASE AND POLICY

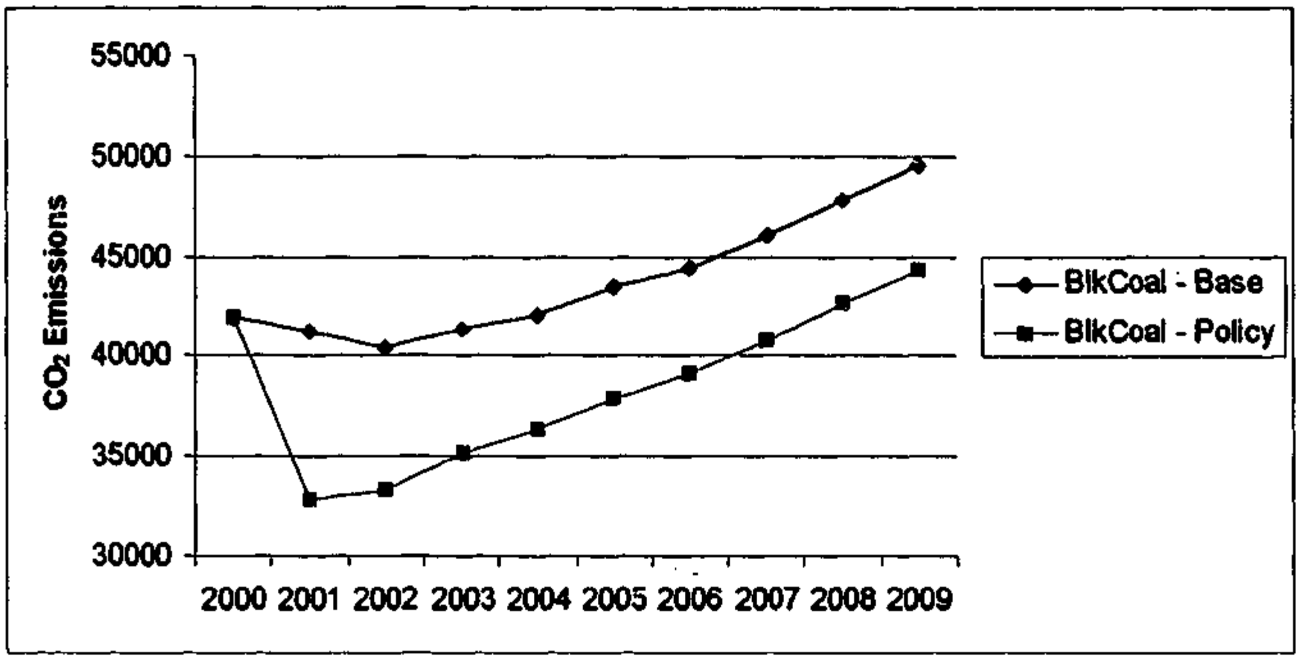


Chart 26-GF

CHANGE IN CO_2 EMISSIONS FROM GAS BETWEEN BASECASE AND POLICY

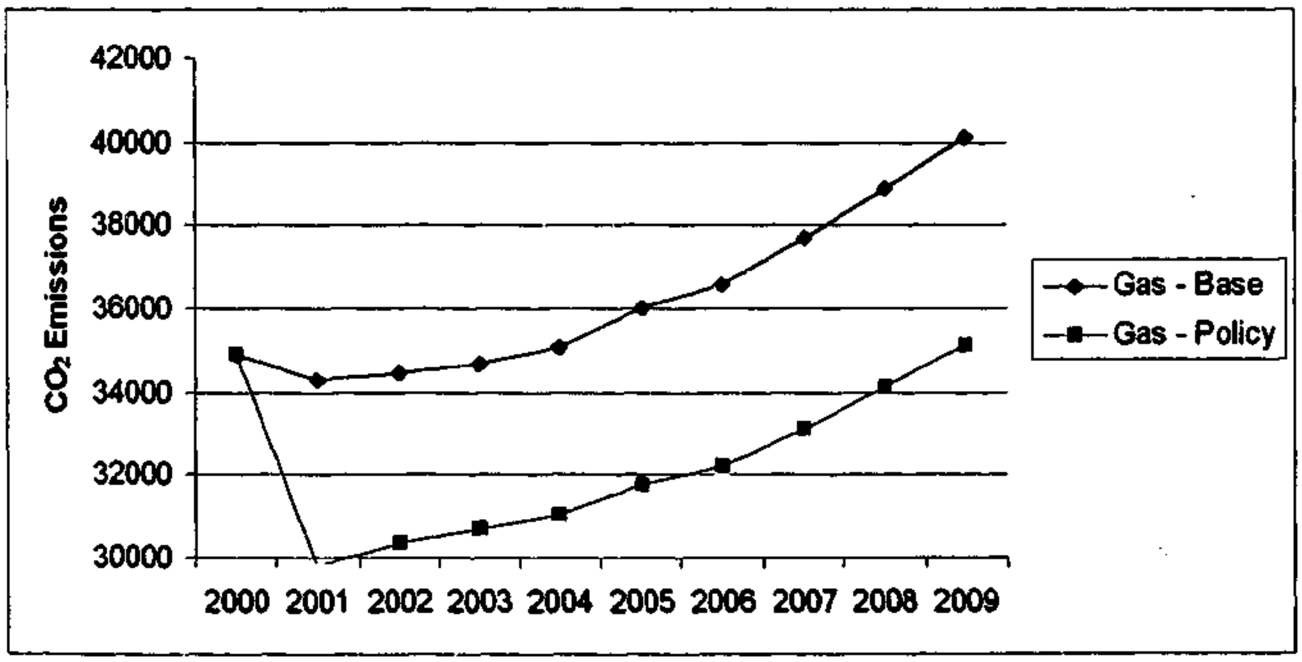
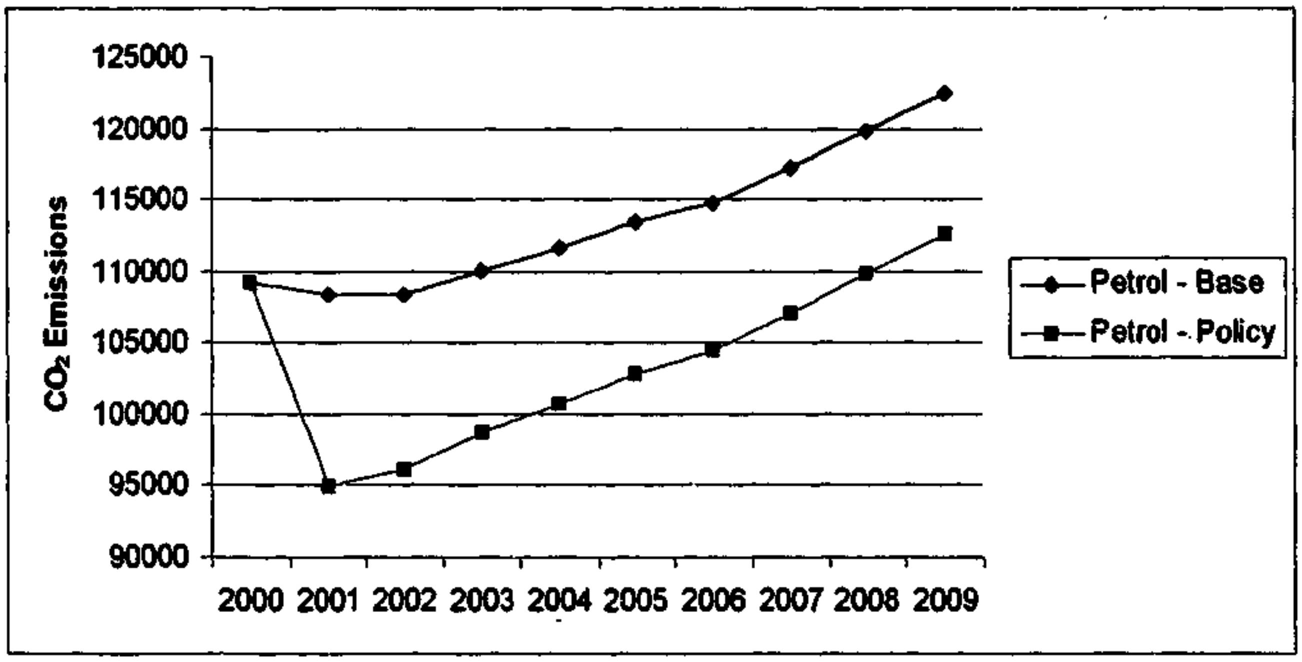


Chart 27-GF

CHANGE IN CO_2 EMISSIONS FROM PETROL BETWEEN BASECASE AND POLICY



Charts 28-GF and 29-GF outline the differences between the CO_2 emission basecase and policy simulation results for the electricity generators *EleBlk* and *EleGas*. There is a distinct difference between the pattern of the results for the two sectors of the electricity market. Whereas emissions for *EleBlk* were below those forecast in the basecase following the policy shock, the reverse was true for *EleGas*. As the greenhouse policy encouraged substitution toward the use of electricity generated from gas, the production of this commodity increased, with emissions following suit.

Chart 28-GF

CHANGE IN CO_2 EMISSIONS FROM ELEBLK BETWEEN BASECASE AND POLICY

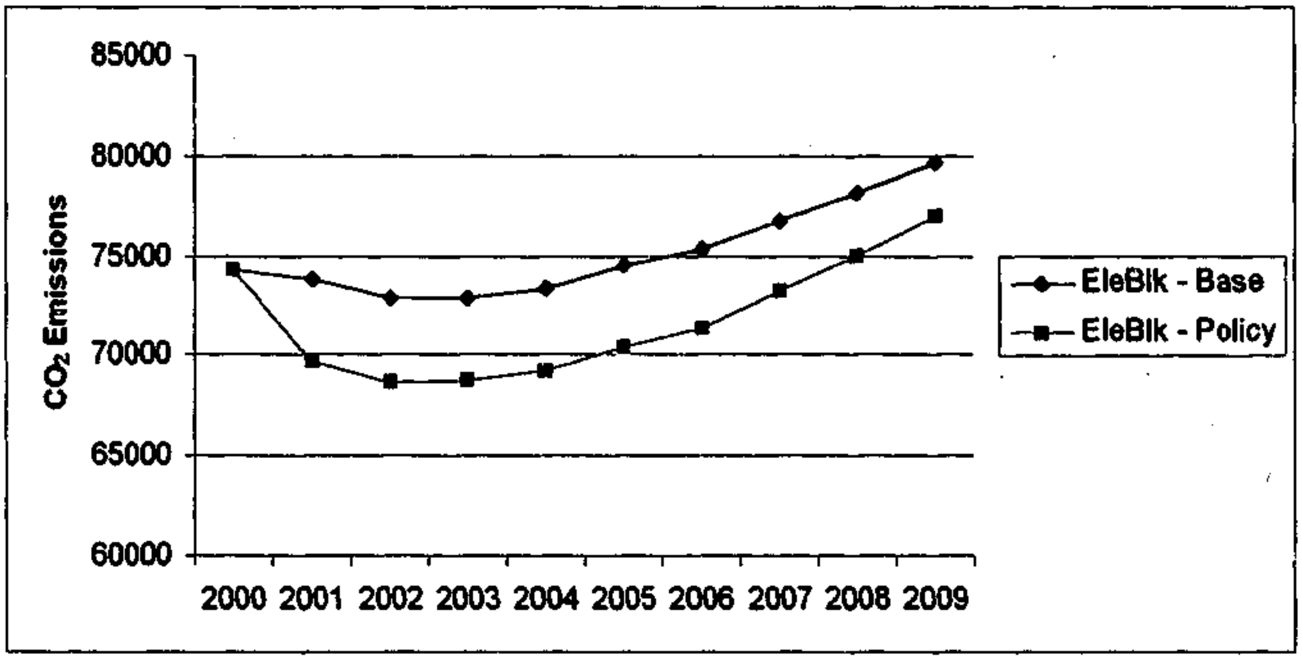
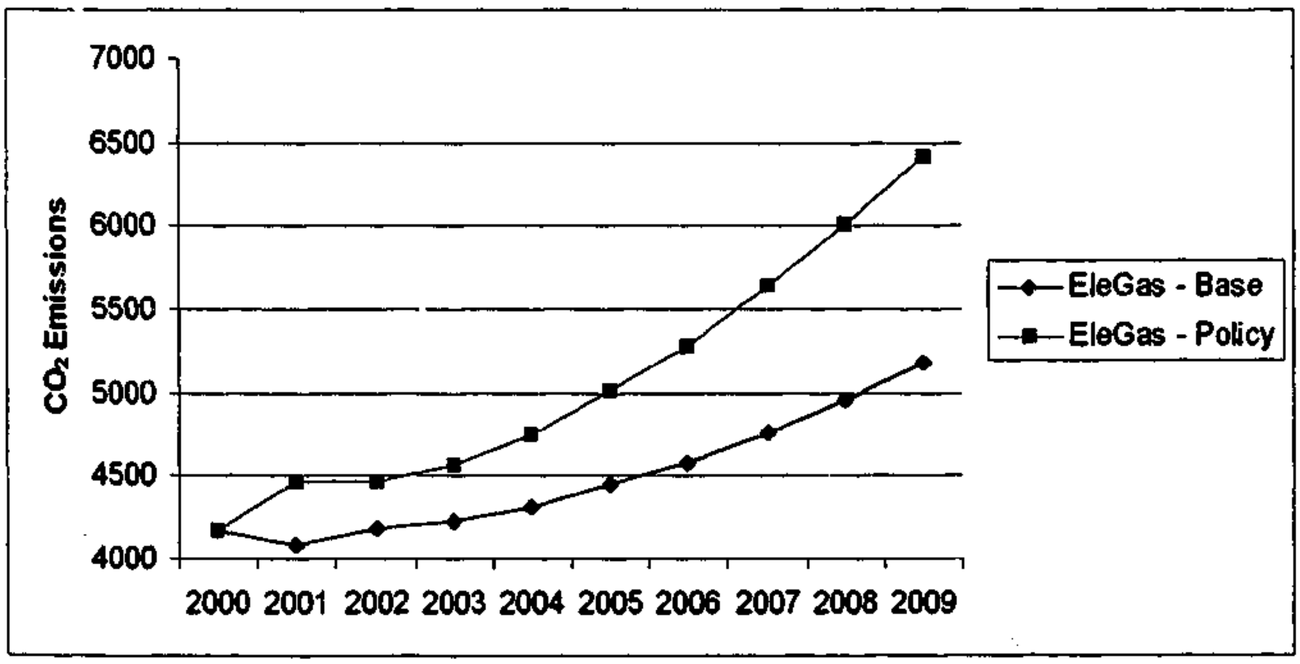


Chart 29-GF

CHANGE IN CO_2 EMISSIONS FROM ELEGAS BETWEEN BASECASE AND POLICY



The following charts outline the differences between the CO_2 emission basecase and policy simulation results for the brown coal electricity generators. In all instances the emissions from each of the generators have been reduced from where they would otherwise have been without the policy shock.

Chart 30-GF

CHANGE IN CO_2 EMISSIONS FROM ENERGY BRIX BETWEEN BASECASE AND POLICY

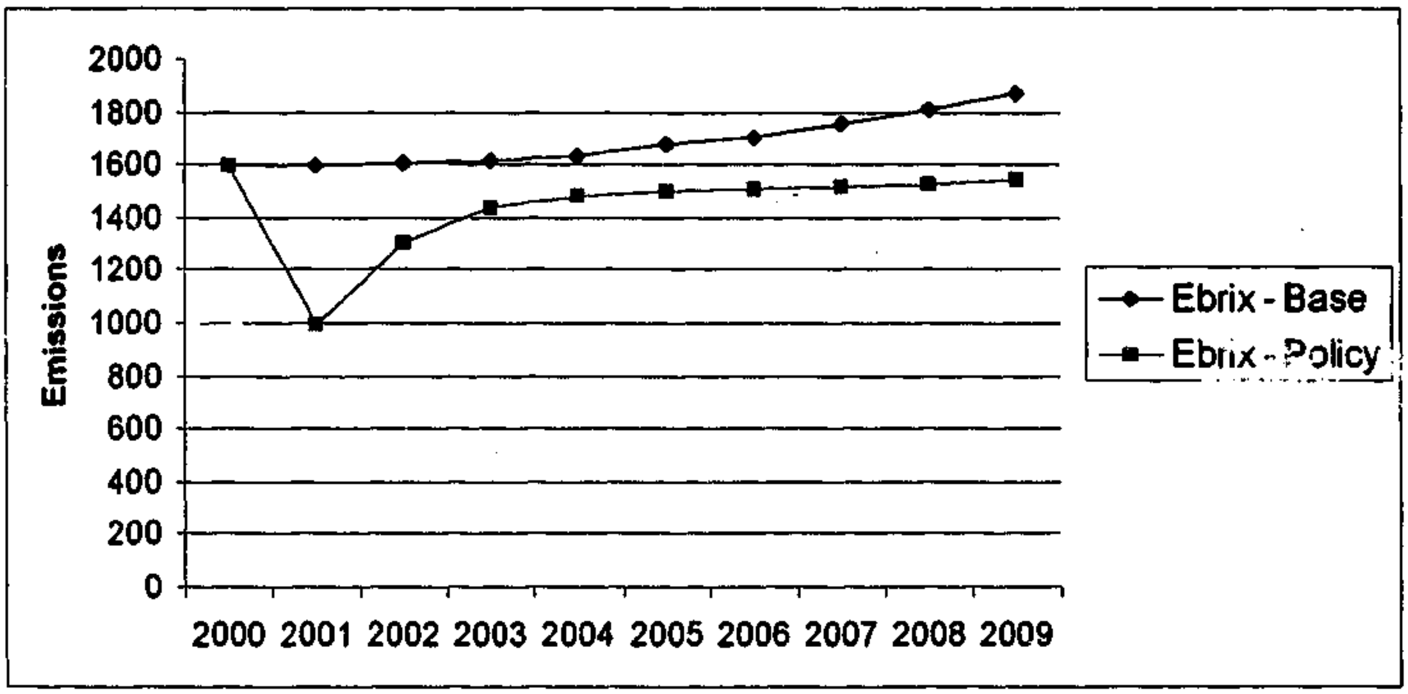


Chart 31-GF

CHANGE IN CO_2 EMISSIONS FROM HAZELWOOD BETWEEN BASECASE AND POLICY

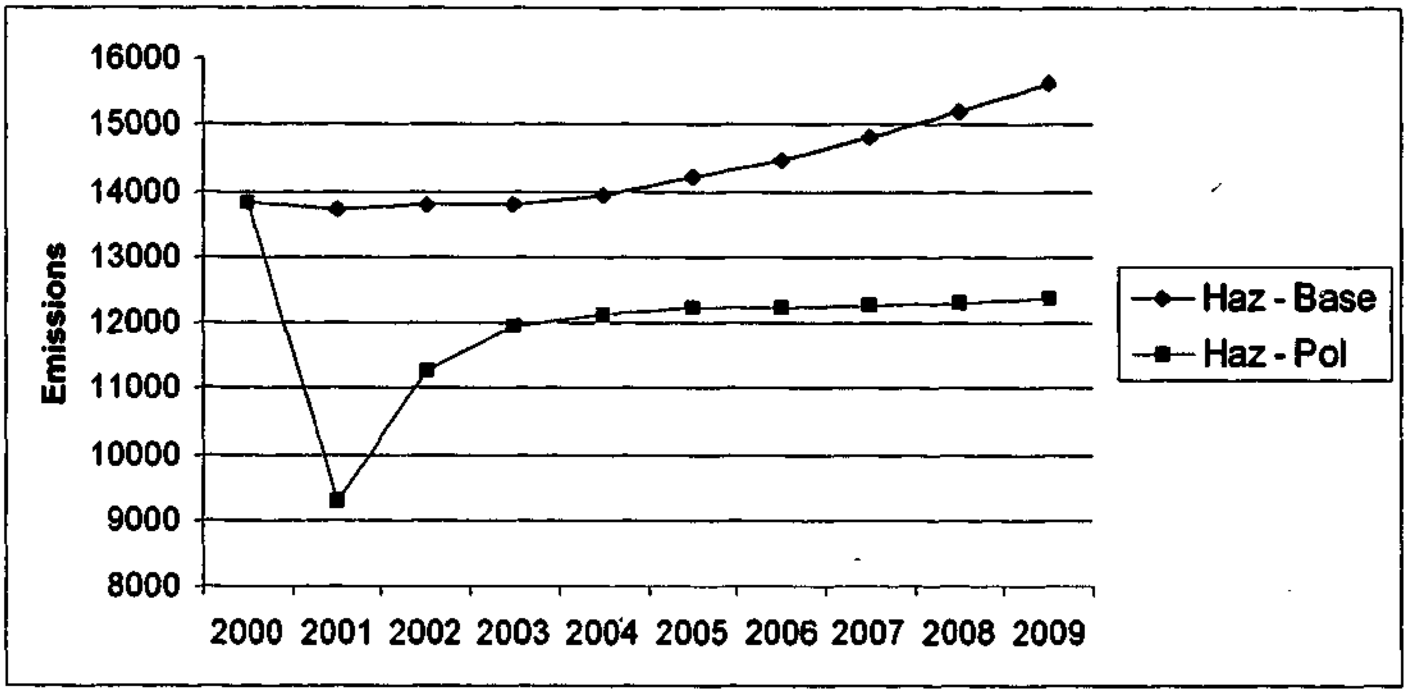


Chart 32-GF

CHANGE IN CO_2 EMISSIONS FROM LOYYANG BETWEEN BASECASE AND POLICY

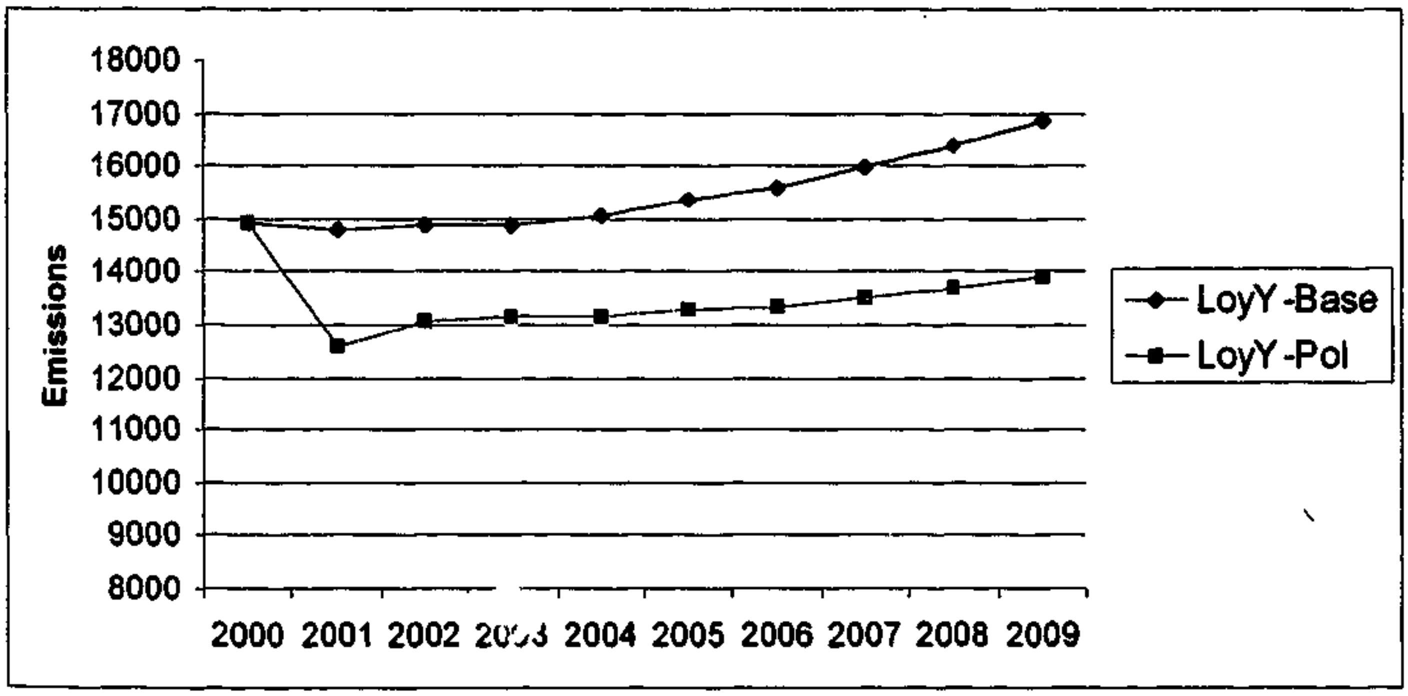


Chart 33-GF

CHANGE IN CO_2 EMISSIONS FROM YALLOURN BETWEEN BASECASE AND POLICY

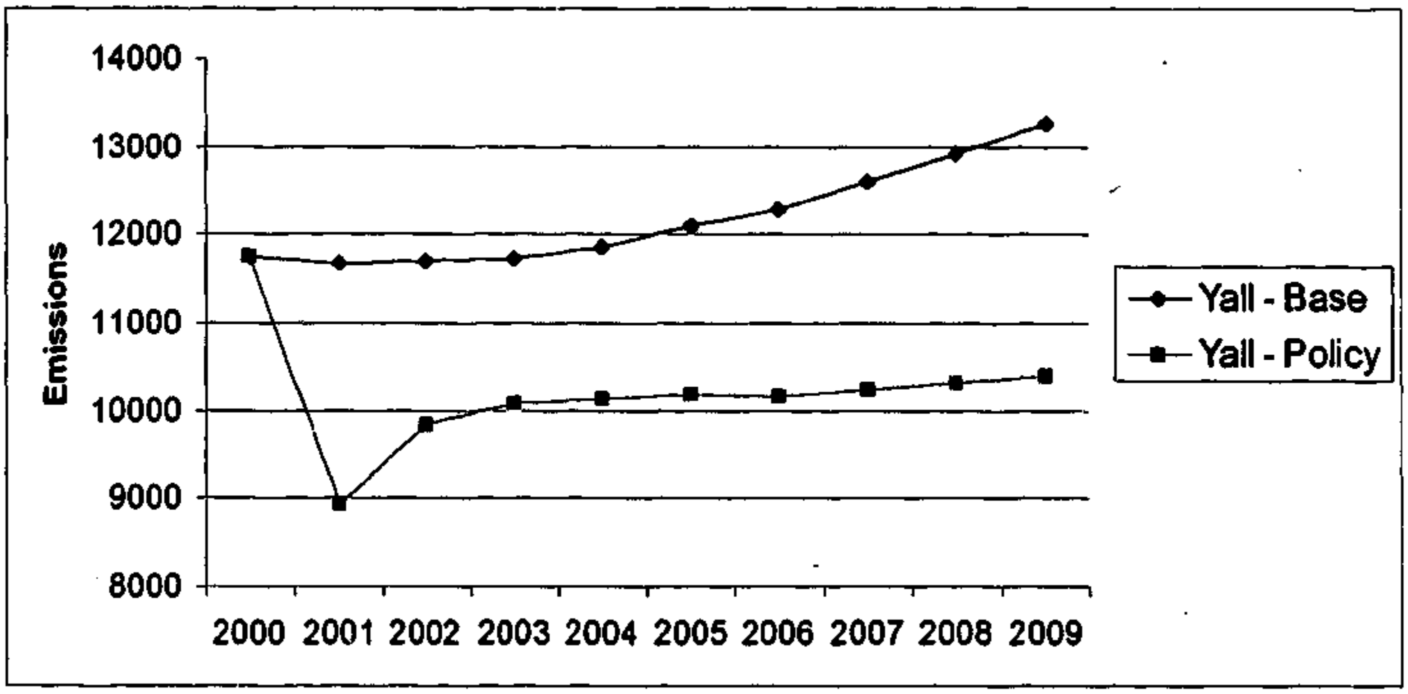
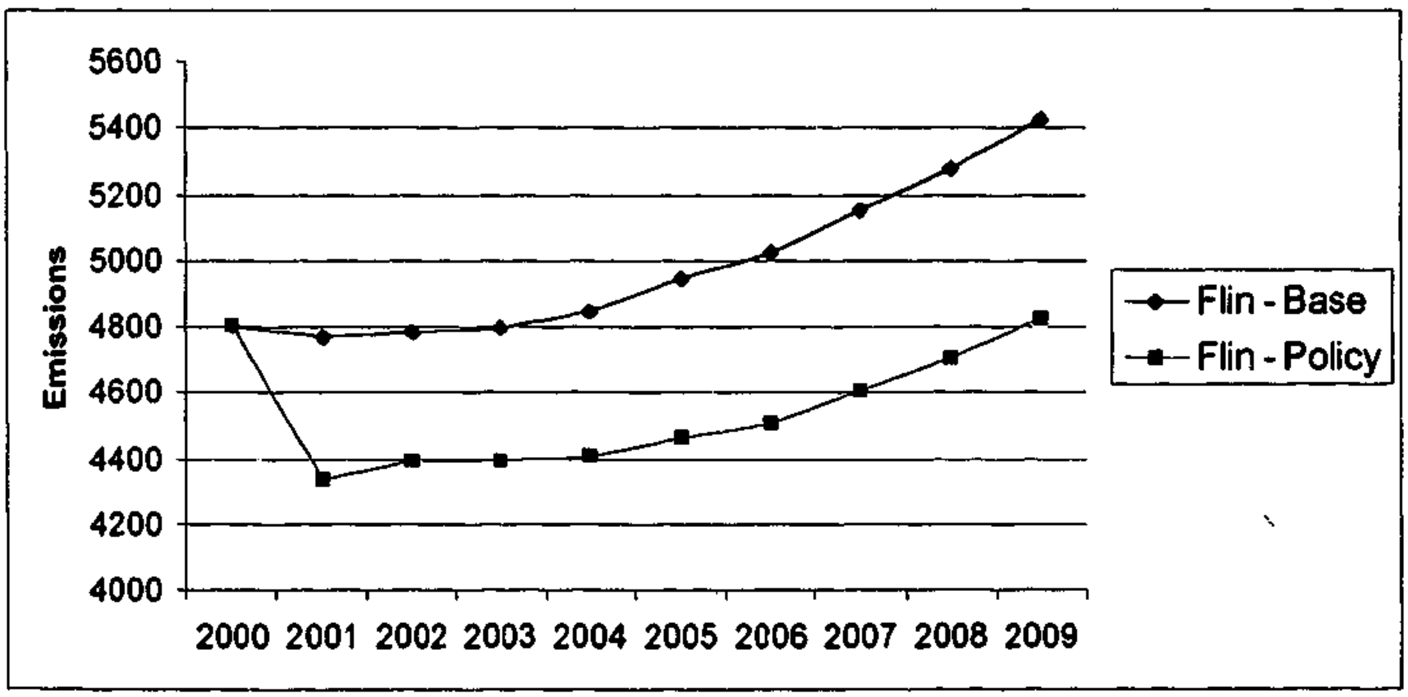


Chart 34-GF

CHANGE IN CO_2 EMISSIONS FROM FLINDERS BETWEEN BASECASE AND POLICY



Although the policy shock implemented in this simulation reduces CO_2 emissions, it is not strong enough. A further reduction of 8 percent is required for the economy to meet its commitment under the Kyoto target. Simulations using more severe shocks have been trialed. A shock in excess of $100 per tonne of CO_2 is required. The results of a larger shock present the same general trends, however the results are magnified in the majority of sectors.

Table 6.18

2009 POLICY MONASH GENERATED DATA: Emissions, CO_2 equivalent, kT

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I1Pastoral	0	0	0	213	0	213
I2WheatSheep	0	3	0	2479	0	2482
I3HighRain	0	2	0	660	0	662
I4NthBeef	0	0	0	270	0	270
I5MilkCattle	0	17	0	477	0	495
I6OthExport	0	24	0	601	0	625
I7ImportComp	0	26	0	632	0	658
I8Poultry	0	85	0	9	0	95
I9AgServ	0	0	0	228	0	228
I10Forestry	0	64	0	1117	0	1180
I11Fishing	0	0	0	1234	0	1234
I12IronOre	515	58	0	319	0	893
I13NFerrous	422	249	0	1275	0	1946
I14BlkCoal	14895	113	0	674	0	15682
I15aOil	127	1494	0	25	0	1645
I15bGas	78	1033	0	15	0	1126
I15cBrCoal	22	253	0	4	0	279
I16OthMin	101	63	0	696	0	860
I17MinServ	0	21	0	240	0	261
I18Meat	668	174	0	310	0	1153
I19Dairy	773	134	0	156	0	1063
I20FrtVeg	322	76	0	121	0	519
I21OilFat	44	6	0	10	0	59
I22Flour	253	58	0	34	0	346
I23Bakery	77	47	0	124	0	249
I24Confect	19	6	0	17	0	42
I25Sea_Sugar	439	175	0	346	0	960
I26SoftDr	36	21	0	132	0	190
I27Beer	101	20	0	21	0	141
I28OthDrink	50	25	0	44	0	119
I29Tobacco	24	3	0	4	0	31
I30Ginning	33	4	0	11	0	49
I31Synthetic	44	8	0	4	0	55
I32CottonYa	62	9	0	5	0	76
I33WoolYarn	0	0	0	8	0	8
I34TextileF	62	20	0	9	0	91
I35Carpets	7	2	0	6	0	15
I36Canvas	1	1	0	13	0	15
I37Knitting	7	2	0	5	0	13
I38Clothing	9	1	0	31	0	42
I39Footwear	0	0	0	3	0	4
I40Sawmill	88	18	0	208	0	314
I41Panels	197	32	0	77	0	306
I42Fittings	20	8	0	93	0	121
I43Furniture	8	8	0	56	0	73
I44PulpPaper	1014	123	0	129	0	1266
I45BagsBoxes	31	14	0	52	0	97
I46Sanitary	267	32	0	28	0	328
I47NewsBooks	3	5	0	146	0	154

Table 6.18 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I48CommPrint	26	21	0	207	0	255
I49Fertilisr	28	130	0	20	0	178
I50BasicChem	1886	1274	0	1025	0	4185
I51Paints	18	4	0	85	0	107
I52Pharmacy	11	4	0	57	0	72
I53Soaps	22	5	0	40	0	67
I54Cosmetics	3	9	0	16	0	28
I55Explosive	58	17	0	129	0	204
I56Petrol	276	0	0	14428	0	14704
I57Glass	80	118	0	56	0	254
I58ClayProd	288	187	0	73	0	548
I59Cement	789	1259	0	174	0	2222
I60Readymix	12	11	0	128	0	151
I61Pipes	82	46	0	101	0	228
I62Plaster	191	44	0	39	0	274
I63IronSteel	6040	1841	0	548	0	8429
I64aNFerrous	4205	513	0	3357	0	8075
I64bAlum	5479	668	0	4384	0	10531
I65Structurl	90	74	0	136	0	300
I66SheetMetl	46	188	0	100	0	334
I67Wire	114	141	0	139	0	394
I68MotorVeh	139	126	0	57	0	323
I69Ships	44	18	0	27	0	88
I70Trains	22	13	0	10	0	45
I71Aircraft	4	6	0	20	0	29
I72SciEquip	3	4	0	18	0	25
I73Electron	30	5	0	55	0	89
I74HousAppl	46	16	0	12	0	74
I75ElectEq	28	43	0	77	0	148
I76AgMach	27	27	0	9	0	63
I77ConMach	14	7	0	10	0	31
I78ManuMach	98	73	0	129	0	300
I79Leather	28	3	0	15	0	47
I80Rubber	33	13	0	33	0	78
I81Plastic	36	20	0	100	0	156
I82Signs	2	2	0	12	0	16
I83SportEq	443	67	0	16	0	527
I84aaaEleBr	0	0	0	0	0	0
I84aaaaEdis	0	0	0	59	6943	7002
I84aaabEBrix	0	0	0	10	1541	1551
I84aaacHaz	0	0	0	87	12357	12444
I84aaadLoyY	0	0	0	116	13905	14022
I84aaaeYall	0	0	0	79	10395	10474
I84aaafFlin	0	0	0	44	4822	4866
I84aabEleBlk	0	0	0	1020	76916	77936
I84aacEleGas	0	0	0	92	6413	6505
I84aadEleHyd	0	0	0	162	0	162
I84aaeEleOth	0	0	0	17	0	17
I84bElectTrn	0	0	0	113	0	113
I84cElectDist	0	0	0	1145	0	1145
I85Gas	54	17422	0	82	0	17558
I86Water	29	0	0	1032	0	1061

Table 6.18 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I87Resident	0	238	0	1744	0	1982
I88OthBuild	124	142	0	2262	0	2528
I89Wholesale	238	106	0	4765	0	5108
I90RetailTrd	1031	429	0	2186	0	3646
I91MechRep	0	0	0	33	0	33
I92OthRepair	0	0	0	536	0	536
I93RoadTrans	0	230	0	6807	0	7037
I94RailTrans	0	407	0	3182	0	3589
I95WaterTran	254	14	0	2027	0	2295
I96AirTransp	0	0	0	9325	0	9325
I97TransServ	0	0	0	235	0	235
I98Communic	0	824	0	1137	0	1961
I99Banking	0	445	0	358	0	803
I100NonBank	0	0	0	85	0	85
I101Investm	0	65	0	90	0	155
I102Insurnce	0	0	0	83	0	83
I103OthFinan	0	0	0	4975	0	4975
I104Dwelling	0	0	0	138	0	138
I105PubAdmin	269	330	0	434	0	1032
I106Defence	97	916	0	1607	0	2620
I107Health	380	315	0	514	0	1209
I108Educate	38	188	0	19	0	245
I109Welfare	9	1076	0	3768	0	4852
I110Entrtain	73	116	0	475	0	665
I111Hotels	8	275	0	182	0	465
I112PerServ	15	27	0	646	0	689
I113Other	0	0	0	0	0	0
Household	103	0	0	21633	0	21736
Total	44283	35095	0	112520	133293	325191

Table 6.21

PERCENTAGE CHANGE IN EMISSIONS FROM FUEL USAGE BY INDUSTRY, SUMMED OVER SOURCE

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I1Pastoral	-3.7	0.2	2.7	3.9	4.6	5.0	5.3	5.6	5.9	6.2
I2WheatSheep	-5.6	-3.1	-1.5	-0.7	-0.1	0.3	0.6	1.0	1.3	1.6
I3HighRain	-4.2	-1.0	1.0	2.0	2.5	2.9	3.1	3.4	3.5	3.7
I4NthBeef	-4.3	-0.6	1.6	2.8	3.5	4.1	4.6	5.2	5.8	6.4
I5MilkCattle	-5.4	-3.6	-2.5	-1.9	-1.6	-1.4	-1.3	-1.2	-1.2	-1.2
I6OthExport	-5.8	-3.6	-2.2	-1.1	-0.3	0.6	1.3	2.1	2.6	3.1
I7ImportComp	-6.5	-4.9	-4.0	-3.5	-3.3	-3.1	-2.9	-2.8	-2.8	-2.7
I8Poultry	-5.6	-3.1	-1.9	-1.4	-1.3	-1.3	-1.4	-1.4	-1.5	-1.6
I9AgServ	-7.6	-6.5	-6.0	-5.7	-5.5	-5.3	-5.2	-5.0	-4.9	-4.8
I10Forestry	-7.8	-7.4	-7.2	-7.1	-7.0	-6.9	-6.8	-6.6	-6.5	-6.4
I11Fishing	-11.4	-7.6	-4.7	-3.1	-2.0	-0.8	0.4	1.5	2.6	3.6
I12IronOre	-12.7	-8.9	-7.1	-6.5	-5.5	-3.3	-1.1	1.0	3.0	4.9
I13NFerrous	-10.3	-6.4	-3.9	-2.8	-2.3	-1.6	-0.9	0.0	1.0	2.0
I14BlkCoal	-7.1	-4.0	-1.4	-0.7	0.1	0.9	1.9	3.0	4.1	5.3
I15aOil	-10.2	-9.8	-9.9	-10.1	-10.3	-10.5	-10.7	-10.8	-10.9	-11.0
I15bGas	-7.3	-6.8	-6.5	-6.5	-6.5	-6.4	-6.4	-6.2	-6.2	-6.1
I15cBrCoal	-29.2	-23.8	-22.3	-22.6	-23.6	-24.5	-25.6	-26.6	-27.7	-28.6
I16OthMin	-10.9	-10.1	-9.5	-9.0	-8.7	-8.4	-8.2	-8.0	-7.9	-7.7
I17MinServ	-10.4	-8.0	-6.4	-5.8	-5.4	-4.9	-4.4	-3.9	-3.3	-2.7
I18Meat	-10.1	-6.1	-3.3	-1.8	-1.0	-0.2	0.2	0.7	1.0	1.4
I19Dairy	-13.8	-13.2	-12.7	-12.5	-12.3	-12.0	-11.9	-11.7	-11.6	-11.5
I20FrtVeg	-14.2	-13.7	-13.3	-13.2	-13.1	-13.0	-12.9	-12.8	-12.7	-12.7
I21OilFat	-14.7	-13.7	-12.9	-12.5	-12.2	-12.0	-11.8	-11.6	-11.5	-11.3
I22Flour	-13.8	-13.0	-12.3	-12.0	-11.7	-11.5	-11.3	-11.1	-11.0	-10.8
I23Bakery	-10.7	-10.5	-10.4	-10.4	-10.3	-10.2	-10.2	-10.1	-10.0	-9.9
I24Confect	-12.4	-11.8	-11.5	-11.3	-11.2	-11.1	-11.1	-11.0	-11.0	-10.9
I25Sea_Sugar	-7.1	-0.4	4.8	9.0	12.0	15.4	18.4	21.3	23.8	26.1
I26SoftDr	-10.3	-10.3	-10.3	-10.5	-10.5	-10.5	-10.5	-10.6	-10.5	-10.5
I27Beer	-15.8	-15.6	-15.3	-15.4	-15.4	-15.4	-15.4	-15.3	-15.3	-15.2
I28OthDrink	-12.6	-11.8	-11.4	-11.2	-11.3	-11.3	-11.4	-11.4	-11.5	-11.5
I29Tobacco	-15.1	-14.4	-13.7	-13.4	-13.1	-12.8	-12.6	-12.4	-12.2	-11.9
I30Ginning	-10.3	-6.6	-3.9	-2.4	-1.9	-1.2	-1.1	-0.9	-0.9	-0.8
I31Synthetic	-14.7	-12.2	-10.5	-9.6	-9.1	-8.6	-8.4	-8.0	-7.9	-7.6
I32CottonYa	-14.6	-12.4	-10.8	-10.0	-9.5	-9.1	-8.9	-8.6	-8.5	-8.3
I33WoolYarn	-8.3	-7.4	-6.9	-6.6	-6.4	-6.3	-6.3	-6.2	-6.2	-6.2
I34TextileF	-14.3	-13.3	-12.6	-12.3	-12.1	-11.9	-11.8	-11.7	-11.7	-11.6
I35Carpets	-14.5	-13.7	-13.2	-13.0	-12.9	-12.9	-12.9	-13.0	-13.0	-13.1
I36Canvas	-9.6	-8.6	-8.1	-7.8	-7.6	-7.4	-7.3	-7.2	-7.1	-7.0
I37Knitting	-12.7	-11.8	-11.3	-11.0	-10.8	-10.6	-10.5	-10.4	-10.3	-10.2
I38Clothing	-9.8	-9.1	-8.6	-8.4	-8.3	-8.2	-8.1	-8.1	-8.1	-8.1
I39Footwear	-7.5	-5.6	-4.7	-4.2	-4.0	-3.8	-3.8	-3.8	-3.8	-3.9
I40Sawmill	-10.2	-8.8	-7.9	-7.4	-7.1	-6.8	-6.6	-6.5	-6.4	-6.3
I41Panels	-14.6	-13.8	-13.1	-12.6	-12.3	-12.0	-11.8	-11.7	-11.5	-11.4
I42Fittings	-10.2	-9.7	-9.4	-9.1	-8.8	-8.7	-8.5	-8.4	-8.3	-8.3
I43Furniture	-11.6	-11.0	-10.8	-10.8	-10.9	-11.1	-11.2	-11.4	-11.6	-11.8
I44PulpPaper	-16.0	-15.0	-14.1	-13.6	-13.2	-12.9	-12.6	-12.4	-12.2	-12.0
I45BagsBoxes	-12.0	-10.9	-10.1	-9.7	-9.4	-9.0	-8.8	-8.5	-8.3	-8.1
I46Sanitary	-16.1	-15.4	-14.8	-14.5	-14.3	-14.1	-14.0	-13.8	-13.7	-13.5
I47NewsBooks	-9.3	-8.9	-8.8	-8.7	-8.6	-8.6	-8.5	-8.5	-8.4	-8.4

Table 6.21 Continued

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I48CommPrint	-10.4	-9.8	-9.4	-9.3	-9.1	-9.0	-8.9	-8.8	-8.8	-8.7
I49Fertilisr	-10.5	-8.7	-7.9	-7.7	-7.7	-7.7	-7.7	-7.7	-7.7	-7.6
I50BasicChem	-14.6	-13.2	-12.3	-11.9	-11.6	-11.3	-11.2	-11.0	-10.9	-10.7
I51Paints	-10.9	-10.1	-9.5	-9.1	-8.8	-8.5	-8.3	-8.2	-8.0	-7.9
I52Pharmacy	-10.4	-9.3	-8.8	-8.6	-8.4	-8.3	-8.2	-8.1	-8.0	-8.0
I53Soaps	-11.4	-11.0	-10.7	-10.6	-10.5	-10.5	-10.4	-10.4	-10.3	-10.3
I54Cosmetics	-9.8	-9.3	-9.2	-9.2	-9.2	-9.3	-9.4	-9.4	-9.5	-9.5
I55Explosive	-11.9	-10.5	-9.5	-9.0	-8.7	-8.3	-8.0	-7.7	-7.5	-7.3
I56Petrol	-11.1	-10.1	-9.2	-8.7	-8.2	-7.9	-7.5	-7.2	-6.9	-6.7
I57Glass	-11.9	-11.1	-10.7	-10.5	-10.4	-10.3	-10.3	-10.3	-10.3	-10.3
I58ClayProd	-13.0	-12.2	-11.6	-11.2	-11.0	-10.8	-10.7	-10.6	-10.6	-10.5
I59Cement	-13.0	-12.4	-12.0	-11.7	-11.4	-11.2	-11.1	-11.0	-11.0	-11.0
I60Readymix	-10.5	-10.2	-9.9	-9.3	-8.7	-8.4	-8.1	-8.0	-7.8	-7.7
I61Pipes	-13.8	-13.3	-12.8	-12.2	-11.6	-11.3	-11.0	-10.8	-10.6	-10.5
I62Plaster	-15.0	-14.2	-13.5	-13.0	-12.6	-12.2	-12.0	-11.7	-11.6	-11.4
I63IronSteel	-16.3	-15.1	-14.1	-13.4	-12.9	-12.4	-12.1	-11.9	-11.7	-11.5
I64aNFerrous	-34.2	-29.7	-24.8	-22.5	-21.1	-19.9	-19.4	-18.9	-19.4	-19.6
I64bAlum	-37.8	-31.9	-25.5	-22.6	-21.1	-19.7	-19.4	-19.2	-19.8	-20.2
I65Structurl	-15.6	-15.8	-15.3	-14.2	-13.1	-12.3	-11.8	-11.5	-11.3	-11.2
I66SheetMetl	-10.2	-9.5	-9.3	-9.2	-9.1	-9.1	-9.1	-9.1	-9.1	-9.1
I67Wire	-13.4	-12.3	-11.3	-10.5	-9.9	-9.4	-9.2	-9.1	-9.0	-9.0
I68MotorVeh	-14.1	-12.4	-11.3	-10.7	-10.3	-10.0	-9.9	-9.8	-9.8	-9.8
I69Ships	-15.2	-13.5	-12.2	-11.4	-11.0	-10.4	-10.1	-9.7	-9.5	-9.3
I70Trains	-15.0	-13.2	-12.0	-11.4	-11.0	-10.4	-10.0	-9.5	-9.1	-8.7
I71Aircraft	-10.3	-8.7	-7.6	-7.0	-6.6	-6.2	-6.0	-5.9	-5.8	-5.7
I72SciEquip	-10.6	-10.4	-10.3	-10.2	-10.2	-10.2	-10.2	-10.2	-10.1	-10.1
I73Electron	-12.9	-11.6	-10.7	-10.2	-9.9	-9.6	-9.4	-9.3	-9.2	-9.1
I74HousAppl	-15.6	-14.7	-14.0	-13.6	-13.4	-13.3	-13.2	-13.1	-13.0	-12.9
I75ElectEq	-12.1	-11.2	-10.6	-10.2	-9.8	-9.6	-9.4	-9.3	-9.2	-9.1
I76AgMach	-12.2	-10.8	-9.9	-9.5	-9.2	-8.8	-8.5	-8.0	-7.7	-7.4
I77ConMach	-14.4	-13.1	-12.3	-11.7	-11.2	-10.8	-10.5	-10.3	-10.1	-9.8
I78ManuMach	-14.6	-13.8	-13.0	-12.3	-11.6	-11.2	-10.9	-10.6	-10.5	-10.3
I79Leather	-12.5	-11.7	-11.1	-10.9	-10.7	-10.5	-10.4	-10.2	-10.2	-10.0
I80Rubber	-13.7	-12.4	-11.6	-11.2	-10.9	-10.6	-10.4	-10.1	-10.0	-9.8
I81Plastic	-11.1	-9.8	-9.0	-8.5	-8.2	-7.9	-7.8	-7.6	-7.5	-7.4
I82Signs	-10.9	-10.0	-9.4	-9.2	-8.9	-8.8	-8.7	-8.6	-8.6	-8.6
I83SportEq	-16.5	-15.3	-14.3	-13.8	-13.5	-13.2	-13.0	-12.9	-12.8	-12.6
I84aaaEleBr	-14.9	-10.1	-8.3	-8.2	-8.9	-9.8	-10.9	-12.1	-13.4	-14.6
I84aaaaEdis	-26.6	-24.4	-23.3	-22.9	-22.9	-23.0	-23.3	-23.7	-24.2	-24.7
I84aaabEBrix	-49.1	-34.2	-27.1	-24.7	-24.2	-24.3	-25.3	-26.3	-27.7	-28.8
I84aaacHaz	-44.3	-33.2	-28.4	-26.7	-26.5	-26.7	-27.6	-28.5	-29.8	-30.9
I84aaadLoyY	-27.3	-24.9	-23.6	-23.3	-23.4	-23.4	-23.8	-24.2	-24.8	-25.3
I84aaaeYall	-35.8	-29.8	-27.3	-26.6	-26.7	-27.0	-27.7	-28.5	-29.6	-30.5
I84aaafFlin	-20.6	-20.2	-19.5	-19.2	-18.9	-18.6	-18.4	-18.2	-18.3	-18.3
I84aabEleBlk	-13.3	-14.0	-13.4	-12.7	-11.9	-11.1	-10.3	-9.6	-9.0	-8.4
I84aacEleGas	1.9	-0.9	0.7	3.3	6.3	9.3	12.3	15.0	17.4	19.6
I84aadEleHyd	7.6	6.8	7.5	8.8	10.2	11.5	12.7	13.7	14.7	15.5
I84aaeEleOth	22.7	17.2	17.3	19.1	21.5	23.7	26.0	28.2	30.8	33.3
I84bElectTrn	-18.3	-16.6	-14.8	-13.7	-13.1	-12.6	-12.3	-12.0	-11.9	-11.6
I84cElectDist	-8.4	-8.1	-7.4	-6.9	-6.5	-6.2	-6.0	-5.8	-5.8	-5.7
I85Gas	-14.4	-13.3	-12.8	-13.0	-13.4	-13.7	-13.9	-13.9	-14.0	-14.0
I86Water	-9.4	-9.2	-9.0	-8.6	-8.1	-7.9	-7.7	-7.6	-7.5	-7.4
I87Resident	-6.6	-6.9	-7.1	-7.2	-7.2	-7.2	-7.1	-7.1	-7.1	-7.0

Table 6.21 Continued

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I88OthBuild	-14.6	-14.0	-13.3	-12.6	-11.6	-11.1	-10.5	-10.2	-9.9	-9.8
I89Wholesale	-11.8	-11.1	-10.5	-10.1	-9.6	-9.3	-9.0	-8.8	-8.5	-8.4
I90RetailTrd	-13.0	-13.2	-13.5	-13.7	-13.8	-13.9	-14.0	-14.0	-14.0	-14.0
I91MechRep	-9.1	-9.1	-9.3	-9.5	-9.5	-9.7	-9.7	-9.8	-9.7	-9.8
I92OthRepair	-9.7	-9.5	-9.5	-9.5	-9.4	-9.3	-9.1	-9.0	-8.8	-8.6
I93RoadTrans	-9.5	-8.7	-8.1	-7.7	-7.3	-7.0	-6.7	-6.4	-6.2	-6.0
I94RailTrans	-8.9	-7.4	-6.5	-6.1	-5.8	-5.4	-4.9	-4.4	-3.9	-3.4
I95WaterTran	-12.4	-7.7	-4.2	-2.5	-1.4	-0.1	1.0	2.0	2.8	3.6
I96AirTransp	-7.5	-5.3	-3.6	-2.3	-1.5	-0.7	-0.2	0.2	0.5	0.7
I97TransServ	-10.6	-9.3	-8.3	-7.8	-7.3	-6.9	-6.5	-6.2	-5.9	-5.7
I98Communic	-10.4	-10.5	-10.7	-11.1	-11.2	-11.4	-11.5	-11.6	-11.6	-11.6
I99Banking	-10.1	-9.9	-9.9	-10.2	-10.3	-10.5	-10.6	-10.8	-10.8	-10.9
I100NonBank	-10.8	-10.1	-9.7	-9.4	-9.1	-8.9	-8.6	-8.4	-8.1	-8.1
I101Investm	-10.7	-10.0	-10.0	-10.2	-10.3	-10.4	-10.4	-10.4	-10.3	-10.3
I102Insurnce	-10.9	-11.0	-11.2	-11.6	-11.8	-12.0	-12.0	-12.1	-12.1	-12.1
I103OthFinan	-9.5	-9.2	-9.0	-8.9	-8.6	-8.4	-8.2	-8.0	-7.8	-7.6
I104Dwelling	-8.6	-9.0	-9.4	-9.8	-10.0	-10.3	-10.5	-10.8	-11.0	-11.4
I105PubAdmin	-12.5	-12.6	-12.7	-12.7	-12.7	-12.8	-12.8	-12.9	-12.9	-13.0
I106Defence	-10.3	-10.6	-10.8	-11.0	-11.1	-11.2	-11.3	-11.5	-11.6	-11.7
I107Health	-13.9	-13.9	-14.1	-14.4	-14.6	-15.0	-15.2	-15.5	-15.8	-16.0
I108Educate	-12.6	-12.8	-13.2	-13.7	-14.1	-14.5	-14.8	-15.2	-15.5	-15.7
I109Welfare	-10.4	-10.6	-10.9	-11.2	-11.3	-11.5	-11.6	-11.8	-11.9	-12.0
I110Entrtain	-11.8	-11.8	-12.0	-12.3	-12.6	-12.9	-13.1	-13.3	-13.4	-13.6
I111Hotels	-8.7	-7.7	-7.2	-7.1	-7.1	-7.1	-7.2	-7.2	-7.3	-7.2
I112PerServ	-10.0	-10.1	-10.3	-10.6	-10.9	-11.2	-11.4	-11.6	-11.7	-12.0
I113Other	-6.6	-6.7	-7.0	-7.1	-7.1	-7.3	-7.4	-7.6	-7.7	-7.9
Household	-14.9	-15.0	-15.3	-15.5	-15.4	-15.4	-15.2	-15.1	-14.9	-14.7

6.6 AUCTIONED REVENUE RESULTS

The results for the two simulations discussed in this chapter differ in their treatment of the greenhouse tax revenue. In the case of grandfathering, the revenue is collected and then returned to the shareholders of the firms who are responsible for Australia's emissions. The grandfathering of the permits is based on the assumption that emission trading permits are distributed to CO_2 emitters free of charge. The grandfathered revenue increases domestic nominal disposable income but it does not alter the emitting industries production or investment decisions. In this section it is assumed that emission permits are auctioned. The Government collects the revenue and redistributes it throughout the economy. For the purpose of this chapter it is assumed that the Government uses the revenue to reduce the level of domestic consumption tax.

Despite the treatment of revenue, the overall pattern of economic activity for most of the macroeconomic and industry results remain the same. Those industries deemed to be energy intensive still bear the cost of greenhouse policy. For most of the results it is only the magnitude of the percentage change in the variables that differs between the simulations.

The discussion of the auctioned permit results takes the following format. Where it is found that the explanation underlying the result is the same as that outlined for the grandfathering results, only differences will be reported. Full explanations will be given where the discussion provided for the grandfathering result is not adequate or not applicable. From herein, the grandfathered simulation described in Section 6.5 above is referred to as the **reference case.**

The relevant charts for the auctioned permits simulation are Charts 1-RR to 20-RR. These charts provide essentially the same information as found in Charts 1-GF to 24-GF. Reference will be made to the main differences between these charts.

Overview

The overview for the first year of the simulation remains unchanged except that this time the price of GDP adjusts to absorb some of the increase in the tax. Maintaining the assumption of sticky wages, the tax does not alter the return on labour. Instead the tax reduces the real return on capital. Albeit slightly, capital is now relatively cheaper than labour and producers attempt to substitute toward the cheaper input. However, the fixed capital stock forces producers to reduce the amount of labour they use. In aggregate, employment falls but by less than in the reference case.

After the first year wages are no longer sticky and the real wage falls, moving employment back toward control. The reduction in the real return on labour now absorbs some of the loss associated with the greenhouse tax and the relative price of capital begins to rise. This encourages the capital stock to rise periodically at the industry level. The supply side of the capital market responds to the relative increase in the price of capital by increasing investment at the industry level.

i In the short-run, employment and real GDP fall by less when the permits are auctioned relative to the reference case

Chart 1-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR EMPLOYMENT AND THE REAL WAGE

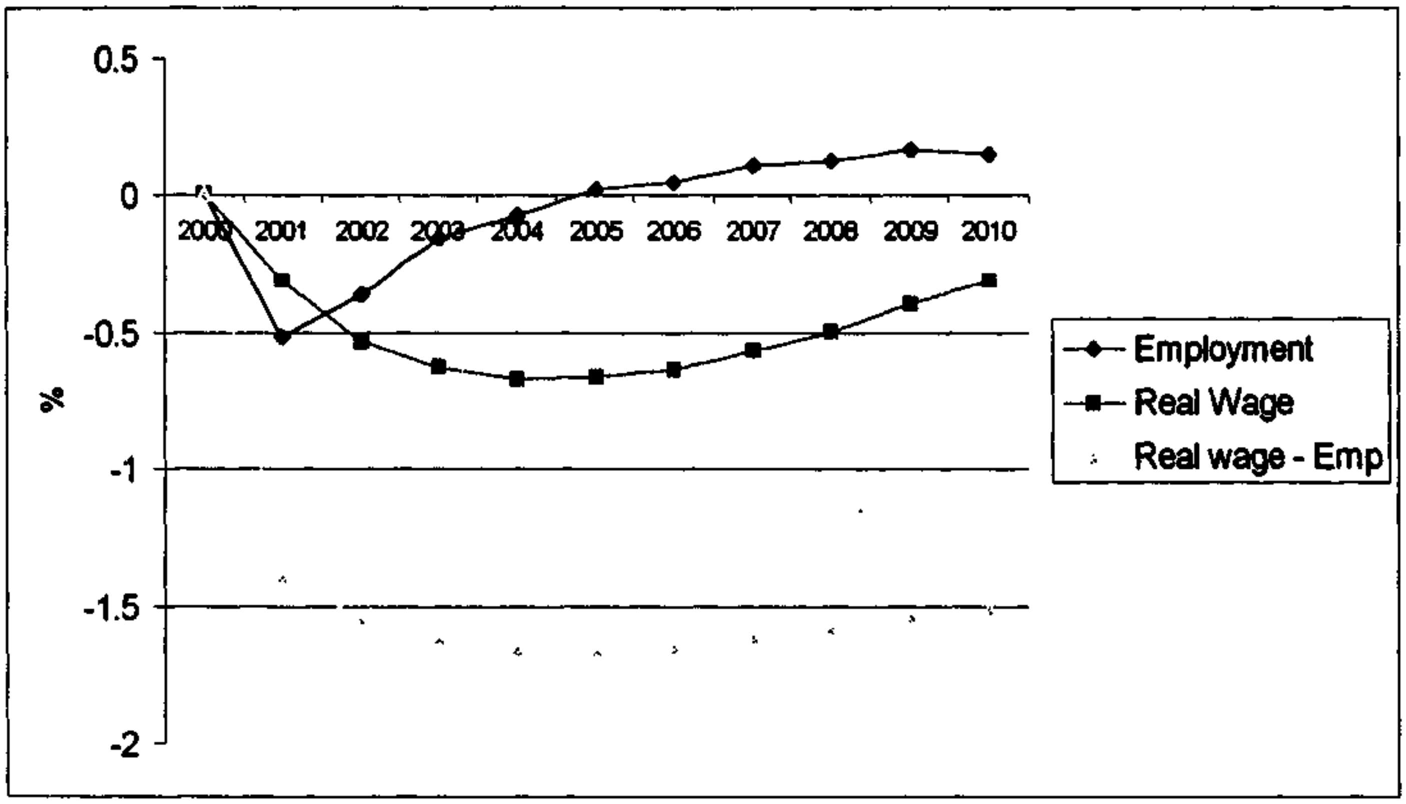


Chart 1-RR shows the deviation-from-base path of employment. The employment result is considerably higher when the permits are auctioned. Whereas employment fell by over 4 percent in the first year of the reference case, it falls by only 0.5 percent in the auctioned simulation. The difference between the employment results for the simulations lies in the modelling of the labour market. In both simulations it is assumed that in the short-run employees are concerned with after-tax real wage rates. It is the after-tax real wage rate that is sticky. As found in the reference case, the greenhouse policy raises the real cost of employing labour. However unlike the reference case, the wedge between the price of expenditure and the price received by producers is smaller due to the reduction in consumption tax. With the real wage from the employee's point of view sticky in the short-run, the reduction in consumption tax rates allows the nominal wage rate to decline relative to the price of consumption. This goes some way to offsetting the increase in the CPI relative to the price of output. In aggregate the real cost of labour increases, but by considerably less than in the reference case.

As was the case in reference simulation, in 2002 employment increases toward control as the wage-adjustment mechanism in MONASH-Electricity alleviates the impact of the greenhouse shock on employment. The wage-mechanism returns employment to control after 2004. This is a considerably shorter period for employment to return to base than found in the reference case. The time elapsed before returning to control differs between the simulations by a period of five years. In the auctioned simulation the fall in employment is not as severe and it responds more readily to the reduction in the real wage. The more positive employment response in this simulation is also due in part to terms of trade effects. In 2005 aggregate employment rises above base, causing real wages to respond. As shown on Chart 1-RR the real wage rises to re-adjust employment back toward control.

Another difference between the simulations is the paths for the real wage and the real wage paid by employers. In the reference case the paths are almost identical. As shown on Chart 1-RR, the real wage paid by employers in the auctioning simulation falls by one percent more than the real wage received by consumers. The gap is attributed to the reduction in consumption tax as consumers respond to the real after-tax wage rate. Consumers receive a lower real wage after-tax because they are compensated by the reduction in the rate of consumption tax they have to pay.

ii As was found in the reference case, the Capital Stock declines

In similar fashion to the reference case, the capital stock falls after the first year of the policy shock in response to the relative price of labour decreasing. The fall in the capital stock is much more gradual, reaching only –0.5 percent after 2010. This is in contrast to the fall in the capital stock of almost 2 percent in the reference case.

It is worth reiterating the reason behind the fall in the price of capital relative to the price of labour in the first year. In the short-run the wage rate is not relatively lower than the price of capital after it has been deflated by the factor price index. As in the reference case, the price of capital falls relative to the price of labour.

The justification for the fall in the price of capital is based on what happens to the price of GDP at the macro level. In this simulation the price of GDP responds to the increase in the price of investment. Imports represent a significant portion of investment. The depreciation of the currency (discussed further in point *vii*) raises the relative price of imports, and increases the price of investment. As was the case in the reference scenario, the increase in the price of government goods also has an impact on the price of GDP. (Appendix 6-B)

At the same time, the economy experiences an increase in the terms of trade, again driven by the depreciation of the currency. The greenhouse tax makes Australia's exports relatively more expensive on the international market as its export commodities are energy intensive. The rise in the price of exports in the first year outweighs the increase in the price of imports associated with the depreciation. This leads to an improvement in the terms of trade.

The price of GDP from the income side can be explained by analysing what happens to taxes in the economy and the relative price and shares of the factor inputs. Auctioning the permits reduces the impact of the tax by returning the revenue as a reduction in consumption tax. The net effect is that the taxes absorb a slightly higher portion of the price of GDP. Given that it has been determined from the expenditure side that the price of GDP increases, and it has been assumed that the price of labour does not change due to sticky wages, the movement in the taxes must be absorbed by a corresponding movement in the price of capital. The increase in taxes, coupled with the higher price of GDP, encourages the price of capital to fall.

The analogy can once again be drawn at the industry level. Industries are taxed very heavily for their intermediate usage of the fuel and electricity commodities. This time the impact of the tax is offset by the reduction in consumption tax which increases the relative price of GDP. At the same time, the wage rate is sticky and employees refuse to accept a reduction in their earnings to offset the impact of the tax. Owners of industry accept a reduction in profits. Thus, the return on capital falls. Investment at the industry level declines and in the short-run industries use less capital than they otherwise would.

iii As was found in the reference case, the results for GDP are driven initially by employment

Chart 2-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR EMPLOYMENT, CAPITAL AND REAL GDP

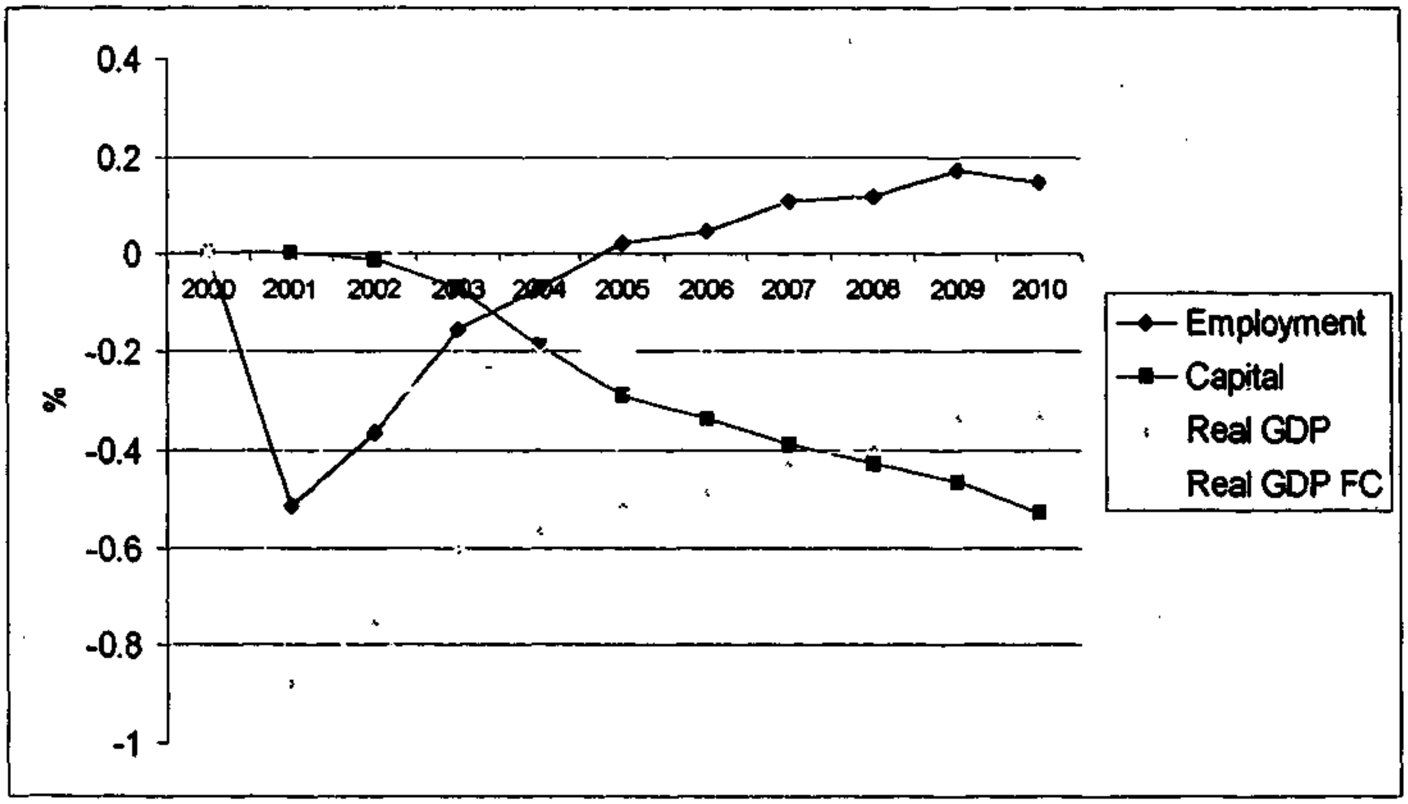


Chart 2-RR shows the deviation-from-base paths for real GDP, aggregate employment and the aggregate capital stock. As was the case in the grandfathering simulation, the change in aggregate employment is driving the change in real aggregate value added, or GDP at factor cost.

iv Fall in real GDP at market prices is greater than fall in real GDP at factor cost

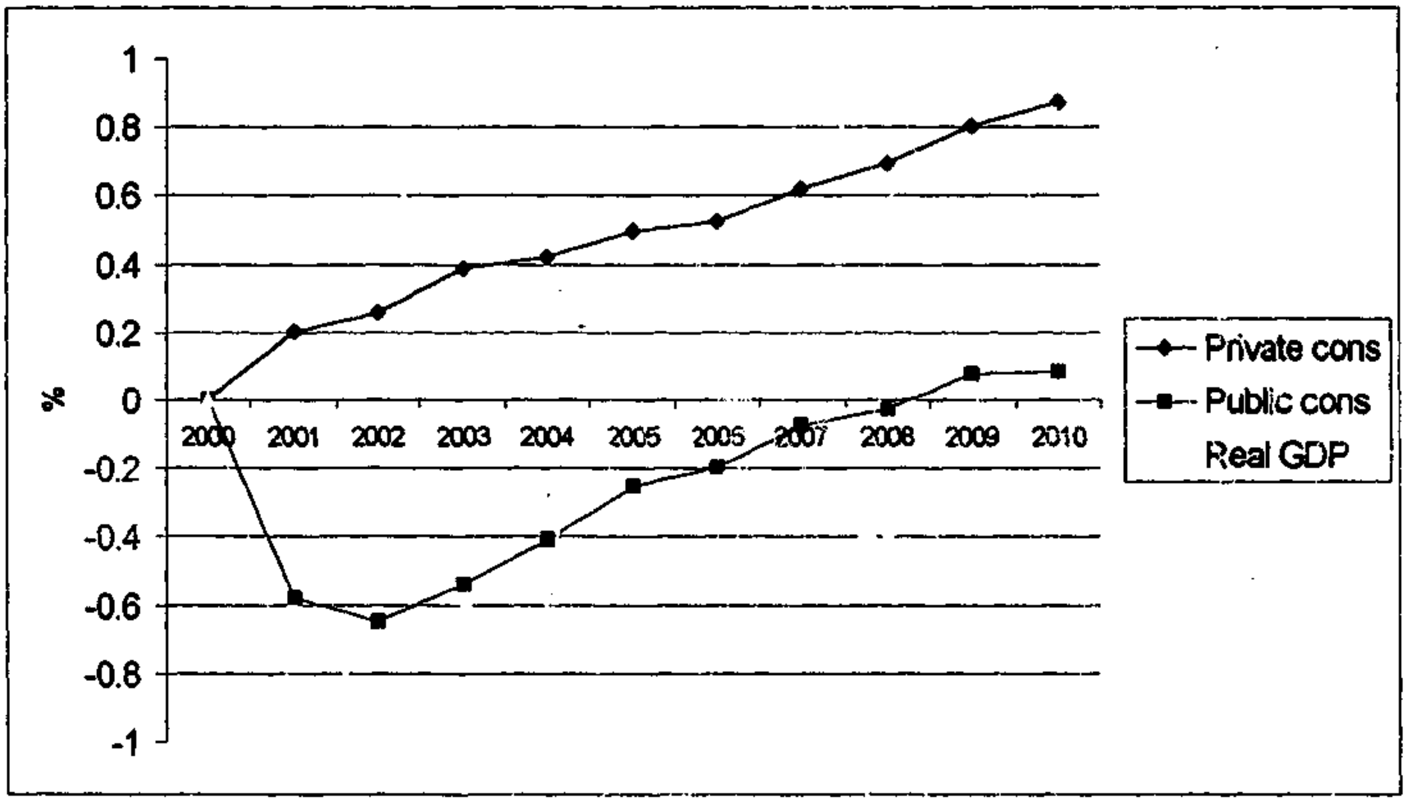
As shown on Chart 2-RR real GDP at market prices falls by considerably more than real GDP at factor cost. The reason for this result is a fall in the real indirect-tax base greater than the reduction in GDP at factor cost. The decline in the real indirect-tax base is attributable to the reduction in usage of petrol.

The gap between real GDP at market prices and factor cost in both simulations is very similar in the first year of the policy shock. Unlike the result for the reference case however, when the permits are auctioned the variable paths converge toward the end of the period. Under the auctioning scenario GDP at factor cost rises toward base and then begins to decline once again. The price of factors increases over the period of the simulation. The reduction in taxes on consumption causes the CPI to decline relative to the factor cost deflator. This causes the CPI to effectively fall as consumers no longer have to pay as much for their commodities.

v Consumption and Government Expenditure Results determined by the Closure

Chart 3-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR PRIVATE AND PUBLIC CONSUMPTION



As shown on Chart 3-RR, private consumption increases from base in response to the policy shock.

The results for private consumption in the two simulations are quite distinct due to the treatment of household expenditure in the closure. In the reference case, nominal total household consumption was encouraged to respond to changes in household disposable income. The closure adopted in this simulation allows the consumption function to operate so that nominal consumption moves with nominal GDP. Nominal GDP increases, raising private consumption expenditure.

The result for private consumption is higher than that of real GDP because lowering the consumption tax reduces the CPI relative to the GDP deflator. The net effect is an increase in real disposable income relative to real GDP which stimulates private consumption, exceeding the percentage change in real GDP.

The deviation-from-base path for public consumption decreases initially and then returns toward base. As was the case in the reference simulation, government expenditure has been tied to real GNE. The initial impact of the greenhouse policy on public consumption in both simulations creates similar paths although the order of magnitude is different. In the long-run the path for public consumption when the permits are auctioned rises toward base. This is in contrast to the result in the reference case which remains well below base throughout the simulation period.

vi Investment remains a key influence on GNE

Chart 4-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR CAPITAL AND INVESTMENT

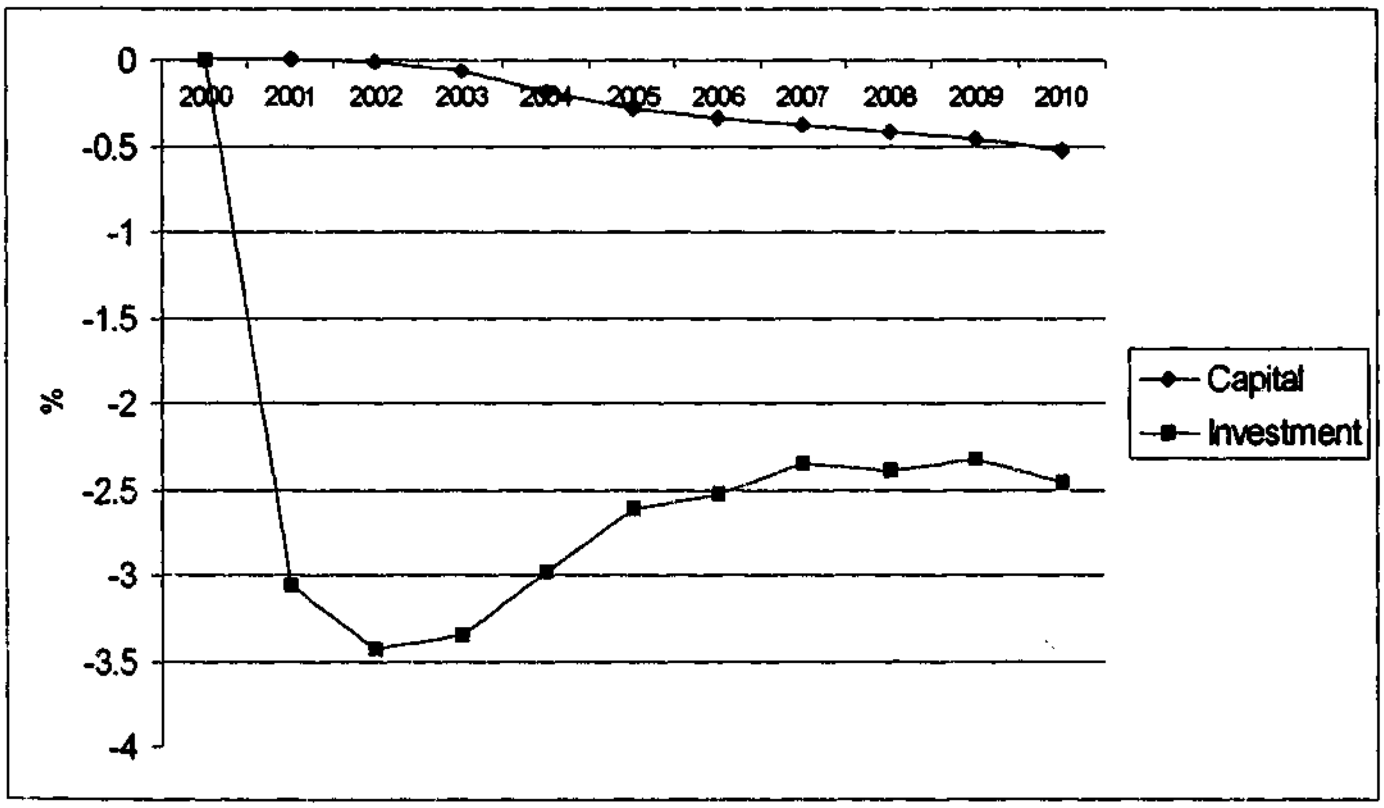


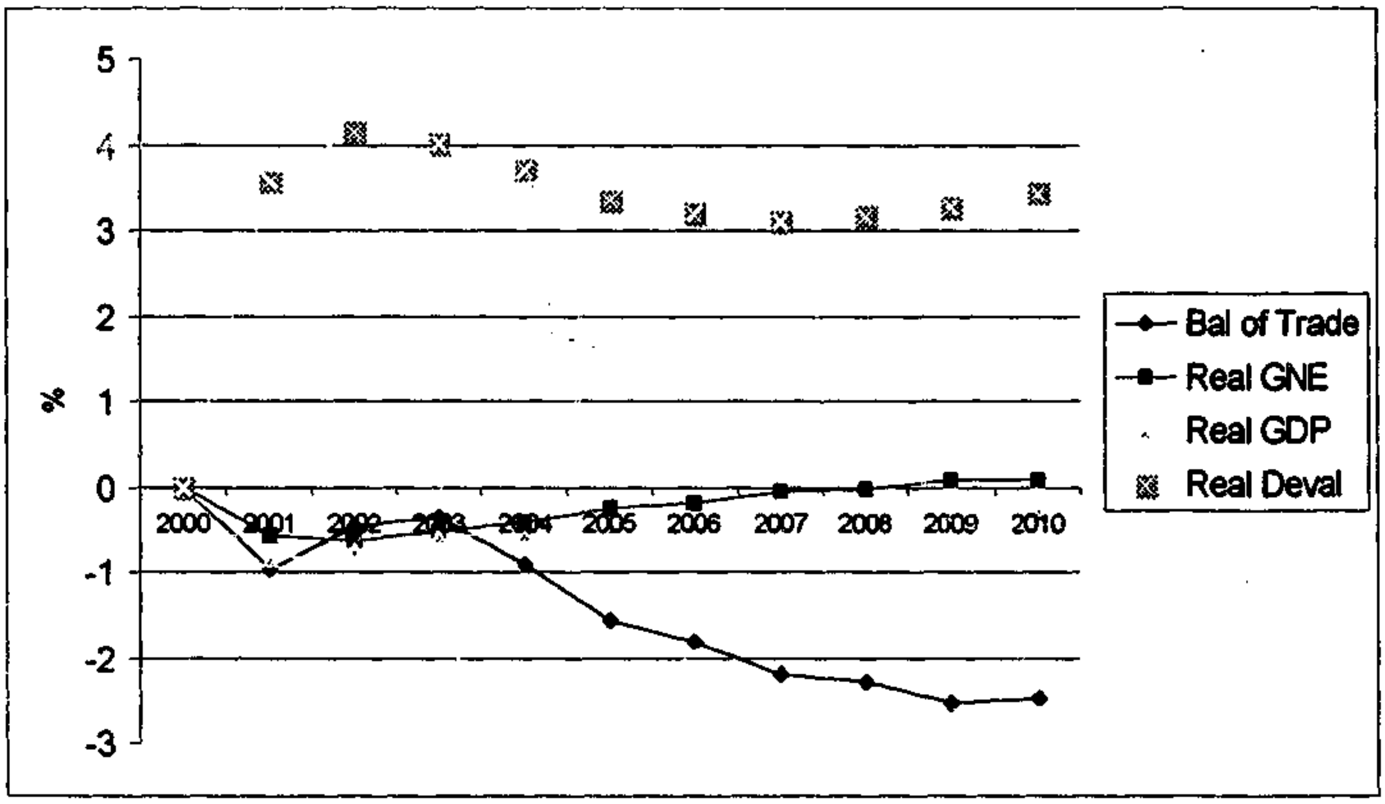
Chart 4-RR shows the percentage deviation from base paths for investment and the capital stock. The fall in investment under the auctioning method is less severe than that experienced in the reference case. Although the fall in investment still contributes to the decline in real GNE relative to real GDP, the greenhouse tax impacts more heavily on export volume, eradicating the impact of the investment decline. In the short-run real GDP declines relative to real GNE. This is in contrast to the result in the reference case.

The path of investment falls by half of that found in the reference case. This is attributable, at least in part, to the lower rate of return on capital found at the industry level in the reference case. One way of thinking about the emissions policy is as a change in the tax mix, substituting a carbon tax for a consumption tax. In the short-run, this generates a sharp increase in the investment price index, reducing rates of return and discouraging investment. The price of consumption falls whilst at the same time the price of investment increases as the tax is imposed on industry.

vii Unlike the reference case, the balance of trade moves toward deficit in the short-run

Chart 5-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR REAL GDP, REAL GNE, BALANCE OF TRADE/GDP RATIO AND REAL DEVALUATION



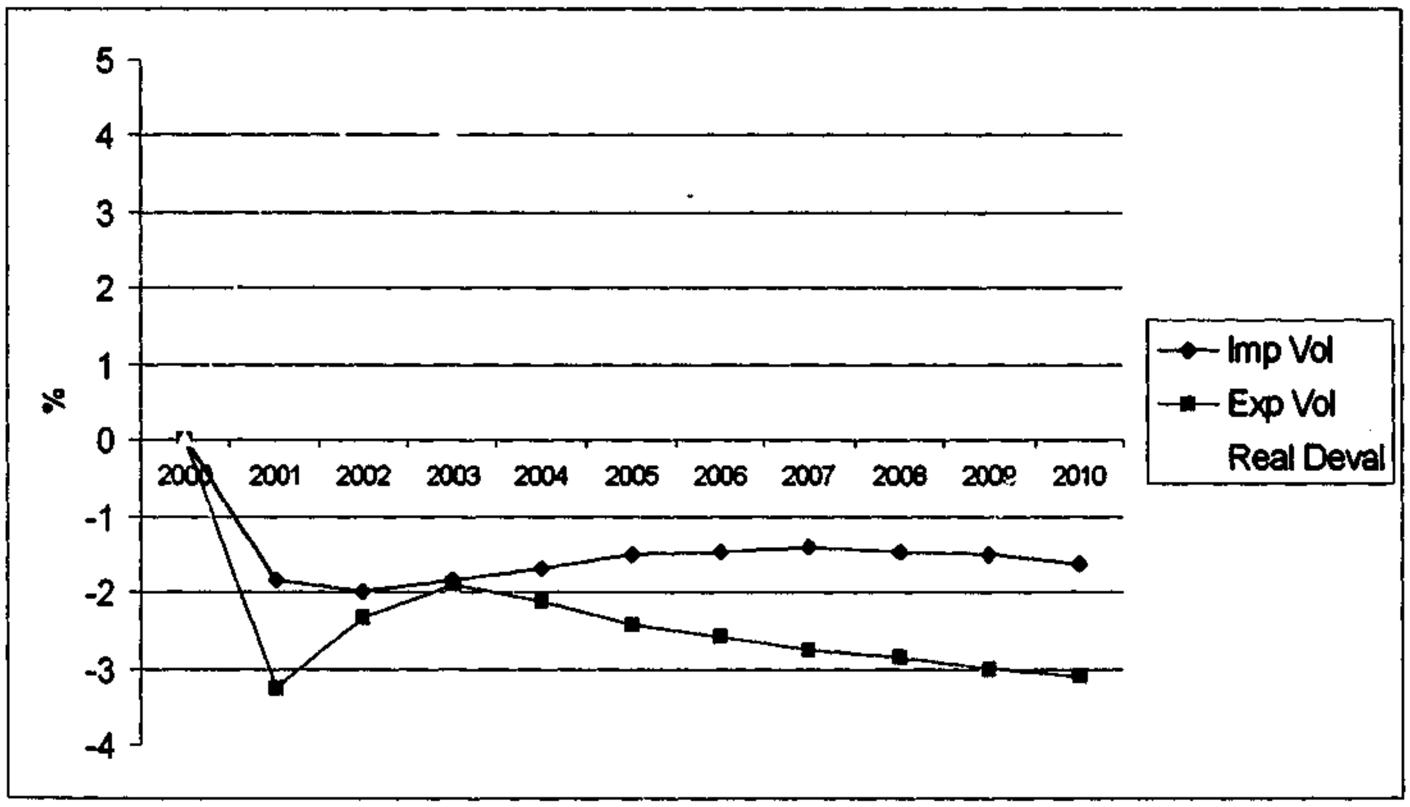
The results shown on Chart 5-RR indicate that in the short-run real GDP falls further from base than real GNE. This is in contrast with the reference case, where the fall in real GNE exceeded the fall in real GDP throughout the period of the simulation. The difference between the indicators is the balance of trade which moves toward deficit when the permits are auctioned.

In both simulations a real depreciation of the Australian dollar is required. Chart 5-RR shows the real depreciation which stimulates export activity and restricts imports. This significant depreciation of the exchange rate is required to encourage export activity in the economy, so as to prevent the trade deficit from becoming even larger.

Unlike the reference case, throughout the period of the simulation exports remain below base. The results, as shown on Chart 6-RR, indicate that both imports and exports decline in the first period of the simulation, however imports decrease relatively less than exports. The result for aggregate exports can be attributed to the activity effect of the collapsing industries. As was found in the reference case, the collapse of the non-ferrous industry both domestically and on the international market has a negative impact upon the result for aggregate exports.

Chart 6-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR IMPORTS, EXPORTS AND REAL DEVALUATION OF THE CURRENCY



As investment returns to base after the first year, it stimulates the demand for imports. Simultaneously, exports respond positively to the depreciation. The net effect in 2002 and 2003 is an improvement in the balance of trade. The depreciation is weakened and import activity increases. This reverses the trend as exports begin to decline and imports improve, once again moving the balance of trade toward deficit.

The export volume in the economy tries to respond to the depreciation of the currency by returning toward base. However, it is sluggish and as the depreciation weakens (moves toward appreciation) the export activity levels in the economy begin to decline once again. This path differs from that found in the reference case where exports responded positively to the depreciation after the first year.

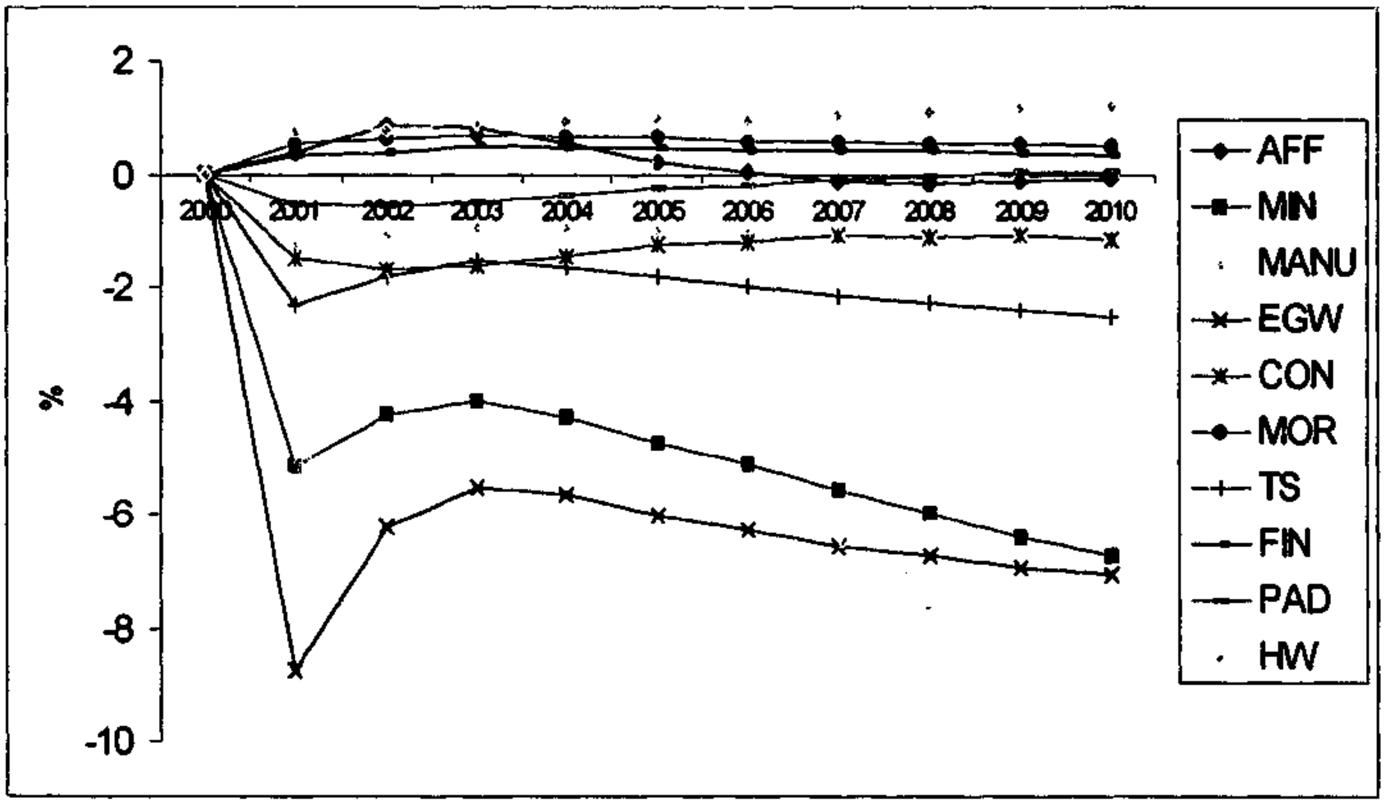
The percentage deviation from base path for imports is similar in both simulations.

viii As in the reference case, Gains and Losses for Industry Sectors are Consistent with the Macroeconomic Results

On the whole, differences in the industry results between the simulations are attributable to differences in the macroeconomic variables. Chart 7-RR shows the percentage deviation-from-base paths for the industry sectors of the Australian economy.

Chart 7-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR SECTORS



As was found in the reference simulation, the industry sector to perform most poorly is *Electricity, Gas and Water* (EGW). However, the results for the export orientated sectors of the economy between the simulations differ. Chart 7-RR also shows a contraction in the *Transport and Storage* (TS) and *Mining* (MIN) sectors. These sectors are now slower to recover with the weakened currency.

Another difference between the simulation results is the improvement in the *Health and Welfare* (HW) sector. This sector benefits from the relatively higher private and public expenditure in the economy when the permits are auctioned.

ix As in the reference case, the two principal industry losers are non-ferrous metals and aluminium

Chart 8-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR INDUSTRIES WHO CONTRACT FOLLOWING THE CO_2 TAX

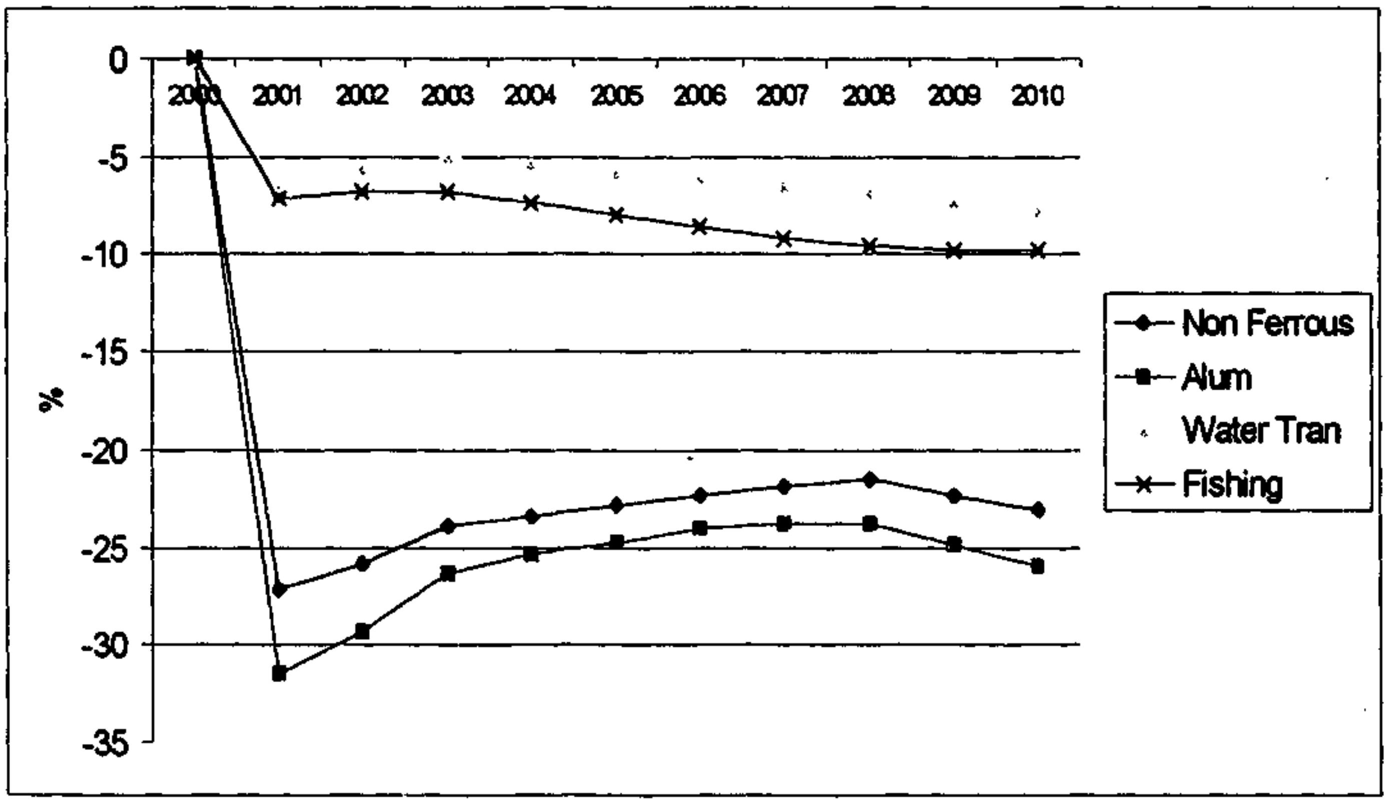


Chart 8-RR shows the deviation-from-base paths for those industries who reduce their output levels after the GFT.

In contrast to its result in the reference case, the water transportation (*I95WaterTrans*) industry contracts its activity level. Whilst the increase in the price of petrol will have some bearing on the industry's intermediate costs, another factor is that it sells 50 percent of its output to industries directly effected by the GFT. In addition, 42 percent of its output is sold to the petrol industry and 8 percent is sold to the mining services sector. The collapse of these industries will in turn lead to a reduction in demand for their intermediate inputs, including water transport. The reason for the different industry response is the relatively worse performance of the Australian dollar in this simulation.

x *Relative to the reference case, Traditional Export Orientated Industries are less prosperous over the long-run*

Chart 9-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR TRADITIONAL EXPORT ORIENTATED INDUSTRIES

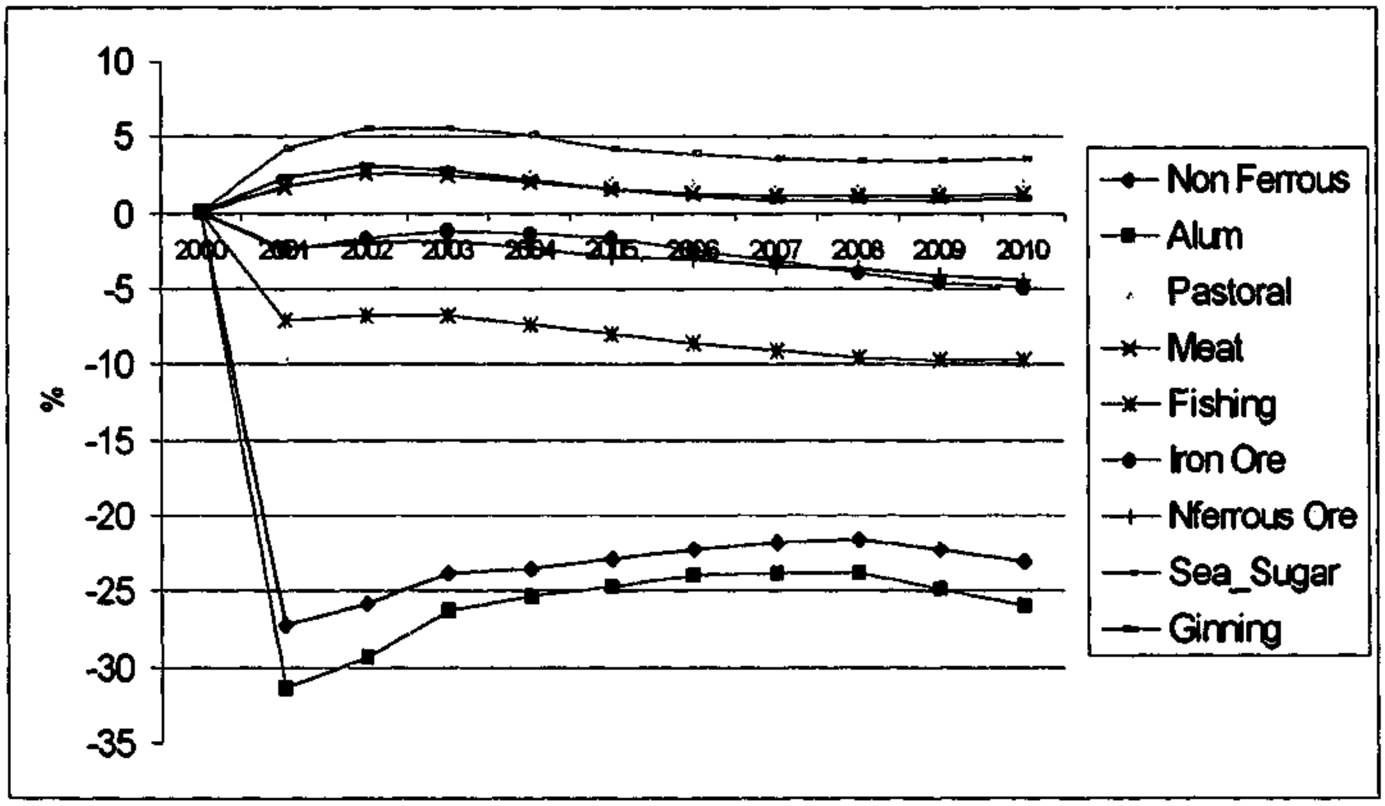


Chart 9-RR shows the deviation-from-base paths for the traditional export orientated industries.

Recovery of the export orientated industries is less rapid when the permits are auctioned. This is attributed to the fact that the currency depreciation is weaker. Those industries who are associated with the energy sector of the Australian economy do not increase their output levels toward base. Such industries include fishing and iron ore.

xi As in the reference case, the industry winners tend to be export orientated and not energy intensive. However the expansion path for these industries differs between simulations

Chart 10-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR INDUSTRIES WHO EXPAND FOLLOWING THE CO_2 TAX

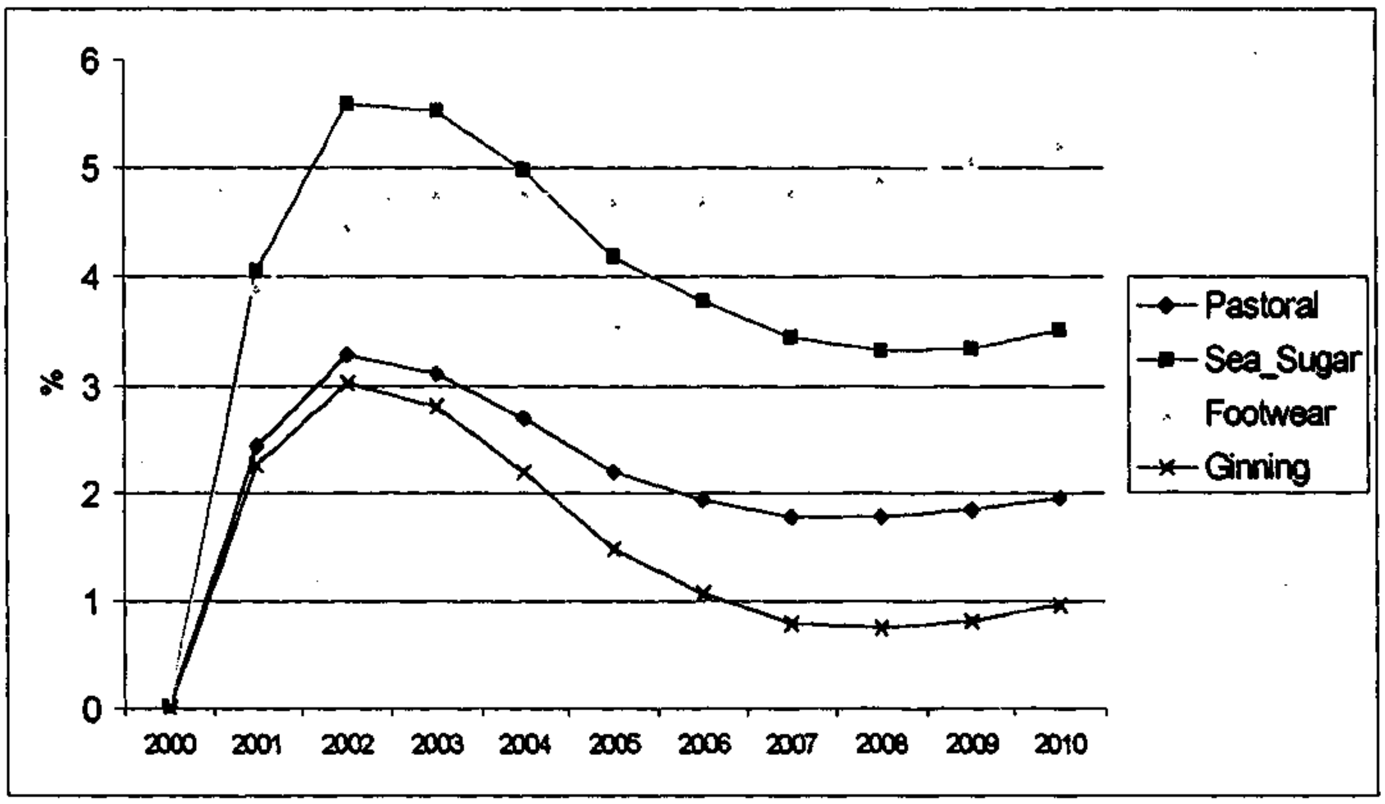


Chart 10-RR shows the deviation-from-base paths for those industries who expand their output levels after the GFT.

The Australian dollar dictates the path for those export orientated industries whose demand responds to changes in the relative price of their output on the international market. For instance, the output for the sea and sugar industry (*125Sea_Sugar*) experiences strong growth until 2004 when the value of the currency improves.

Unlike the result in the reference case, aggregate household consumption increased in response to the greenhouse policy shock. As expected, the results indicate an expansion in the industry activity of those industries who produce commodities purchased by the household sector, such as health. (Appendix 6-B)

xii As in the reference case, the results for the fuel and electricity sectors is in line with the relative emission intensities

Charts 11-RR and 12-RR illustrate the impact of the policy shock on the industry activity levels of the fuel and electricity industries respectively.

Chart 11-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR CO_2 FUEL INDUSTRIES

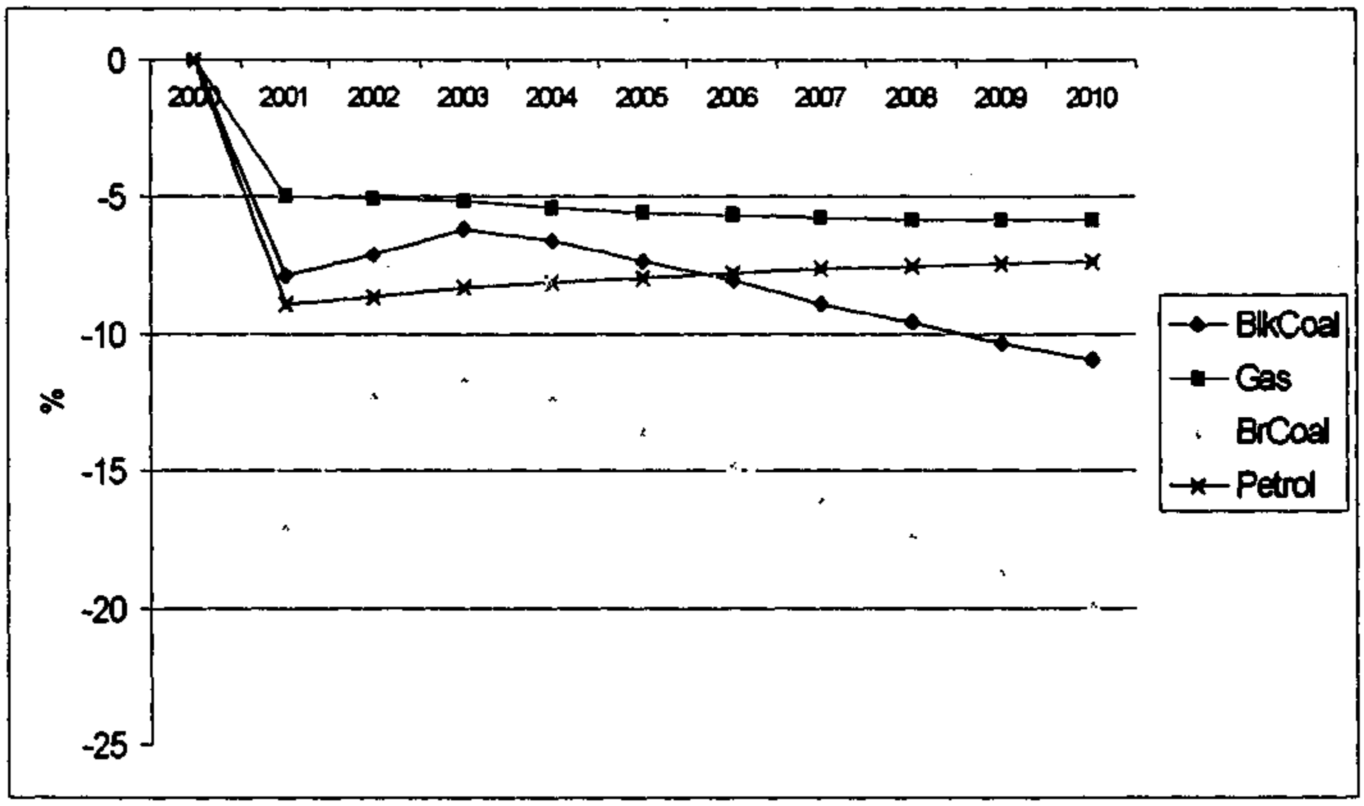
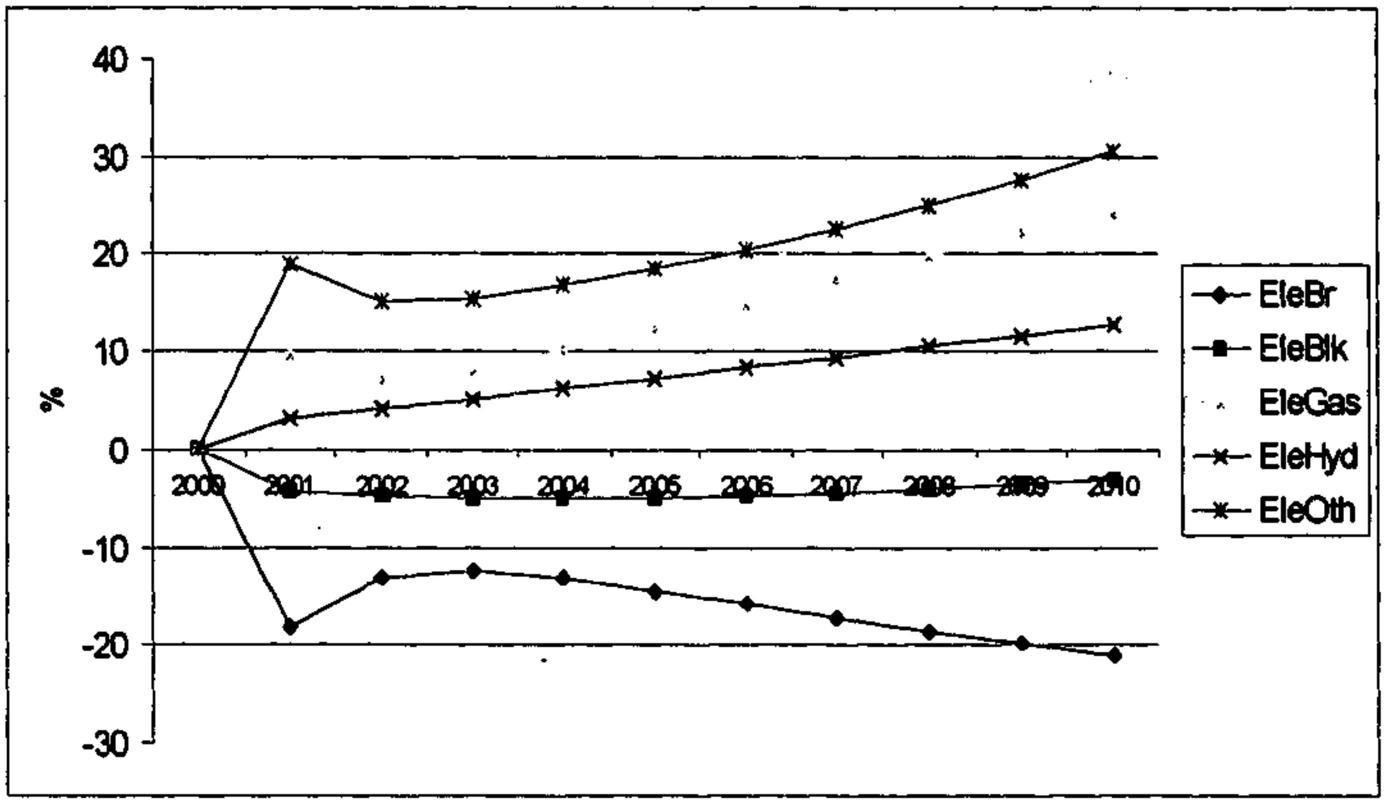


Chart 12-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR ELECTRICITY INDUSTRIES



Whilst the order of the electricity industry results are the same for each simulation, the percentage change from deviation results differ. The result for the electricity sector is less severe when the permits are auctioned. This situation arises as the economic performance of the overall economy is better than the reference case. For instance, demand for electricity by the household sector will be higher after the permits have been auctioned and consumption taxes have been reduced.

Although the collapse of the electricity sector was less pronounced, the result for the electricity distribution industry improves toward base much slower in the auctioning simulation.

After the initial impact of the greenhouse policy, demand for electricity will depend on the activity levels of those industries who consume it. The weighty depreciation in the reference case encourages export orientated industries to increase their output levels. Hence, industries such as *NFerrous* respond to the depreciation by increasing their activity level toward base.

To achieve higher output levels, the industry will demand more intermediate inputs such as electricity. The same situation does not arise when the permits are auctioned as the depreciation is less severe and it is not prolonged throughout the period of the entire simulation. As the dollar strengthens, the activity levels of *NFerrous* will once again decline, reducing demand for intermediate inputs such as electricity. A comparison of Chart 12-RR with Chart 12-GF reiterates this. In summary, whilst the electricity industry itself does not respond to changes in the exchange rate, it is indirectly impacted upon by movements in its value.

Charts 13-RR, 14-RR and 15-RR support a similar explanation to that given in Section 6.5 point *xi* above.

Chart 13-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR BROWN COAL GENERATORS

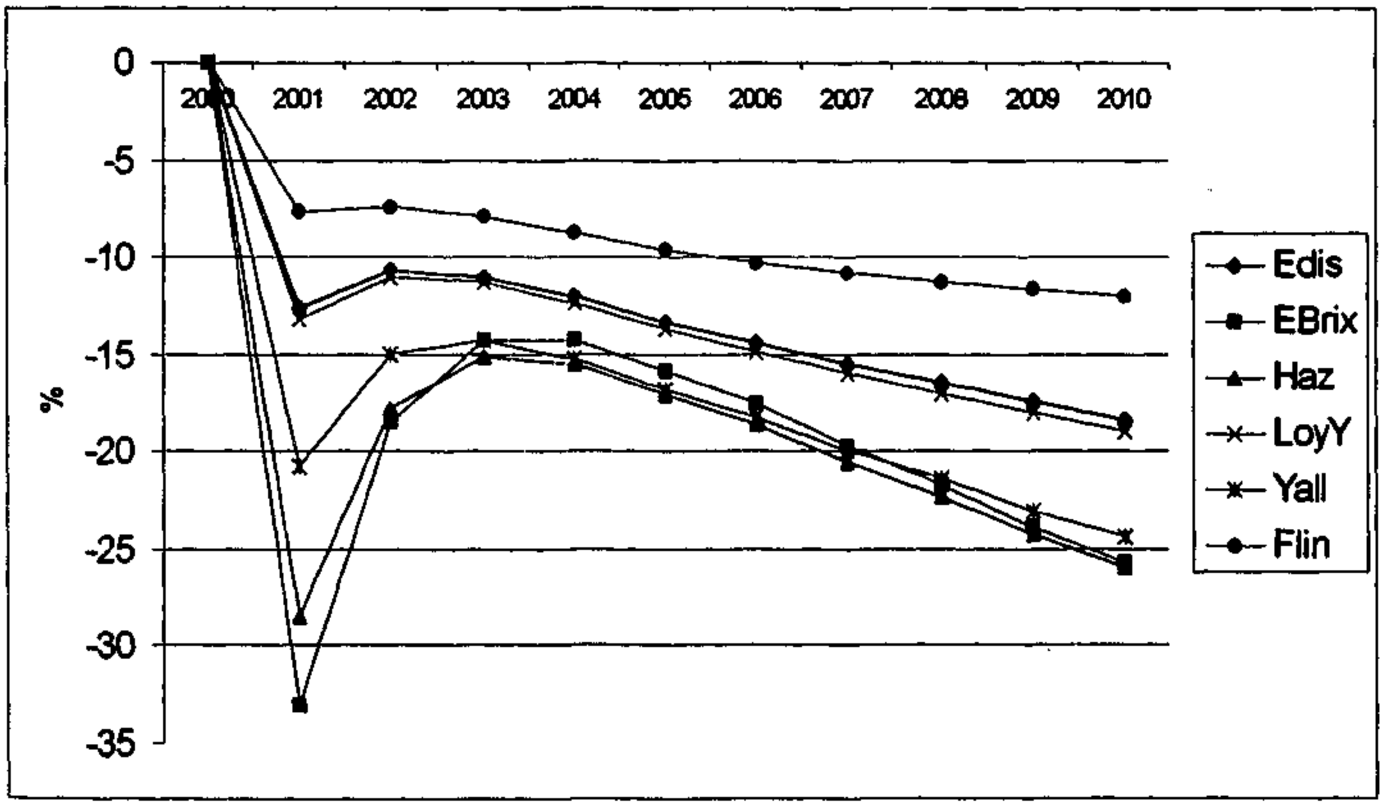


Chart 14-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR DOMESTIC PRICE OF CO_2 ELECTRICITY INDUSTRIES

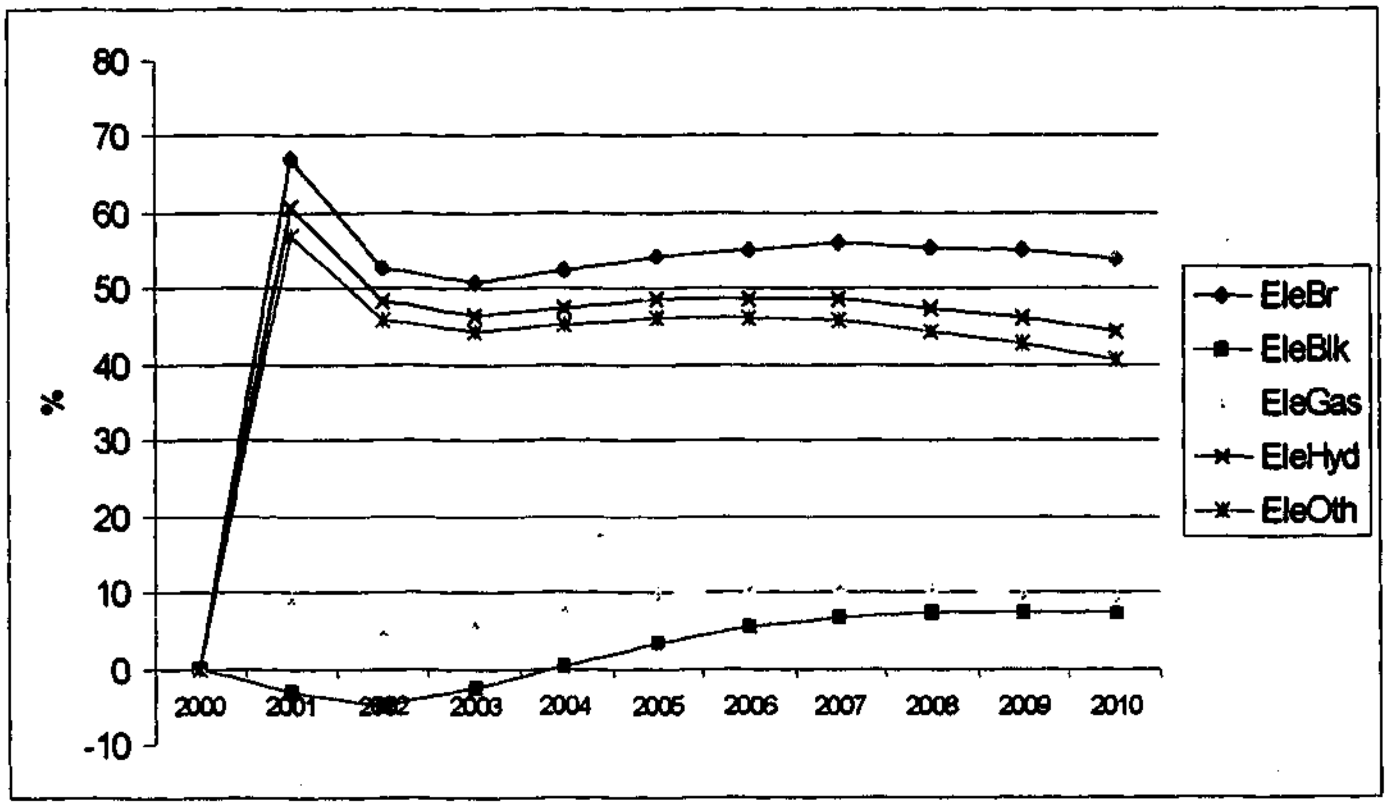
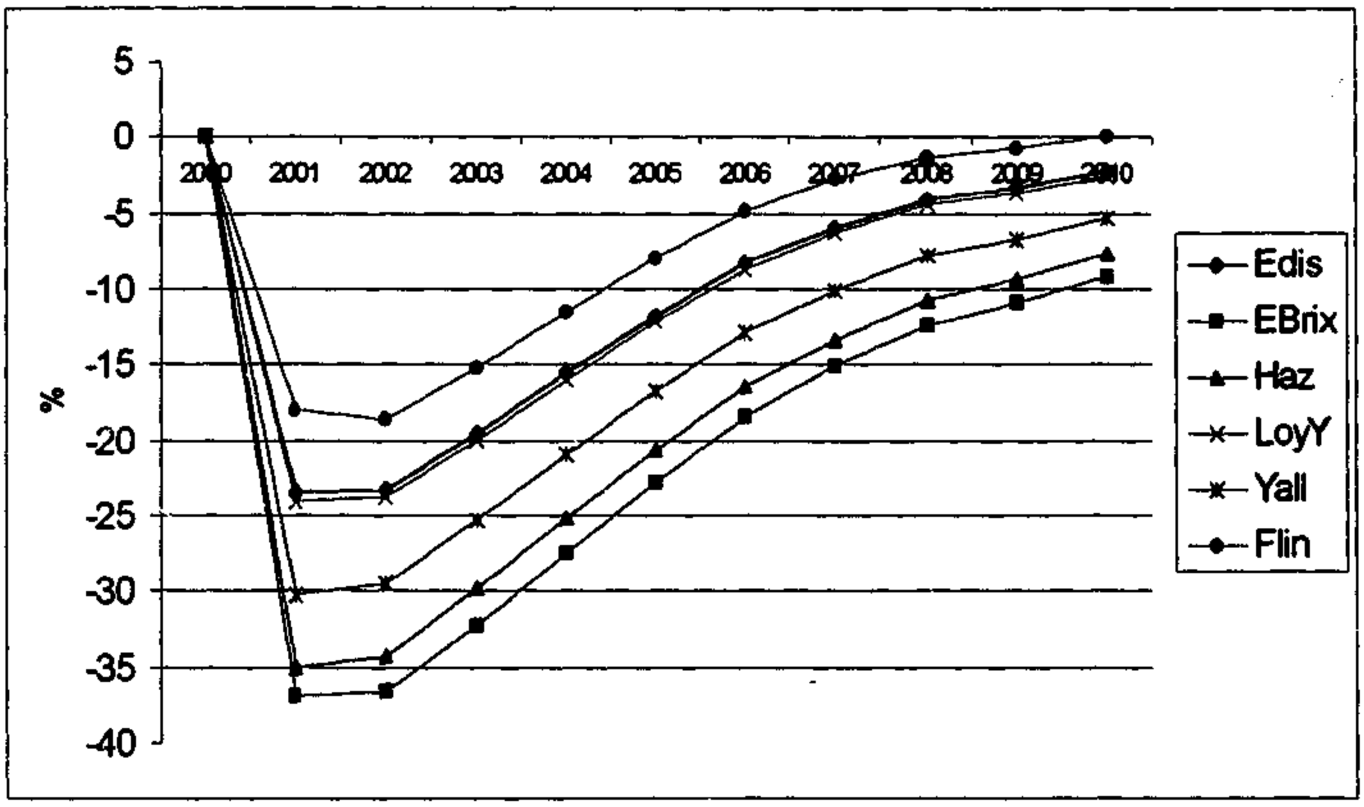


Chart 15-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR DOMESTIC PRICE OF BROWN COAL GENERATORS



xiii Results for the States of Australia differ between simulations in line with their dependence on the export markets and their reliance on public consumption

Chart 16-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR GROSS STATE PRODUCT

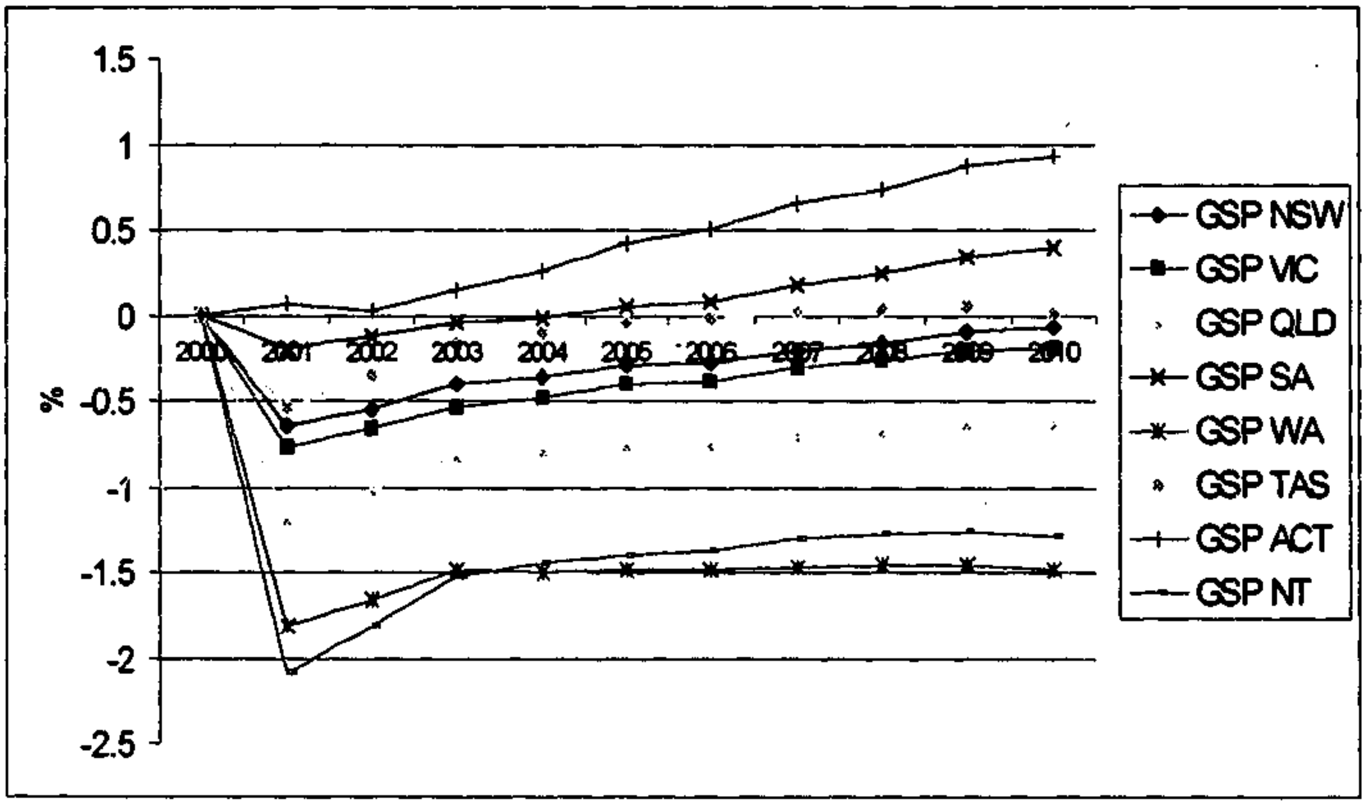


Chart 16-RR shows the deviation-from-base paths of GSP for the States of Australia.

As per the reference case, the states to perform poorly after the introduction of greenhouse policy are those who rely on the non-ferrous metal industries for a large percentage of their economic activity.

The collapse of the states' GSP is less pronounced. Drawing comparison between Chart 18-GF and Chart 16-RR, it is evident that the impact upon the states is not as severe in the short-run when the permits are auctioned. In contrast to the recovery of the economy in the reference case, when the permits are auctioned the long-run path of economic activity for the states remains relatively stable, showing only a slight upward trend.

With the exception of the ACT, the GSP paths for the remaining states are in the same order as the results in the first year of the reference case. The state results between the simulations differ after the first year as the impact of the depreciation is not as dominant.

This time the ACT is the best performer of the states. The result for the ACT is due partly to the expansion of its industry base, and partly to the fact that it does not support any of the industries who are detrimentally effected by the greenhouse policy. The news and books industry (*I47NewsBooks*) which is well represented in the ACT expands. The ACT does not produce any of its own electricity and therefore does not experience the same negative impacts as experienced by other states.

Another State to benefit relatively more when the permits are auctioned is SA. The State benefits from the depreciation of the currency as imports become relatively more expensive. Import competing local industries are then able to take advantage of the exchange rate fluctuation as domestically produced commodities become relatively cheaper. For instance, 25 percent of the domestic motor vehicle manufacturing industry is located in SA. This industry competes vigorously with imported manufacturers. The price of the imported commodity becomes more expensive, allowing consumers to substitute toward the domestically produced motor vehicle.

Energy intensive states do not recover to the same degree as was found in the reference case. The strengthening of the dollar in later years of the simulation period forces the activity levels of these sectors to decline.

xiv The results for the Statistical Divisions are similar to those found in the reference case, although the collapse is less severe

Chart 17-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR GROSS REGIONAL PRODUCT

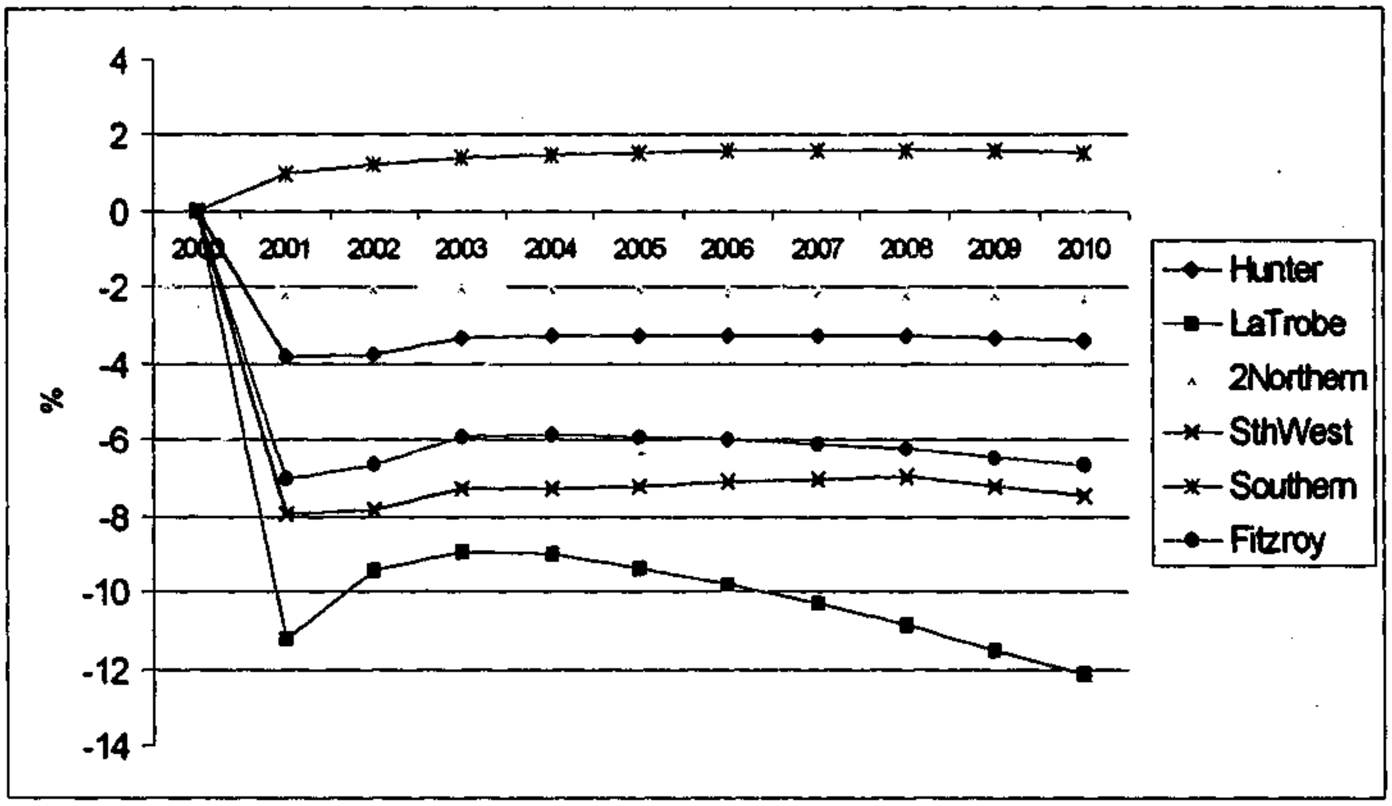


Chart 17-RR shows the deviation-from-base paths of GRP for the statistical divisions whose industry base is of direct relevance to greenhouse policy. The results between the simulations once again differ in their paths toward base. Compared to Chart 19-GF, the GRP outlook for the statistical divisions on Chart 17-RR is very stable throughout the entire simulation period.

xv Results for the La Trobe Valley are similar to the reference case

As mentioned in point *xiv* above, the main compositional difference between the Gippsland and La Trobe statistical divisions in the MONASH-Electricity model is the importance of the electricity industry.

Chart 18-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR GSP AND GRP

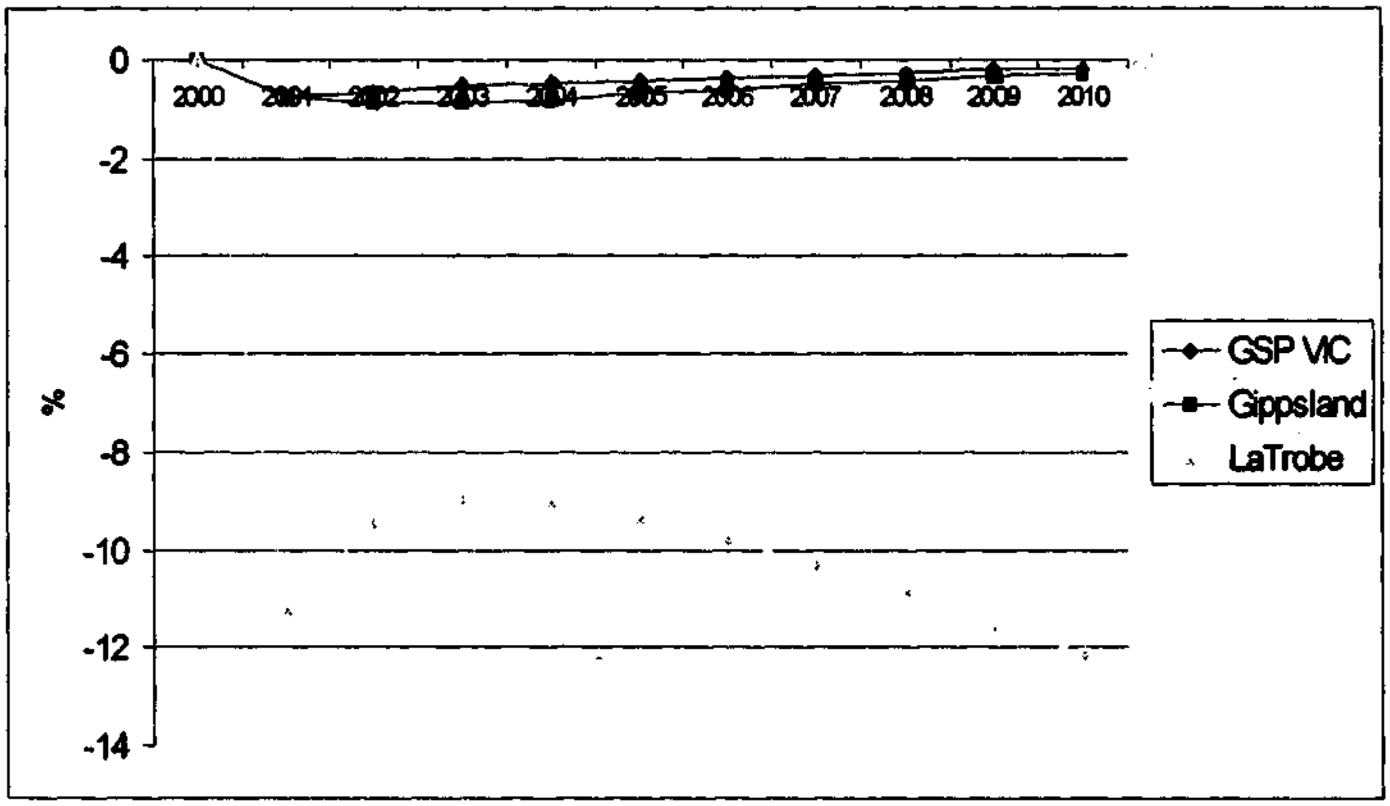
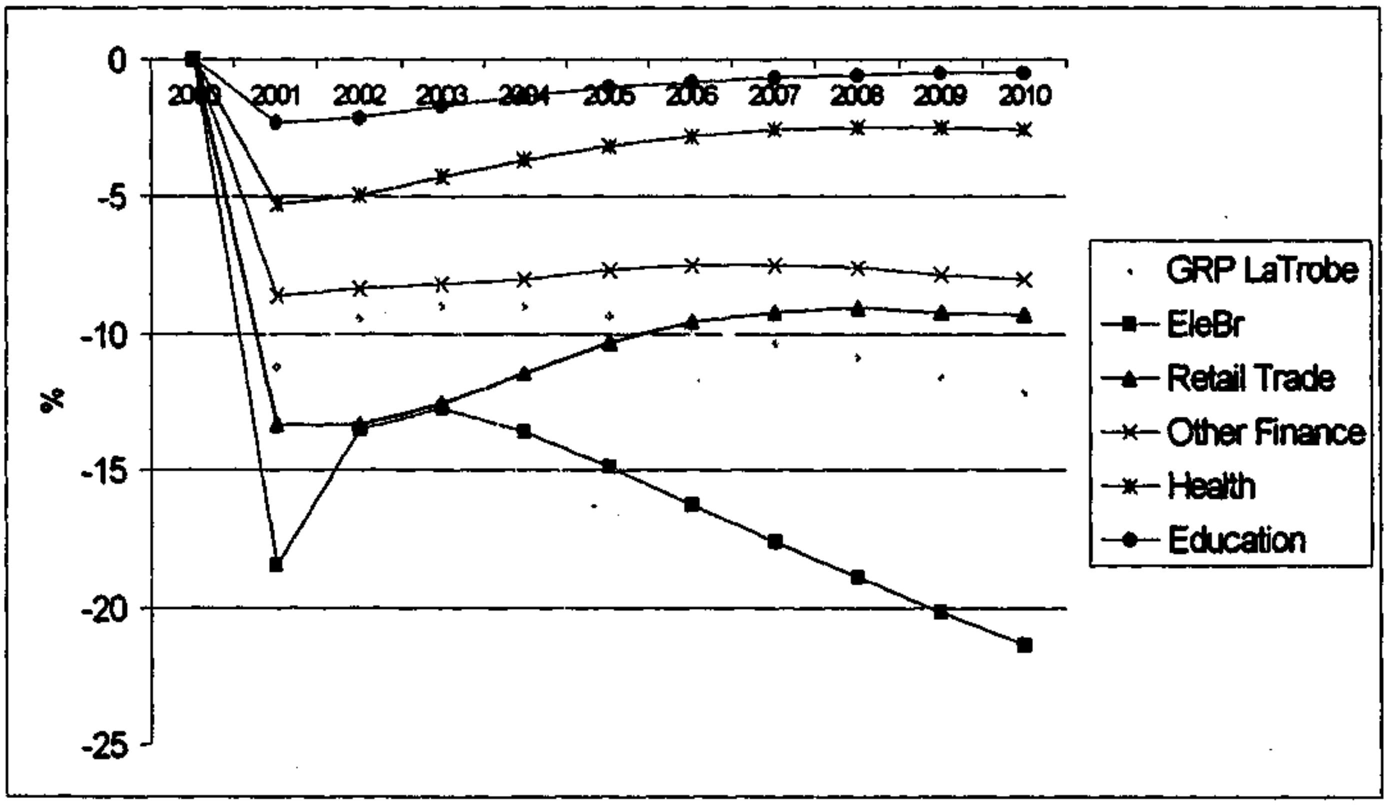


Chart 18-RR shows the deviation-from-base paths of GSP for Victoria, and GRP for Gippsland and the La Trobe Valley.

The main industry base in the La Trobe Valley region experienced a mixed reaction in its deviation-from-base output. (Appendix 6-J) Chart 19-RR illustrates that the pattern of the statistical division's *local-region* industries and GRP follow the pattern of activity levels in *EleBr*.

Chart 19-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR LA TROBE VALLEY'S MAIN INDUSTRIES



The activity result for the health industry declines by relatively less when the permits are auctioned due the expansion of private consumption expenditure at the macroeconomic level.

Chart 20-RR

PERCENTAGE DEVIATION FROM BASE PATHS FOR LA TROBE VALLEY'S ELECTRICITY INDUSTRY

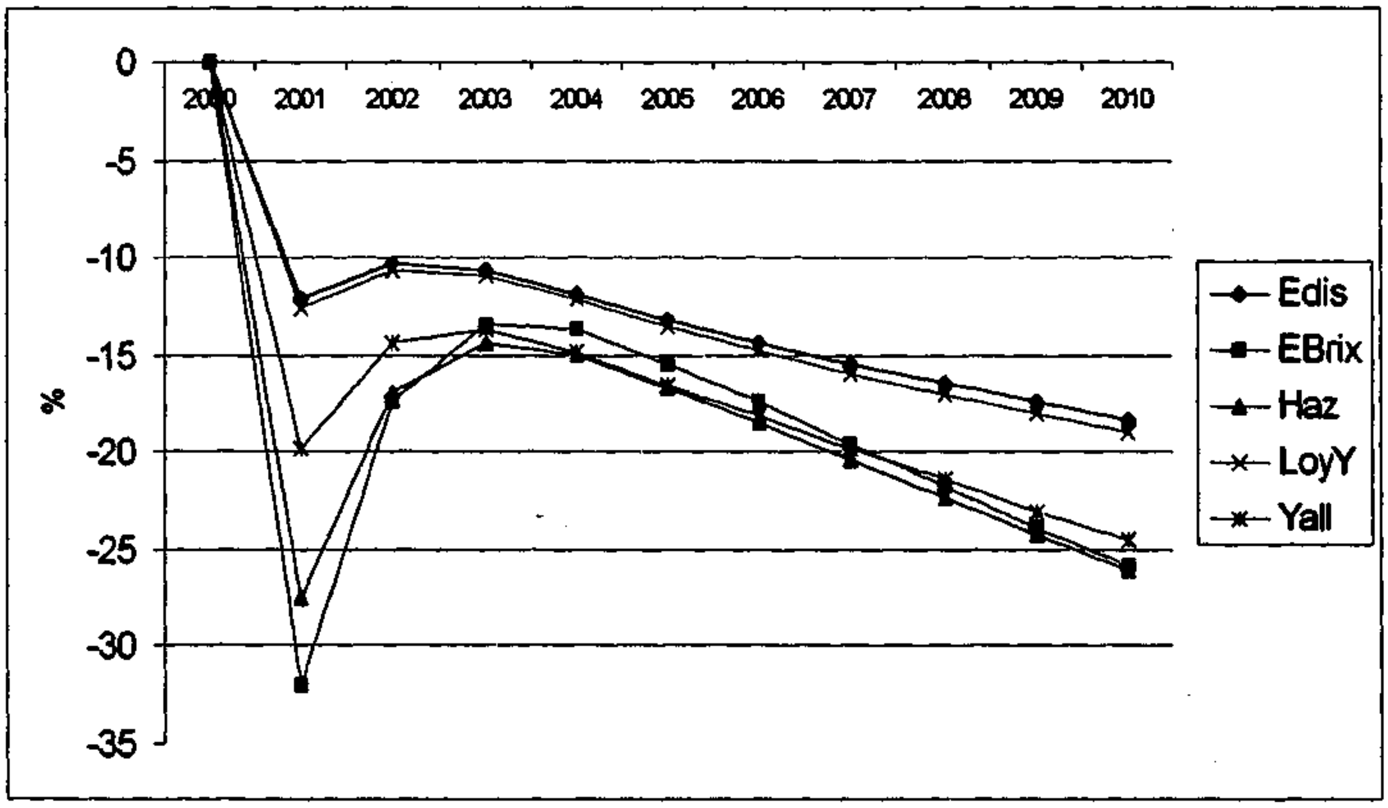


Chart 20-RR shows the percentage deviation from base paths for the brown coal electricity generators in the La Trobe Valley. The only difference between the simulations in the order of the generators is that *EBrix* experiences a greater decline in its activity level.

xvi Results for greenhouse emissions are similar to the reference case

In the long-run auctioning the CO_2 emission permits reduces the total level of greenhouse gas emissions in the Australian economy by 11 percent relative to the basecase. Table 6.22 (shown at the end of this section) illustrates the level of CO_2 emissions by Australian industry following the imposition of greenhouse policy (with the permits auctioned). Table 6.22 can be compared with table 6.18 which shows the projections for greenhouse gas emissions in the reference case.

Table 6.23 below shows the differences between the greenhouse gas emissions at the beginning (2000 basecase) and end of the simulation after the policy shock (2009 policy). This table should be compared to Table 6.19 from the reference case. There is a slight reduction in the growth in CO_2 emissions relative to the reference case. Table 6.23 suggests that introducing a greenhouse policy with an emissions charge of $50 per tonne of CO_2 released will hold constant the current level of emissions in the Australian economy. Industry abatement in some areas of the economy will occur but this will be offset by growth in other sectors.

Table 6.23

CO_2 EMISSIONS

	2000 Basecase	**2009 Policy**	**% change**
BlkCoal	41961	40639	-0.03
Gas	34887	34724	-0.004
Petrol	109066	111426	0.02
Electricity	132673	132018	-0.004
Total Emissions	318586	318807	0

Table 6.24 shows the differences between the basecase and policy simulation results for CO_2 emissions by energy source. As was found in the reference case, there is a significant reduction in the emissions following the introduction of greenhouse policy. In summary, whilst the emission levels recorded at the start of the simulation period are sustained, the economy does not experience the same level of emissions growth as would be found in the absence of greenhouse policy.

The reduction in total greenhouse gas emissions in the Australian economy is 2 percent greater when the permits are auctioned. An explanation for this difference is the fact that, relative to the reference case, the energy intensive export industries in the Australian economy did not benefit to the same extent from the depreciation of the currency. Whereas in the reference case these industries improve their activity levels after the initial impact of the shock (and continue to emit CO_2), in this simulation the energy sector is slower to recover.

Table 6.24

CO_2 EMISSIONS

	2009 Basecase	**2009 Policy**	**% diff**
BlkCoal	49455	40639	-18
Gas	40069	34724	-13.5
Petrol	122397	111426	-9
Electricity	146192	132018	-10
Total Emissions	358113	318807	-11

Table 6.25 (shown at the end of this section) illustrates the percentage change in fuel usage by industry, summed over source for the different treatment of revenue. It can be compared with table 6.21 from the reference case. In both instances the largest reduction in emissions is made by the non-ferrous metals sector.

Table 6.22

2009 POLICY MONASH GENERATED DATA: Emissions, CO_2 equivalent, kT

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I1Pastoral	0	0	0	192	0	192
I2WheatSheep	0	3	0	2300	0	2302
I3HighRain	0	2	0	606	0	608
I4NthBeef	0	0	0	243	0	243
I5MilkCattle	0	17	0	456	0	472
I6OthExport	0	22	0	555	0	577
I7ImportComp	0	26	0	613	0	638
I8Poultry	0	79	0	9	0	87
I9AgServ	0	0	0	225	0	225
I10Forestry	0	64	0	1124	0	1188
I11Fishing	0	0	0	1035	0	1035
I12IronOre	429	49	0	264	0	741
I13NFerrous	368	217	0	1107	0	1692
I14BlkCoal	12930	98	0	579	0	13607
I15aOil	125	1475	0	24	0	1625
I15bGas	78	1025	0	15	0	1117
I15cBrCoal	21	248	0	4	0	274
I16OthMin	101	62	0	691	0	854
I17MinServ	0	19	0	221	0	240
I18Meat	596	155	0	276	0	1028
I19Dairy	773	134	0	156	0	1062
I20FrtVeg	329	77	0	124	0	531
I21OilFat	44	6	0	10	0	59
I22Flour	251	58	0	33	0	342
I23Bakery	78	48	0	125	0	251
I24Confect	20	6	0	17	0	43
I25Sea_Sugar	329	131	0	259	0	719
I26SoftDr	37	22	0	136	0	196
I27Beer	104	20	0	22	0	147
I28OthDrink	51	25	0	45	0	121
I29Tobacco	24	3	0	4	0	30
I30Ginning	30	4	0	10	0	44
I31Synthetic	42	7	0	4	0	53
I32CottonYa	60	8	0	4	0	73
I33WoolYarn	0	0	0	8	0	8
I34TextileF	63	20	0	9	0	92
I35Carpets	7	2	0	6	0	15
I36Canvas	1	1	0	13	0	15
I37Knitting	7	2	0	5	0	14
I38Clothing	9	1	0	32	0	42
I39Footwear	0	0	0	3	0	4
I40Sawmill	86	18	0	203	0	307
I41Panels	198	32	0	77	0	308
I42Fittings	20	8	0	94	0	121
I43Furniture	9	8	0	59	0	76
I44PulpPaper	1012	122	0	129	0	1262
I45BagsBoxes	31	14	0	51	0	96
I46Sanitary	272	33	0	29	0	334
I47NewsBooks	3	5	0	149	0	157

Table 6.22 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I48CommPrint	27	22	0	210	0	258
I49Fertilisr	26	125	0	19	0	171
I50BasicChem	1849	1247	0	1005	0	4101
I51Paints	18	4	0	84	0	107
I52Pharmacy	11	4	0	57	0	73
I53Soaps	22	5	0	41	0	68
I54Cosmetics	3	9	0	16	0	28
I55Explosive	56	17	0	126	0	199
I56Petrol	275	0	0	14310	0	14586
I57Glass	80	118	0	56	0	254
I58ClayProd	285	185	0	73	0	543
I59Cement	789	1257	0	174	0	2219
I60Readymix	12	11	0	129	0	151
I61Pipes	82	46	0	102	0	229
I62Plaster	190	43	0	39	0	272
I63IronSteel	5960	1813	0	540	0	8313
I64aNFerrous	3697	450	0	2943	0	7091
I64bAlum	4678	570	0	3730	0	8978
I65Structurl	90	74	0	136	0	299
I66SheetMetl	46	187	0	99	0	332
I67Wire	112	137	0	136	0	385
I68MotorVeh	137	124	0	56	0	318
I69Ships	42	17	0	26	0	85
I70Trains	21	12	0	9	0	43
I71Aircraft	4	5	0	19	0	29
I72SciEquip	3	4	0	19	0	26
I73Electron	30	5	0	55	0	89
I74HousAppl	47	16	0	12	0	76
I75ElectEq	28	42	0	76	0	146
I76AgMach	26	25	0	9	0	60
I77ConMach	14	6	0	10	0	30
I78ManuMach	97	71	0	127	0	295
I79Leather	28	3	0	15	0	47
I80Rubber	32	13	0	32	0	77
I81Plastic	35	20	0	99	0	155
I82Signs	2	2	0	12	0	16
I83SportEq	443	67	0	16	0	527
I84aaaEleBr	0	0	0	0	0	0
I84aaaaEdis	0	0	0	58	6888	6946
I84aaabEBrix	0	0	0	9	1423	1433
I84aaacHaz	0	0	0	83	11808	11891
I84aaadLoyY	0	0	0	116	13790	13906
I84aaaeYall	0	0	0	78	10210	10288
I84aaafFlin	0	0	0	44	4792	4836
I84aabEleBlk	0	0	0	1019	76780	77799
I84aacEleGas	0	0	0	91	6327	6418
I84aadEleHyd	0	0	0	162	0	162
I84aaeEleOth	0	0	0	16	0	16
I84bElectTrn	0	0	0	112	0	112
I84cElectDist	0	0	0	1137	0	1137
I85Gas	53	17232	0	81	0	17367
I86Water	29	0	0	1042	0	1071

Table 6.22 Continued

INDUSTRY	C16BlkCoal	C17bGas	C17cBrCoal	C58Petrol	Electricity Generators	Total
I87Resident	0	239	0	1751	0	1990
I88OthBuild	125	142	0	2276	0	2543
I89Wholesale	237	105	0	4755	0	5097
I90RetailTrd	1085	450	0	2309	0	3845
I91MechRep	0	0	0	35	0	35
I92OthRepair	0	0	0	550	0	550
I93RoadTrans	0	226	0	6707	0	6933
I94RailTrans	0	385	0	3022	0	3408
I95WaterTran	214	12	0	1707	0	1933
I96AirTransp	0	0	0	8952	0	8952
I97TransServ	0	0	0	231	0	231
I98Communic	0	865	0	1197	0	2061
I99Banking	0	456	0	368	0	825
I100NonBank	0	0	0	85	0	85
I101Investm	0	66	0	93	0	159
I102Insurnce	0	0	0	89	0	89
I103OthFinan	0	0	0	5043	0	5043
I104Dwelling	0	0	0	147	0	147
I105PubAdmin	281	345	0	456	0	1082
I106Defence	102	959	0	1688	0	2748
I107Health	414	343	0	562	0	1319
I108Educate	41	200	0	20	0	261
I109Welfare	9	1137	0	4004	0	5149
I110Entrtain	79	126	0	514	0	719
I111Hotels	8	276	0	184	0	468
I112PerServ	17	29	0	703	0	749
I113Other	0	0	0	0	0	0
Household	108	0	0	22952	0	23060
Total	40639	34724	0	111426	132019	318807

Table 6.25

PERCENTAGE CHANGE IN EMISSIONS FROM FUEL USAGE BY INDUSTRY, SUMMED OVER SOURCE

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I1Pastoral	-4.0	-3.2	-3.5	-4.0	-4.4	-4.6	-4.7	-4.7	-4.5	-4.3
I2WheatSheep	-5.9	-5.5	-5.6	-5.9	-6.1	-6.2	-6.3	-6.2	-6.1	-5.9
I3HighRain	-4.5	-3.8	-4.1	-4.5	-4.8	-5.0	-5.1	-5.0	-4.9	-4.8
I4NthBeef	-4.6	-3.8	-4.1	-4.5	-4.9	-5.1	-5.2	-5.1	-4.9	-4.8
I5MilkCattle	-5.4	-5.0	-5.2	-5.5	-5.7	-5.8	-5.8	-5.8	-5.7	-5.6
I6OthExport	-5.0	-4.6	-4.7	-5.0	-5.2	-5.3	-5.3	-5.3	-5.3	-5.2
I7ImportComp	-5.3	-5.0	-5.2	-5.5	-5.7	-5.8	-5.8	-5.8	-5.7	-5.6
I8Poultry	-5.8	-5.4	-6.0	-6.8	-7.5	-8.0	-8.4	-8.7	-8.9	-9.0
I9AgServ	-6.2	-6.1	-6.2	-6.3	-6.4	-6.4	-6.3	-6.2	-6.1	-6.0
I10Forestry	-5.9	-5.8	-5.9	-6.0	-6.0	-6.0	-6.0	-6.0	-5.9	-5.9
I11Fishing	-11.6	-11.2	-11.3	-11.9	-12.5	-13.0	-13.5	-13.8	-13.9	-13.8
I12IronOre	-14.0	-13.0	-12.4	-12.4	-12.6	-13.0	-13.6	-14.1	-14.5	-14.7
I13NFerrous	-10.9	-10.4	-10.3	-10.8	-11.3	-11.4	-11.7	-11.9	-12.2	-12.4
I14BlkCoal	-7.7	-7.1	-6.2	-7.0	-7.6	-8.2	-8.8	-9.2	-9.7	-10.0
I15aOil	-9.6	-9.7	-10.2	-10.7	-11.1	-11.4	-11.7	-11.8	-12.0	-12.1
I15bGas	-6.3	-6.4	-6.5	-6.7	-6.8	-6.9	-6.9	-6.9	-6.9	-6.9
I15cBrCoal	-26.9	-22.9	-22.4	-23.2	-24.4	-25.5	-26.7	-27.9	-29.1	-30.1
I16OthMin	-9.4	-9.3	-9.1	-9.0	-8.8	-8.7	-8.6	-8.6	-8.5	-8.4
I17MinServ	-10.3	-10.0	-9.9	-10.2	-10.5	-10.7	-10.8	-11.0	-11.1	-11.3
I18Meat	-10.5	-9.5	-9.4	-9.6	-10.0	-10.1	-10.2	-10.1	-10.0	-9.7
I19Dairy	-13.1	-12.8	-12.5	-12.3	-12.2	-12.0	-11.9	-11.8	-11.7	-11.5
I20FrtVeg	-12.2	-11.9	-11.6	-11.5	-11.3	-11.2	-11.0	-10.9	-10.8	-10.6
I21OilFat	-13.2	-12.8	-12.4	-12.3	-12.2	-12.0	-11.9	-11.7	-11.6	-11.4
I22Flour	-13.1	-12.7	-12.4	-12.3	-12.3	-12.1	-12.0	-11.9	-11.8	-11.6
I23Bakery	-9.7	-9.6	-9.5	-9.5	-9.4	-9.4	-9.3	-9.3	-9.2	-9.1
I24Confect	-10.7	-10.4	-10.2	-10.1	-10.0	-9.9	-9.7	-9.6	-9.5	-9.3
I25Sea_Sugar	-7.4	-5.8	-5.7	-6.1	-6.8	-7.1	-7.3	-7.3	-7.2	-7.0
I26SoftDr	-8.3	-8.2	-8.2	-8.2	-8.1	-8.0	-7.9	-7.8	-7.8	-7.7
I27Beer	-13.9	-13.5	-13.1	-12.9	-12.7	-12.5	-12.4	-12.2	-12.0	-11.9
I28OthDrink	-10.9	-10.5	-10.3	-10.4	-10.4	-10.4	-10.4	-10.3	-10.2	-10.1
I29Tobacco	-14.4	-14.0	-13.5	-13.4	-13.2	-13.0	-13.0	-12.8	-12.7	-12.6
I30Ginning	-11.0	-10.0	-9.9	-10.2	-10.7	-10.8	-10.9	-10.8	-10.6	-10.3
I31Synthetic	-13.3	-12.6	-12.2	-12.3	-12.3	-12.2	-12.2	-12.1	-11.9	-11.7
I32CottonYa	-13.2	-12.5	-12.1	-12.0	-12.0	-11.9	-11.8	-11.6	-11.4	-11.2
I33WoolYarn	-6.4	-6.2	-6.3	-6.3	-6.3	-6.3	-6.3	-6.2	-6.1	-6.0
I34TextileF	-12.2	-11.9	-11.5	-11.4	-11.3	-11.1	-11.1	-10.9	-10.8	-10.7
I35Carpets	-11.2	-10.9	-10.6	-10.5	-10.4	-10.3	-10.2	-10.1	-10.0	-9.9
I36Canvas	-7.2	-7.0	-7.0	-7.1	-7.1	-7.1	-7.0	-7.0	-6.9	-6.8
I37Knitting	-11.0	-10.7	-10.4	-10.4	-10.3	-10.2	-10.1	-9.9	-9.8	-9.6
I38Clothing	-8.1	-7.8	-7.7	-7.7	-7.6	-7.5	-7.4	-7.3	-7.2	-7.1
I39Footwear	-4.3	-3.7	-3.5	-3.6	-3.6	-3.6	-3.4	-3.3	-3.1	-2.9
I40Sawmill	-9.2	-8.9	-8.8	-8.8	-8.9	-8.8	-8.8	-8.7	-8.6	-8.5
I41Panels	-12.7	-12.4	-12.1	-11.9	-11.7	-11.5	-11.4	-11.2	-11.1	-11.0
I42Fittings	-8.6	-8.6	-8.5	-8.4	-8.3	-8.3	-8.2	-8.1	-8.0	-8.0
I43Furniture	-7.6	-7.4	-7.4	-7.4	-7.4	-7.4	-7.3	-7.2	-7.1	-7.1
I44PulpPaper	-14.2	-13.9	-13.5	-13.3	-13.1	-12.9	-12.8	-12.6	-12.4	-12.2
I45BagsBoxes	-10.1	-9.8	-9.6	-9.6	-9.6	-9.6	-9.5	-9.4	-9.4	-9.3
I46Sanitary	-14.1	-13.7	-13.2	-13.0	-12.8	-12.6	-12.4	-12.2	-12.1	-11.9
I47NewsBooks	-6.9	-6.8	-6.8	-6.8	-6.8	-6.7	-6.7	-6.6	-6.5	-6.5

Table 6.25 Continued

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I48CommPrint	-7.8	-7.7	-7.7	-7.7	-7.7	-7.6	-7.6	-7.5	-7.4	-7.4
I49Fertilisr	-9.2	-8.9	-9.2	-9.8	-10.3	-10.7	-11.0	-11.2	-11.4	-11.4
I50BasicChem	-13.3	-12.9	-12.8	-12.9	-12.9	-12.8	-12.8	-12.7	-12.7	-12.5
I51Paints	-9.2	-9.1	-9.1	-9.0	-8.9	-8.9	-8.8	-8.7	-8.6	-8.5
I52Pharmacy	-7.7	-7.4	-7.4	-7.5	-7.6	-7.5	-7.5	-7.4	-7.3	-7.1
I53Soaps	-9.7	-9.5	-9.3	-9.3	-9.2	-9.1	-9.0	-8.9	-8.8	-8.6
I54Cosmetics	-8.4	-8.3	-8.4	-8.5	-8.6	-8.7	-8.7	-8.7	-8.7	-8.7
I55Explosive	-10.5	-10.2	-10.0	-10.1	-10.1	-10.2	-10.2	-10.1	-10.1	-10.0
I56Petrol	-9.3	-9.0	-8.6	-8.5	-8.3	-8.1	-7.9	-7.8	-7.7	-7.6
I57Glass	-10.0	-9.9	-9.9	-10.0	-10.1	-10.2	-10.2	-10.2	-10.3	-10.3
I58ClayProd	-12.0	-11.7	-11.6	-11.5	-11.5	-11.5	-11.5	-11.4	-11.4	-11.3
I59Cement	-10.9	-10.9	-11.0	-10.9	-10.9	-10.9	-11.0	-11.1	-11.1	-11.2
I60Readymix	-8.3	-8.4	-8.4	-8.2	-7.9	-7.8	-7.6	-7.6	-7.5	-7.6
I61Pipes	-11.4	-11.4	-11.3	-11.1	-10.8	-10.7	-10.5	-10.5	-10.4	-10.4
I62Plaster	-13.6	-13.3	-12.9	-12.7	-12.5	-12.3	-12.2	-12.1	-12.0	-11.9
I63IronSteel	-14.5	-14.2	-13.8	-13.5	-13.4	-13.2	-13.1	-13.0	-12.9	-12.8
I64aNFerrous	-34.3	-33.0	-31.1	-30.6	-30.0	-29.3	-28.9	-28.6	-29.2	-29.8
I64bAlum	-38.3	-36.3	-33.5	-32.5	-31.8	-31.0	-30.8	-30.7	-31.7	-32.5
I65Structurl	-12.5	-13.4	-13.5	-13.0	-12.3	-11.9	-11.6	-11.6	-11.6	-11.6
I66SheetMetl	-8.6	-8.5	-8.8	-9.0	-9.2	-9.3	-9.5	-9.6	-9.6	-9.7
I67Wire	-11.1	-11.3	-11.3	-11.3	-11.1	-11.1	-11.0	-11.0	-11.0	-11.0
I68MotorVeh	-11.5	-11.2	-11.2	-11.3	-11.3	-11.3	-11.3	-11.3	-11.2	-11.2
I69Ships	-13.8	-13.3	-13.0	-13.0	-13.0	-13.0	-13.0	-12.9	-12.8	-12.7
I70Trains	-13.4	-12.9	-12.6	-12.7	-12.9	-13.0	-13.3	-13.5	-13.7	-13.9
I71Aircraft	-8.1	-7.7	-7.6	-7.7	-7.8	-7.8	-7.8	-7.7	-7.6	-7.5
I72SciEquip	-8.2	-8.1	-8.1	-8.2	-8.1	-8.1	-8.0	-8.0	-7.9	-7.8
I73Electron	-10.2	-9.9	-9.8	-9.7	-9.6	-9.5	-9.4	-9.3	-9.2	-9.1
I74HousAppl	-12.8	-12.5	-12.2	-12.1	-12.0	-11.9	-11.8	-11.7	-11.6	-11.4
I75ElectEq	-9.9	-9.9	-9.9	-9.9	-10.0	-10.0	-10.0	-10.1	-10.0	-10.0
I76AgMach	-11.3	-11.1	-11.1	-11.3	-11.5	-11.6	-11.7	-11.7	-11.6	-11.5
I77ConMach	-13.2	-12.8	-12.6	-12.4	-12.4	-12.4	-12.4	-12.4	-12.3	-12.3
I78ManuMach	-12.4	-12.6	-12.5	-12.4	-12.2	-12.1	-12.0	-12.0	-11.9	-11.9
I79Leather	-11.7	-11.5	-11.3	-11.3	-11.2	-11.1	-11.0	-10.8	-10.7	-10.5
I80Rubber	-11.5	-11.2	-11.0	-11.0	-11.0	-11.0	-10.9	-10.9	-10.8	-10.7
I81Plastic	-9.1	-8.8	-8.8	-8.8	-8.8	-8.8	-8.8	-8.7	-8.6	-8.6
I82Signs	-8.2	-8.0	-8.0	-8.0	-8.0	-8.0	-7.9	-7.9	-7.8	-7.8
I83SportEq	-14.8	-14.3	-13.8	-13.6	-13.4	-13.2	-13.1	-12.9	-12.8	-12.6
I84aaaEleBr	-12.5	-9.2	-8.4	-8.8	-9.8	-10.9	-12.3	-13.8	-15.3	-16.8
I84aaaaEdis	-24.5	-23.0	-22.5	-22.6	-22.8	-23.1	-23.5	-24.0	-24.7	-25.3
I84aaabEBrix	-44.9	-33.3	-29.0	-28.0	-28.2	-28.8	-30.0	-31.2	-32.8	-34.1
I84aaacHaz	-40.7	-32.0	-28.9	-28.3	-28.6	-29.1	-30.1	-31.2	-32.7	-33.9
I84aaadLoyY	-25.2	-23.5	-22.9	-23.0	-23.2	-23.6	-24.0	-24.6	-25.3	-25.9
I84aaaeYall	-33.1	-28.4	-26.8	-26.7	-27.2	-27.7	-28.6	-29.5	-30.7	-31.7
I84aaafFlin	-18.9	-19.0	-18.7	-18.7	-18.6	-18.5	-18.5	-18.5	-18.7	-18.8
I84aabEleBlk	-11.8	-12.8	-12.5	-12.1	-11.5	-10.9	-10.2	-9.6	-9.1	-8.7
I84aacEleGas	2.8	-0.1	1.2	3.5	6.2	8.9	11.5	13.9	16.0	17.9
I84aadEleHyd	7.8	7.0	7.7	8.9	10.3	11.5	12.7	13.7	14.7	15.5
I84aaeEleOth	23.2	17.6	17.4	18.9	21.1	23.1	25.4	27.5	30.0	32.5
I84bElectTrn	-16.3	-15.3	-14.2	-13.5	-13.1	-12.7	-12.6	-12.3	-12.3	-12.2
I84cElectDist	-6.7	-7.0	-6.9	-6.7	-6.5	-6.4	-6.3	-6.3	-6.4	-6.5
I85Gas	-12.5	-12.3	-12.5	-13.1	-13.7	-14.2	-14.5	-14.7	-14.9	-15.1
I86Water	-7.0	-7.1	-7.1	-7.1	-6.9	-6.8	-6.7	-6.7	-6.6	-6.6
I87Resident	-6.6	-6.7	-6.8	-6.9	-6.8	-6.8	-6.8	-6.7	-6.7	-6.6

Table 6.25 Continued

INDUSTRY	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I88OthBuild	-10.4	-10.8	-10.7	-10.4	-10.0	-9.8	-9.5	-9.5	-9.3	-9.5
I89Wholesale	-9.6	-9.5	-9.4	-9.3	-9.1	-9.0	-8.9	-8.8	-8.8	-8.7
I90RetailTrd	-10.2	-10.1	-10.0	-10.0	-9.8	-9.7	-9.6	-9.4	-9.3	-9.3
I91MechRep	-5.2	-5.2	-5.2	-5.2	-5.1	-5.1	-5.0	-5.0	-5.0	-5.0
I92OthRepair	-6.6	-6.6	-6.6	-6.7	-6.6	-6.5	-6.5	-6.4	-6.4	-6.4
I93RoadTrans	-7.8	-7.7	-7.7	-7.8	-7.7	-7.7	-7.6	-7.6	-7.6	-7.6
I94RailTrans	-7.1	-6.8	-6.8	-7.0	-7.4	-7.7	-8.1	-8.4	-8.8	-9.0
I95WaterTran	-13.2	-12.2	-11.6	-11.9	-12.3	-12.5	-12.8	-13.0	-13.4	-13.7
I96AirTransp	-4.7	-4.1	-4.0	-4.0	-4.0	-4.0	-3.9	-3.8	-3.5	-3.3
I97TransServ	-8.0	-7.7	-7.6	-7.6	-7.5	-7.5	-7.4	-7.4	-7.3	-7.3
I98Communic	-6.1	-6.2	-6.4	-6.6	-6.7	-6.8	-6.9	-7.0	-7.1	-7.2
I99Banking	-7.0	-7.1	-7.3	-7.6	-7.8	-8.0	-8.1	-8.3	-8.4	-8.5
I100NonBank	-7.5	-7.4	-7.4	-7.4	-7.4	-7.3	-7.4	-7.2	-7.4	-7.2
I101Investm	-7.3	-7.3	-7.4	-7.6	-7.7	-7.9	-8.0	-8.1	-8.2	-8.3
I102Insurnce	-5.6	-5.6	-5.5	-5.5	-5.4	-5.4	-5.3	-5.2	-5.1	-5.1
I103OthFinan	-6.9	-7.0	-6.9	-6.9	-6.8	-6.7	-6.6	-6.6	-6.5	-6.5
I104Dwelling	-5.8	-5.8	-5.7	-5.7	-5.6	-5.5	-5.4	-5.2	-5.1	-4.9
I105PubAdmin	-9.3	-9.4	-9.3	-9.2	-9.0	-9.0	-8.9	-8.8	-8.7	-8.7
I106Defence	-7.2	-7.3	-7.4	-7.4	-7.3	-7.4	-7.3	-7.3	-7.3	-7.2
I107Health	-8.6	-8.6	-8.4	-8.4	-8.3	-8.3	-8.2	-8.1	-8.1	-8.0
I108Educate	-8.5	-8.6	-8.8	-9.1	-9.3	-9.5	-9.7	-9.8	-9.9	-10.0
I109Welfare	-6.5	-6.6	-6.7	-6.7	-6.6	-6.7	-6.6	-6.6	-6.5	-6.5
I110Entrtain	-6.8	-6.7	-6.6	-6.7	-6.6	-6.6	-6.5	-6.4	-6.3	-6.3
I111Hotels	-5.4	-5.2	-5.4	-5.7	-6.0	-6.3	-6.5	-6.6	-6.7	-6.7
I112PerServ	-4.8	-4.7	-4.5	-4.5	-4.4	-4.4	-4.2	-4.1	-4.0	-3.9
I113Other	-3.2	-3.3	-3.4	-3.4	-3.3	-3.3	-3.3	-3.3	-3.2	-3.3
Household	-12.4	-12.2	-12.0	-11.8	-11.4	-11.0	-10.5	-10.1	-9.7	-9.3

Appendix 6-A

LABOUR / CAPITAL INTENSITIES

Labour / Capital Intensive Analysis for Selected Industries

INDUSTRY	Labour (L)	Capital (K)	K/Lratio	Total
Soft Drink	230	166	0.72	396
Beer	278	231	0.83	509
EleHyd	110	186	1.69	296
EleOth	10	17	1.7	27
Retail Trade	18200	2597	0.14	20797
Mechanical Repair	3563	387	0.11	3950
Insurance	3693	271	0.07	3964
Defence	3729	0	0	3729
Health	18494	1091	0.06	19585
Education	18446	971	0.05	19417
Welfare	11100	543	0.05	11643
Entertainment	2960	972	0.33	3932
Personal Services	1745	812	0.47	2557

Results for Capital Intensive Industries – Expressed as percentage change in activity levels at 2001 GF – Grandfathering permits activity levels RR – Auctioned permits activity levels					
Industry	**Labour**	**Capital**	**K/L ratio**	**GF**	**RR**
Oil	232	1421	6.13	-1.88	-1.39
Gas	166	1015	6.13	-5.94	-4.99
BrCoal	52	317	6.13	-19.54	-16.96
Other Mining	331	468	1.42	-3.07	-1.78
EleBr			1.7	-20.81	-18.30
Edis	50	85	1.7	-14.52	-12.67
EBrix	9	15	1.7	-37.49	-33.05
Haz	80	137	1.7	-32.25	-28.55
LoyY	101	171	1.7	-15.18	-13.27
Yall	73	124	1.7	-23.46	-20.79
Flin	35	60	1.7	-9.13	-7.66
EleBlk	754	1280	1.7	-5.55	-4.28
EleGas	47	80	1.7	9.05	9.54
EleHyd	110	186	1.7	3.00	3.00
EleOth	10	17	1.7	18.50	18.90
ElectTrn	82	139	1.7	-8.88	-7.35
ElectDis	806	1369	1.7	-8.75	-7.22
Gas	318	658	2.07	-11.38	-9.48
Water	1265	1903	1.5	-1.98	-0.18
Non Bank	1589	4168	2.62	-2.48	-0.14
Dwelling	0	33765		0	0

GF – Grandfathering permits activity levels 2001

RR – Auctioned permits activity levels 2001

Industry	% capital stock	GF	RR
Wholesale	0.06	-4.45	-2.18
Banking	0.06	-2.59	0.10
NonBank	0.04	-2.48	-0.14
Other Finance	0.04	-3.01	-0.40
Dwelling	0.33	0	0

INVESTMENT AND CAPITAL RATIOS

Industries whose share of investment outweighs their share of capital

Industry	Share of Investment > Capital	GF	RR
Non Ferrous ore	0.01	-1.75	-2.44
BlkCoal	0.02	-7.25	-7.88
Rail Transportation	0.01	-4.12	-2.51
Other Finance	0.03	-3.01	-0.40
Public Administration	0.08	-3.92	-0.57
Health	0.01	-4.09	1.50
Education	0.01	-3.79	0.65

Industries whose share of capital outweighs their share of investment

Industry	Share of Investment > Capital	GF	RR
Oil	0.01	-1.88	-1.39
Gas	0.01	-5.94	-4.99
Water	0.01	-1.98	-0.18
Residential	0.01	0	0
Wholesale	0.03	-4.45	-2.18
Communication	0.01	-3.50	0.55
Banking	0.04	-2.59	0.10
Non Bank	0.03	-2.48	-0.14
Investment	0.02	-2.82	-0.01

Appendix 6-B

AGGREGATE REAL GOVERNMENT DEMAND

Commodity	% Govt spending	GF Activity Level	RR Activity Level	GF Domestic Price	RR Domestic Price
Other Building	6	-7.49	-3.04	-0.81	2.31
Public Administration	21	-3.92	-0.57	-0.73	2.65
Defence	12	-3.88	-0.57	0.82	3.68
Health	18	-4.09	1.50	-1.31	1.86
Education	23	-3.79	0.65	-2.44	0.37
Welfare	16	-4.07	0.01	0.50	3.60
Entertainment	2	-4.10	1.06	-0.70	3.15

Appendix 6-C

IMPORTS

Percentage of Imports for those Industries who Collapse

GRANDFATHERING

Industry	Activity Level	Intermediate domestic	Intermediate imported	% Imports
Gas	-11.38	456	105	19
Other Building	-7.49	913	208	19
Health	-4.09	3971	534	12
Non Ferrous Metals	-27.10	3052	200	6
Aluminium	-30.89	4001	268	6
Water Transportation	-5.76	1740	177	9

REVENUE RECYCLING

Industry	Activity Level	Intermediate domestic	Intermediate imported	% Imports
Fishing	-7.23	456	105	19
Iron Ore	-2.56	913	208	19
Non Ferrous Metals	-27.24	3052	200	6
Aluminium	-31.52	4001	268	6
Water Transportation	-6.70	1740	177	9

Imported Commodities

Commodity	% Imports
Synthetic	64
Cotton Yarn	54
Footwear	51
Aircraft	58
Science Equipment	69
Electronics	66
Construction Machinery	82
Manufacturing Machinery	52
Sport Equipment	51
Other	100

Sales of Imported Commodities to Industry

SYNTHETIC

Industry	% of commodity sales	GF	RR
Synthetic	11	-0.65	0.77
Carpets	8	-3.33	0.15
Canvas	11	-2.18	0.35
Knitting	16	-1.11	0.72
Clothing	17	-0.74	1.07

COTTON YARN

Industry	% of commodity sales	GF	RR
Cotton Yarn	9	-0.28	1.13
Textile	9	-1.24	0.92
Clothing	36	-0.74	1.07

FOOTWEAR

Industry	% of commodity sales	GF	RR
Footwear	36	0.50	3.91
Other Building	8	-7.49	-3.04
Health	12	-4.09	1.50
Welfare	7	-4.07	0.01

AIRCRAFT

Industry	% of commodity sales	GF	RR
BlkCoal	10	-7.25	-7.88
Aircraft	43	-1.94	0.33
Air Transportation	20	-2.63	-0.10
Defence	19	-3.88	-0.57

SCIENCE EQUIPMENT

Industry	% of commodity sales	GF	RR
Science Equipment	11	-2.63	-0.14
Health	28	-4.09	1.50
Education	16	-3.79	0.65
Entertainment	14	-4.10	1.06

ELECTRONICS

Industry	% of commodity sales	GF	RR
Electronics	13	-3.19	-0.37
Other Building	19	-7.49	-3.04
Communication	16	-3.50	0.55
Other Finance	12	-3.01	-0.40
Entertainment	15	-4.10	1.06

CONSTRUCTION MACHINERY

Industry	% of commodity sales	GF	RR
Iron Ore	11	-1.10	-2.56
Non Ferrous Ore	21	-1.75	-2.44
BlkCoal	15	-7.25	-7.88
Other Repair	10	-3.43	-0.17
Rail Transportation	9	-4.12	-2.51

MANUFACTURING MACHINERY

Industry	% of commodity sales	GF	RR
Non Ferrous Ore	10	-1.75	-2.44
Petrol	8	-10.74	-8.92
Manufacturing Machinery	10	-4.91	-2.52
Other Building	10	-7.49	-3.04

SPORT EQUIPMENT

Industry	% of commodity sales	GF	RR
Fishing	9	-7.03	-7.23
Manufacturing Machinery	10	-4.91	-2.52
Health	12	-4.09	1.50
Education	19	-3.79	0.65

OTHER

Industry	% of commodity sales	GF	RR
Petrol	6	-10.74	-8.92
Public Administration	11	-3.92	-0.57
Defence	36	-3.88	-0.57

Appendix 6-D

FUELS

Sales Of The Fuel Commodities

BLACK COAL

Industry	% of total intermediate sales
BlkCoal	8
Iron Steel	5
Non Ferrous Metals	4
Aluminium	5
EleBlk	67

GAS

Industry	% of total intermediate sales
Oil	4
Gas	3
Basic Chemicals	3
Cement	3
Iron Steel	4
Aluminium	2
EleGas	9
Retail Gas	49
Retail Trade	1
Communication	2
Banking	1
Defence	2
Welfare	3

BROWN COAL

Industry	% of total intermediate sales
Edis	14
EBrix	3
Haz	23
LoyY	29
Yall	21
Flin	10

PETROL

Industry	% of total intermediate sales
Wheat Sheep	3
Forestry	1
Fishing	1
Non Ferrous Ore	1
Petrol	14
Non Ferrous Metals	4
Aluminium	5
EleBlk	1
ElectDist	1
Residential	2
Other Building	3
Wholesale	5
Retail Trade	3
Road Transportation	8
Rail Transportation	4
Water Transportation	2
Air Transportation	8
Communication	5
Other Finance	6
Defence	2
Welfare	5
Personal Services	1

Intermediate inputs purchased by the fuel industries

BLACK COAL

Commodity	% of total intermediate inputs
BlkCoal	6
Forestry	2
Mining Services	2
Fertiliser	2
Explosive	5
Petrol	3
Iron Steel	6
Electrical Equipment	2
Manufacturing Machinery	4
Rubber	2
ElectDist	11
Other Building	2
Other Repair	4
Road Transport	4
Transport Services	4
Communication	2
Banking	5
Non Bank	5
Investment	3
Other Finance	11
Public Administration	1
Welfare	1

GAS

Commodity	% of total intermediate inputs
Gas	7
Mining Services	38
Explosive	3
Iron Steel	4
Wire	1
Manufacturing Machinery	3
Rubber	2
ElectDist	2
Other Building	2
Other Repair	3
Road Transportation	3
Transport Services	3
Communication	2
Banking	4
Non Bank	3
Investment	2
Other Finance	7

BROWN COAL

Commodity	% of total intermediate inputs
Gas	7
Mining Services	38
Explosive	3
Iron Steel	4
Wire	1
Manufacturing Machinery	3
Rubber	2
ElectDist	2
Other Building	2
Other Repair	3
Road Transportation	3
Transport Services	3
Communication	2
Banking	4
Non Bank	3
Investment	2
Other Finance	7

PETROL

Commodity	% of total intermediate inputs
Oil	26
Other Mining	5
Basic Chemicals	8
Petrol	18
Water	2
Retail Trade	2
Road Transportation	2
Water Transportation	2
Transport Services	1
Communication	1
Banking	2
Non Bank	3
Investment	3
Insurance	1
Other Finance	8
Public Administration	4
Welfare	1

Industries Where The Fuel Commodities Represent An Important Part Of Intermediate Usage

BLACK COAL

Industry	% of Industry Intermediate Usage	GF	RR
BlkCoal	6	-7.25	-7.88
EleBlk	57	-5.55	-4.28

GAS

Industry	% of Industry Intermediate Usage	GF	RR
Oil	7	-1.88	-1.39
Gas	7	-5.94	-4.99
BrCoal	7	-19.54	-16.96
Cement	10	-4.45	-2.36
EleGas	70	9.05	9.54
Retail Gas	68	-11.38	-9.48

BROWN COAL

Industry	% of Industry Intermediate Usage	GF	RR
Edis	64	-14.52	-12.67
EBrix	67	-37.49	-33.05
Haz	64	-32.25	-28.55
LoyY	64	-15.18	-13.27
Yall	64	-23.46	-20.79
Flin	64	-9.13	-7.66

PETROL

Industry	% of Industry Intermediate Usage	GF	RR
Pastoral	12	2.61	2.42
Wheat Sheep	16	0.37	0.12
High Rain	11	2.12	1.95
Northern Beef	12	1.86	1.69
Milk Cattle	6	0.96	1.06
Other Export	10	0.48	1.05
Import Competing	10	0.11	1.52
Agricultural Services	16	-0.60	0.88
Forestry	25	-2.74	-0.84
Fishing	32	-7.03	-7.23
Non Ferrous Metals	13	-27.10	-27.24
Aluminium	12	-30.89	-31.52
EleHyd	15	3.00	3.00
EleOth	15	18.50	18.90
Water	19	-1.98	-0.18
Other Repair	17	-3.43	-0.17
Road Transportation	21	-3.13	-1.44
Rail Transportation	13	-4.12	-2.51
Water Transportation	12	-5.76	-6.70
Air Transportation	19	-2.63	-0.10
Defence	6	-3.88	-0.57
Welfare	8	-4.07	0.01

Appendix 6-E

RESIDENTIAL

RESIDENT

Commodity	**% of Residential industry's intermediate inputs**
Sawmill	8
Fittings	13
Clay Products	9
Readymix	7
Pipes	5
Plaster	5
Iron Steel	4
Structural	4
Banking	4
Non Bank	5
Other Finance	6

Appendix 6-F

HOUSEHOLD CONSUMPTION

Industries Which Sell a Large Portion of Their Commodity Output to the Household Sector

Commodity	% of total household input expenditure	GF	RR
Meat	3	2.20	1.68
Dairy	2	-0.45	0.10
Bakery	1	-0.85	0.10
Sea_Sugar	2	4.42	4.05
Clothing	2	-0.74	1.07
Furniture	1	-3.78	0.42
Petrol	2	-10.74	-8.92
Motor Vehicle	2	-2.99	-0.28
ElectDis	2	-8.75	-7.22
Mechanical Repair	3	-2.78	1.22
Road Transportation	1	-3.13	-1.44
Air Transportation	2	-2.63	-0.10
Communication	2	-3.50	0.55
Banking	2	-2.59	0.10
Other Finance	1	-3.01	-0.40
Dwelling	30	0	0
Health	9	-4.09	1.50
Education	3	-3.79	0.65
Welfare	3	-4.07	0.01
Entertainment	4	-4.10	1.06
Hotels	5	-1.53	1.88
Personal Services	2	-3.13	1.78

Appendix 6-G

INDUSTRY ANALYSIS

Industry	GF	RR	Intermediate Input	Household	Export
Fishing	-7.03	-7.23	544	463	279
Iron Ore	-1.10	-2.56	569	0	1579
Sea_Sugar	4.42	4.05	2354	3727	2276

Industries who purchase the above commodities

SEA_SUGAR

Industry	% of commodity input	GF	RR
Milk Cattle	8	0.96	1.06
Poultry	21	1.53	1.37
Sea_Sugar	28	4.42	4.05
Soft Drink	8	-1.89	0.08

Commodities purchased by the industries

SEA_SUGAR

Commodity	% of total intermediate input
Other Export	13
Fishing	5
Meat	7
Sea_Sugar	16
Other Finance	9

Appendix 6-H

EXPANDING INDUSTRIES

Industries who do not collapse following the imposition of the GFT

GRANDFATHERING

Industry	**% Usage Blkcoal**	**% Usage Gas**	**% Usage Brcoal**	**% Usage Petrol**	**GF**
Pastoral	0	0	0	0.3	2.61
High Rain	0	0	0	1	2.12
Northern Beef	0	0	0	0.3	1.86
Meat	0	0	0	0	2.20
Sea_Sugar	0	0	0	0	4.42
Footwear	0	0	0	0	0.50
EleGas	0	10	0	0	9.05
EleHyd	0	0	0	0	3.00
EleOth	0	0	0	0	18.50

REVENUE RECYCLING

Industry	% Usage Blkcoal	% Usage Gas	% Usage Brcoal	% Usage Petrol	GF
Pastoral	0	0	0	0.3	2.42
High Rain	0	0	0	1	1.95
Northern Beef	0	0	0	0.3	1.69
Meat	0	0	0	0	1.68
Sea_Sugar	0	0	0	0	4.05
Soft Drink	0	0	0	0	0.08
Footwear	0	0	0	0	3.91
EleGas	0	10	0	0	9.54
EleHyd	0	0	0	0	3.00
EleOth	0	0	0	0	18.90
Mechanical Repair	0	0	0	0	1.22
Insurance	0	0	0	0	1.24
Health	0	0	0	0	1.50
Education	0	0	0	0	0.65
Welfare	0	3	0	5	0.01
Entertainment	0	0	0	0	1.06
Personal Services	0	0	0	1	1.78

Appendix 6-I

STATES

NSW

Industry	**% of total Australian employment**	**GF**	**RR**
BlkCoal	79	-7.25	-7.88
Oil Fat	54	-1.26	0.24
Ginning	53	3.12	2.26
Pharmacy	57	-1.99	0.72
Soaps	57	-1.62	0.11
Cosmetics	72	-1.45	-0.07
Iron Steel	53	-4.16	-2.35
EleBlk	57	-5.55	-4.28
EleHyd	52	3.00	3.00
EleOth	53	18.50	18.90

Industries that collapse

GRANDFATHERING

Industry	**Activity Level**	**Share of Employment by Industry**							
		NSW	***VIC***	***QLD***	***SA***	***WA***	***TAS***	***ACT***	***NT***
Non Ferrous Metals	-27.10	0.21	0.17	0.34	0.04	0.17	0.06	0	0
Aluminium	-30.89	0.17	0.14	0.27	0	0.32	0.04	0	0.06
Structural	-6.49	0.27	0.22	0.25	0.09	0.13	0.02	0.01	0.01
Gas	-11.38	0.21	0.45	0.04	0.16	0.10	0	0.01	0.02
Other Building	-7.49	0.36	0.22	0.17	0.05	0.14	0.02	0.02	0.01
Health	-4.09	0.35	0.23	0.18	0.10	0.10	0.03	0.01	0.01

REVENUE RECYCLING

Industry	Activity Level	Share of Employment by Industry							
		NSW	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*ACT*	*NT*
NonFerrous Metals	-27.24	0.21	0.17	0.34	0.04	0.17	0.06	0	0
Aluminium	-31.52	0.17	0.14	0.27	0	0.32	0.04	0	0.06
Fishing	-7.23	0.33	0.12	0.26	0.06	0.15	0.06	0	0.02
Water Transport	-6.70	0.34	0.22	0.25	0.05	0.08	0.05	0	0.01

Industries that expand

GRANDFATHERING

Industry	Activity Level	Share of Employment by Industry							
		NSW	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*ACT*	*NT*
Pastoral	2.61	0.37	0	0.33	0.17	0.13	0	0	0
Northern Beef	1.86	0	0	0.76	0	0.11	0	0	0.14
Poultry	1.53	0.44	0.17	0.19	0.07	0.11	0.02	0	0
Meat	2.20	0.37	0.20	0.26	0.06	0.08	0.03	0	0
Sea_Sugar	4.42	0.29	0.17	0.42	0.04	0.07	0.03	0	0
Ginning	3.12	0.53	0.16	0.12	0.12	0.07	0	0	0
Footwear	0.50	0.26	0.57	0	0.09	0.05	0.03	0	0

REVENUE RECYCLING

Industry	Activity Level	Share of Employment by Industry							
		NSW	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*ACT*	*NT*
Pastoral	2.42	0.37	0	0.33	0.17	0.13	0	0	0
Sea_Sugar	4.05	0.29	0.17	0.42	0.04	0.07	0.03	0	0
Ginning	2.26	0.53	0.16	0.12	0.12	0.07	0	0	0
Footwear	3.91	0.26	0.57	0	0.09	0.05	0.03	0	0

Breakdown of the electricity industries

Industry	GF	RR	Share of Employment by Industry							
			NSW	*VIC*	*QLD*	*SA*	*WA*	*TAS*	*ACT*	*NT*
EleBr	-20.81	-18.30	0	0.92	0	0.08	0	0	0	0
Edis	-14.52	-12.67	0	1	0	0	0	0	0	0
EBrix	-37.49	-33.05	0	1	0	0	0	0	0	0
Haz	-32.25	-28.55	0	1	0	0	0	0	0	0
LoyY	-15.18	-13.27	0	1	0	0	0	0	0	0
Yall	-23.46	-20.79	0	1	0	0	0	0	0	0
Flin	-9.13	-7.66	0	0	0	1	0	0	0	0
EleBlk	-5.55	-4.28	0.57	0	0.32	0	0.10	0.01	0	0
EleGas	9.05	9.54	0.08	0.12	0.07	0.44	0.24	0	0	0.06
EleHyd	3.00	3.00	0.52	0.08	0.02	0	0	0.38	0	0
EleOth	18.50	18.90	0.53	0	0.28	0	0.06	0	0	0.12
ElectTrn	-8.88	-7.35	0	0	0	0	0	0	0	0
ElectDis	-8.75	-7.22	0	0	0	0	0	0	0	0

ANALYSIS FOR THE NT

Industry	Share of NT	GF	RR
Non Ferrous Ore	6.4	-1.75	-2.44
Oil	4.2	-1.88	-1.39
Gas	4.2	-5.94	-4.99
Aluminium	4.8	-30.89	-31.52
EleGas	4.1	9.05	9.54
EleOth	9.1	18.50	18.90
Transport Services	2	-3.32	-0.85
Dwelling	9.5	0	0
Other	9	-3.94	-0.57

Appendix 6-J

STATISTICAL DIVISION ANALYSIS

LA TROBE VALLEY[128]

Industry	% of employment in La Trobe Valley
BrCoal	1.3
Dairy	1.1
Pulp Paper	1
Edis	1
Haz	1.6
LoyY	2
Yall	1.5
ElectTrn	1
ElectDis	8.5
Resident	4
Other Building	6
Wholesale	4
Retail Trade	13
Mechanical Repair	3
Road Transportation	1.6
Communication	1.4
Other Finance	4.6
Public Administration	5.8
Health	6.6
Education	8
Welfare	3

[128] There may exist an inconsistency in the employment by industry database for the statistical division of La Trobe Valley, following the disaggregation of the original electricity industry. As shown in the first table of Appendix 6-J, *ElectDist* accounts for 8.5 percent of total employment in the region, whilst the electricity generators combined account for only 6 percent. These percentages are consistent with the sector shares according to industry data (ESAA). In the case of the La Trobe Valley however, the electricity generators employ a larger share of the population than the distribution arm of the sector. Evidence to support this statement is readily available. Such evidence would not however be available for all other statistical divisions in the model. It was therefore decided that no alteration would be made to the data for the La Trobe Valley. This ensures that it remains consistent with the disaggregation across remaining statistical divisions.

Entertainment	1.1
Hotels	3.7
Personal Services	1.5

Analysis Of Statistical Divisions Who Host Collapsing Industries

FISHING

Statistical Division	% of total employment in the region
Mid-North Coast	10
Perth	10

IRON ORE

Statistical Division	% of total employment in the region
Pilbura	90

BLACK COAL

Statistical Division	% of total employment in the region
Hunter	50
Central West	10
South West	10
Fitzroy	20
Wide Bay - Burnett	10

NON FERROUS METALS

Statistical Division	% of total employment in the region
Sydney	20
Hunter	10
Illawarra	10
Melbourne	10
Barwon	10
Fitzroy	10
Perth	10
South West	10

ALUMINIUM

Statistical Division	% of total employment in the region
Hunter	20
Western District	10
Fitzroy	20
South West	30

Analysis Of Statistical Divisions Who Host Expanding Industries

SEA_SUGAR

Statistical Division	% of total employment in the region
Sydney	20
Melbourne	20
Brisbane	10
Wide Bay - Burnett	10
Mackay	10
Northern	10
Far North	10
Perth	10

WATER TRANSPORTATION

Statistical Division	% of total employment in the region
Sydney	40
Hunter	10
Melbourne	10
Brisbane	20

CHAPTER SEVEN

CONCLUSION AND AREAS FOR FURTHER RESEARCH

7.1 CONCLUSION AND CONTRIBUTION

A number of conclusions can be drawn from the research outlined in the preceding chapters of the thesis. The most prevalent is that the introduction of greenhouse policy will be highly detrimental to the electricity sector of the Australian economy.

The thesis makes a significant contribution to the interpretation and understanding of how greenhouse policy is likely to effect the Australian electricity industry and the La Trobe Valley region. The development of the MONASH-Electricity model of the Australian economy facilitated an explanation of the economic impact of greenhouse policy on different regions. The macroeconomic impact was explored in detail, taking into account the interrelationships between sectors of the economy. Results were available for each State of Australia and for each statistical division. A level of electricity sector detail not previously explored in other Australian CGE models has been achieved in the thesis.

The thesis also makes a significant contribution to knowledge. The MONASH-Electricity model is the most comprehensive CGE model of the Australian electricity sector. The MONASH-Electricity model is a product of the thesis which can be adapted to future research in this area. The model can be used in future greenhouse policy simulations or for more generic topics relating to the electricity sector of the Australian economy.

Chapter one of the thesis explained the importance of the topic area and outlined the methodology applied.

The literature on greenhouse policy analysis using CGE modelling techniques was explored in chapter two. The chapter was divided into a review of the Australian CGE greenhouse models and a broader review of the international literature.

Chapter three outlined the nature of greenhouse policy from both a domestic and international perspective. The benefits and disadvantages of the Kyoto Protocol were explored. The chapter concluded with an overview of the Australian Government's position on greenhouse policy.

An overview of the Victorian electricity supply industry and its relationship with the La Trobe Valley region is detailed in Chapter four. The importance of the electricity sector to the region was highlighted.

Chapter five provided an explanation of the model used to predict the economic impact of the Australian Government's greenhouse policy. The first part of the chapter outlined the MONASH-RES model of the Australian economy. The remainder of the chapter is dedicated to explaining the modifications made to the original model to facilitate greenhouse policy analysis.

The disaggregation of the original Gippsland statistical division is also explained in Chapter five. As identified in Chapter six, the ramifications of greenhouse policy are more severe for the La Trobe Valley relative to the Gippsland region. Without the disaggregation of the original Gippsland statistical division, such results could not be explicitly drawn as the industrial composition of the region's differ.

The results reported in Chapter six indicate that some industries within the electricity sector will experience more severe economic loss relative to others. In particular, the brown coal electricity generators will experience a significant decline in their economic activity as the electricity distribution sector substitutes toward the lower CO_2 emission generators such as renewable energy.

Chapter six further identified that industries relying on electricity and other energy sources as an important component of their intermediate inputs will experience a decline in their economic activity. In some instances, the percentage deviation from base exceeds that of the collapsing electricity sectors. This occurred in the case of the non-ferrous metals sector. These industries face highly elastic demand curves as they sell a high percentage of their homogenous output to foreigners on the international market.

The modification to the regional database also enabled conclusions to be drawn as to which statistical divisions experienced the greatest downturn in their economic outlook following the introduction of greenhouse policy.

A direct correlation is drawn between those statistical divisions associated in some way with energy intensive industries and those regions which experience the greatest decline in their economic activity. Regions such as South West in the State of Western Australia are responsible for most of Australia's alumina production. These regions experience a large economic downturn as their main industry base collapses. The reverse is true of regions such as the Southern and Northern statistical divisions in the State of Tasmania which benefit from increased demand for hydro electricity.

The rest of this chapter explores the areas for further research. The scope of the topic area is very wide and could be the focus of many new research projects. Suggestions are provided in the following section.

7.2 AREAS FOR FURTHER RESEARCH

7.2.1 FURTHER INDUSTRY DISAGGREGATION

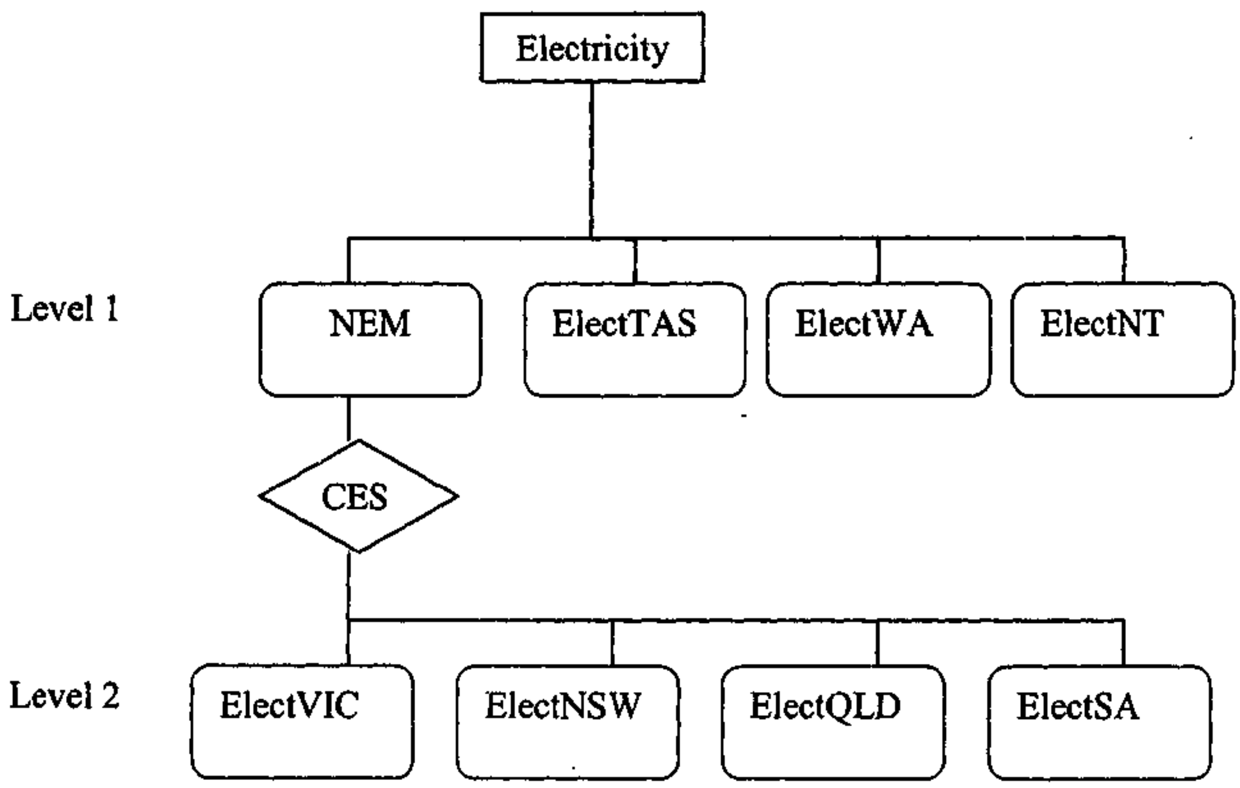
A number of further adjustments could be made to the MONASH-Electricity model if a more detailed analysis was attractive to the stakeholders.

State Based Disaggregation

As identified in Chapter four, the NEM allows for limited interstate trade of electricity. The modifications made to the database to capture the interstate trade are based on the type of fuel used in the generation process. For example, brown coal electricity generation is found in the State of Victoria.

Further model database modifications could be made to extend the recognition of the NEM. One method is to introduce another level of substitution. Each of the states in Australia could operate an electricity generation industry – electricity generated in NSW would be known as *ElectNSW*; Victoria *ElectVIC*; South Australia *ElectSA*; Queensland *ElectQLD*; Western Australia *ElectWA*; Tasmania *ElectTAS*; and the Northern Territory *ElectNT*. Figure 7.1 uses a flow diagram to illustrate the possible disaggregation.

Figure 7.1



Each state based generator would sell its output ultimately to the electricity distribution industry (*ElectDist*). As shown at level 1 on Figure 7.1, there would be no substitution between electricity produced in the States of WA (*ElectWA*) and NT (*ElectNT*) and the other states because of the absence of transmission lines. Whilst in the short-run there would be no substitution between electricity produced in TAS (*ElectTAS*) and the other states, this assumption would be relaxed in a long-run scenario when the transmission lines between VIC and TAS are operational.

Database modifications such as those described above are likely to have an important impact upon the results of the simulation. Rather than restricting the growth of hydro electricity in the closure, any growth in this industry would come as a result of increased generation in the Snowy region or TAS. The result for the gas generated electricity industry (*EleGas*) may also be altered as the electricity could not be substituted between the North-West shelf of WA and the remaining states.

Base and Peak Electricity Markets

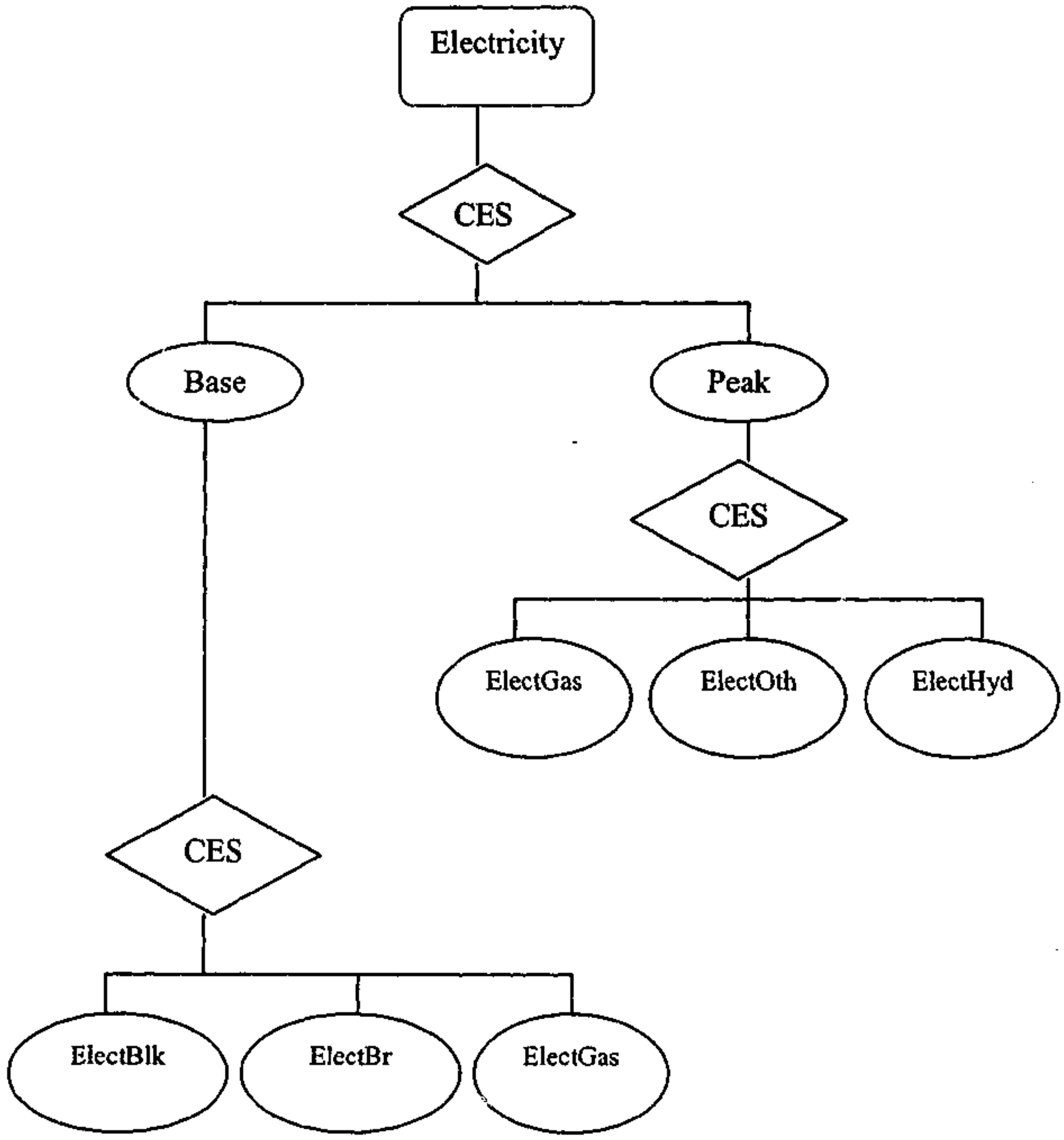
ESAA 1999 publishes load forecasts for the base and peak electricity markets, clearly identifying which generators sell to each market. Base electricity has a much lower average price of $15.17 relative to the peak electricity price of $40.00 (NEMMCO, 2001). This is attributable to market conditions and the fast-start nature of the peak plants. The prices of electricity between base suppliers varies considerably due to the fact that generators in some states such as Queensland traditionally have not been exposed to competition from interstate generators.

Although it was decided not to separately model the base and peak markets in this thesis, such a database modification could be performed at a later date. In line with industry findings, the model could be set up so that the brown coal (*EleBr*) and black coal (*EleBlk*) electricity industries sell their output solely to the base electricity market (*Base*). Likewise, the hydro electricity industry (*EleHyd*) and the renewable electricity sector (*EleOth*) sell their output to the peak electricity market (*Peak*). As the gas electricity industry (*EleGas*) is deemed to be selling into both markets, a share weighted allocation could be adopted.[129]

According to the ESAA, the electricity distribution industry (*ElectDist*) draws 90 percent of its electricity from the base electricity market and 10 percent from the peak electricity market. The black coal electricity sector supplies 65 percent of the base market's electricity requirements. A further 34 percent is sourced from the brown coal generators, and 1 percent from the gas electricity sector. Almost 85 percent of electricity sold into the peak market is sourced from hydro electricity. The renewable electricity industry supplies 8 percent of the peak market, and the gas electricity industry supplies the remaining 7 percent. Figure 7.2 uses a flow diagram to illustrate the possible disaggregation.

[129] The gas electricity industry sells its output into both the base and peak markets, depending on state of origin. For instance, *EleGas* in the NT of Australia forms part of the base market.

Figure 7.2

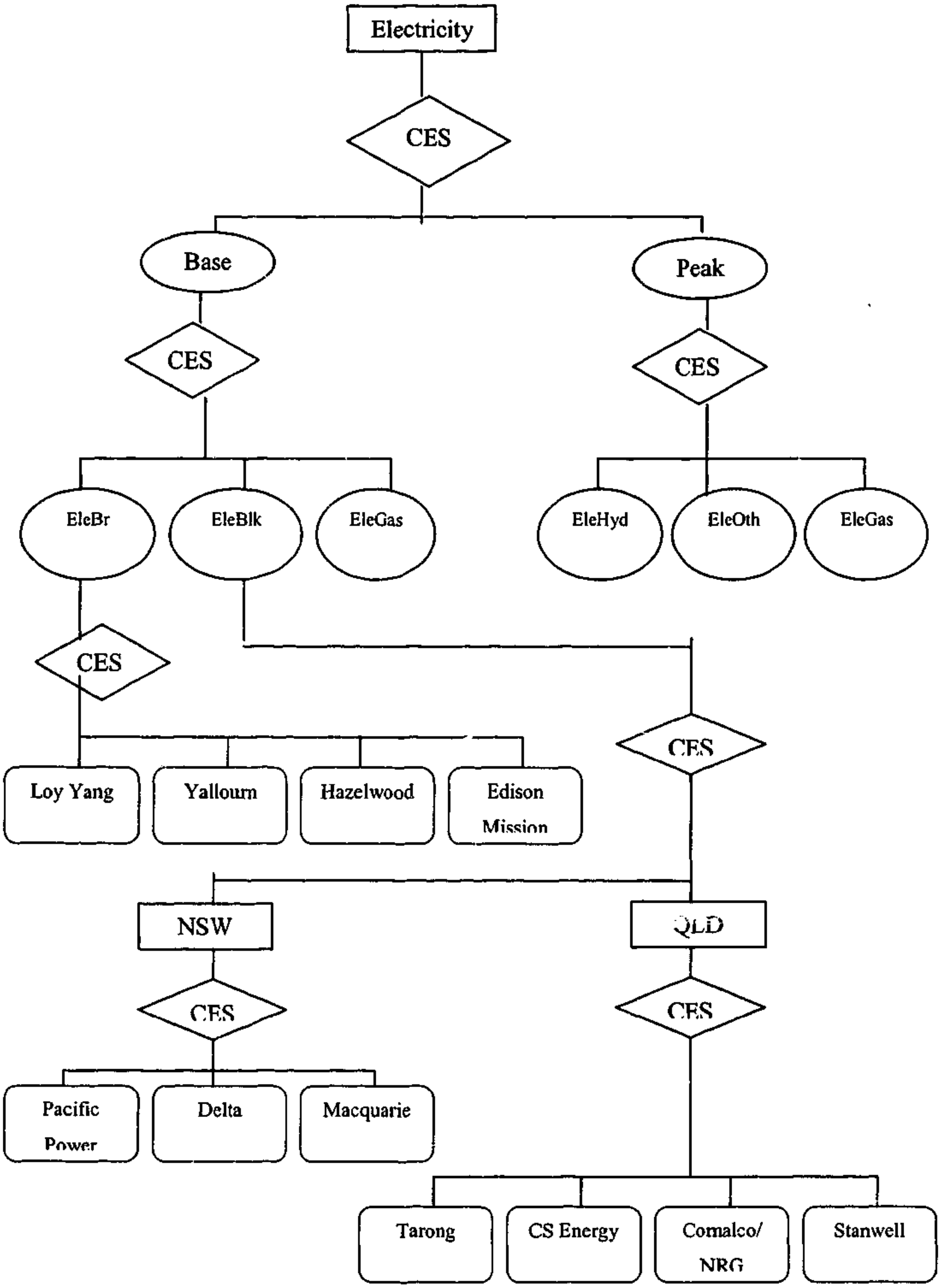

Electricity
CES
Base
Peak
CES
ElectGas
ElectOth
ElectHyd
CES
ElectBlk
ElectBr
ElectGas

Electricity Generator Disaggregation

In a similar fashion to the disaggregation of the brown coal electricity generating industry, other sources of electricity generation could also be disaggregated. The most obvious candidate is the black coal electricity generating sector (*EleBlk*). Data facilitating such a disaggregation is available in the same format as that used to disaggregate the brown coal electricity industry in this thesis. A flow diagram of the disaggregation (combined with the disaggregation of the base and peak electricity markets is shown in Figure 7.3).

Whilst beyond the scope of this thesis, disaggregation down to this lower tier would be of interest to the generators operating in the black coal electricity market. As these generators are predominantly State Government owned, the exercise would also be useful to the State Governments of NSW and QLD. Regional economic interest would also be found in statistical divisions such as the Hunter region of NSW.

Figure 7.3

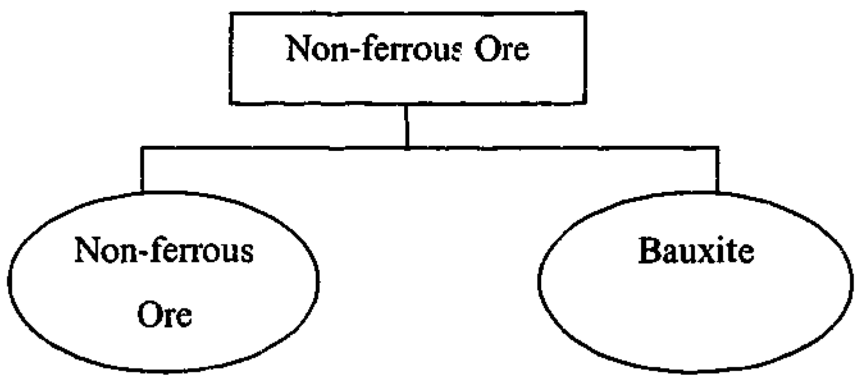


Electricity
CES
Base
Peak
CES
CES
EleBr
EleBlk
EleGas
EleHyd
EleOth
EleGas
CES
Loy Yang
Yallourn
Hazelwood
Edison Mission
CES
NSW
QLD
CES
CES
Pacific Power
Delta
Macquarie
Tarong
CS Energy
Comalco/ NRG
Stanwell

Non-ferrous Ore Industry

Further modifications could involve the disaggregation of the existing non-ferrous ore industry (*I13Nferrous*) in the MONASH-Electricity database. The non-ferrous ore industry consists of the mining activities bauxite, copper, gold, nickel, lead, silver and tin. The aim of the disaggregation would be to isolate the mining of bauxite from the rest of the industry (see Figure 7.4).

Figure 7.4



The data to facilitate the disaggregation could be sourced from the ABS publication *5215.0, Section 1302*. The publication provides a dollar figure for Australian production which can then be calculated as a share of total output for this industry group. A new industry known as bauxite (*Bauxite*) could be created. In accordance with the ABS publication, the bauxite industry would produce 9.5 percent of total non-ferrous ore industry output. The remaining 90.5 percent would be attributed to the remainder of the original non-ferrous ore industry (*NFerrous*). These shares could be used to disaggregate the original non-ferrous ore industry.

Manual modifications would have to be made to the data on domestic flows to current production. The new bauxite commodity should flow to the bauxite industry rather than to other metal ore activities, such as found in the rest of non-ferrous ore industry. To ensure that the overall percentage of bauxite activity in the aggregated industry is not over-represented, the allocated amount should be removed from the total.

7.2.2 CARBON SINKS

A description of carbon sinks and their role in reducing global greenhouse gas emissions was provided in Chapter three. A limitation of the existing database is that it does not account for CO_2 emissions from agriculture and it does not recognise sequestration from carbon sinks. Data on agriculture is available for the Australian economy and could be adapted to the MONASH-Electricity model if desired.

Incorporating carbon sinks into the MONASH-Electricity model is a more difficult task due to the nature of carbon sink accounting. Research could however be conducted into the nature of the forestry plantations existing in the Australian economy. A permit subsidy could be allocated based on the type of tree and the number of hectares. An entire thesis could be written on analysing the impact of carbon sinks on the Australian forestry sector.

A simpler method may be to offer a subsidy to the existing forestry industry in the MONASH-Electricity model. This industry would benefit from the introduction of greenhouse policy as it could sell its emission permits onto the domestic emission trading market.

There are regional implications of including carbon sinks in the model. Aside from the paper manufacturer Amcor, which is predominantly located in the La Trobe Valley, the remainder of the Gippsland forestry industry is located in East Gippsland. There are 1,007 people employed in the forestry sector in Gippsland and only 86 in the La Trobe Valley. If the simulation had taken into consideration the carbon sink benefits accruing to the forestry sector, an improvement in the economic activity of the Gippsland statistical division would be expected. A similar improvement would be experienced on a smaller scale in the La Trobe Valley but it would be more than offset by the collapsing electricity sector. The GRP gap between the two neighbouring regions would consequently be expected to widen.

7.2.3 HOUSEHOLD TWIST AWAY FROM CO_2 INTENSIVE COMMODITIES

Electricity consumers are likely to change their consumption patterns as more energy efficient products are introduced to the market. As discussed throughout the thesis, the main impact of the Australian Government's policy is to reduce the emission intensity of electricity generation.

A secondary long term impact of Australia's push toward lower emittance of greenhouse gases is that household and commercial users will begin to purchase more energy efficient goods and services. In the absence of new technology, both of these scenarios are likely to have a real impact upon the La Trobe Valley region as the demand for brown coal generated electricity inevitably falls.

There is anecdotal evidence to suggest that over time the household sector of the economy will make a conscience effort to substitute away from the consumption of CO_2 emission intensive goods. Marketing agencies are already drawing consumers focus to the relatively lower CO_2 emission properties of certain types of motor vehicles. For instance, advertising for the latest release of the Honda Accord in Australia is centred on the fact that it emits less CO_2 per kilometre driven, and is therefore more environmentally friendly than other motor vehicles on the market.

Most retailers in the Australian electricity industry have offered their consumers the option of purchasing 'green electricity'. Green electricity is electricity sourced from renewable energy sources such as hydro and wind generated power stations. As was explained in Chapter four, the physical flow of electricity does not occur between the hydro electricity station and the household, but rather flows into the national pool. The individual consumer who opts for green electricity may still receive electricity generated from a brown coal power station. The premium paid for green electricity enables the electricity retailer to purchase a greater amount of its electricity from the renewable energy source than it otherwise would under normal market conditions. In the current climate, renewable energy costs relatively more than fossil fuel generated electricity. This increased cost is passed onto those household who agree to purchase the green electricity.

The MONASH-Electricity model can incorporate a household twist in taste away from CO_2 emission intensive products, such as electricity, by lowering the variable for household consumption preferences in the forecasting closure.

7.2.4 RECOGNITION OF ADVANCED PRESSURISED FLUID BED COMBUSTION TECHNOLOGY

It has been assumed in the modelling component of the thesis that there are no technological advances that would change the level of CO_2 emissions from any of the generators operating in the NEM. Given the relatively short-run time frame of the simulations, this is a valid assumption. The long-run for the electricity industry is generally considered to be over 20 years. Within this time frame the introduction of new technology is feasible.

Section 4.4.1 highlighted the research currently being conducted by CRC Clean Power into new technologies capable of reducing the CO_2 emission levels of electricity generated from brown coal. The introduction of Advanced Pressurised Fluid Bed Combustion (APFBC) technology will enable the industry to generate electricity with a fraction of its current emission levels.

Future simulations over a longer time frame could incorporate this new technology. The shift in demand away from the brown coal generators as experienced in the short-run simulation could be reversed in a long-run analysis. The new technology must of course make allowances for improvements in the CO_2 emission levels of other generating techniques, such as black coal electricity generation, and for the advent of presently unknown methods of electricity generation.

7.2.4 ASPECTS FOR FURTHER CONSIDERATION

A Global Agreement

It is assumed that Australia is the only country to introduce greenhouse policy. In terms of Australia's current trading partners this may be a valid assumption. There are however likely to be terms of trade implications if it was assumed that other countries also implemented greenhouse policy mechanisms. Whilst it is beyond the scope of this thesis to incorporate the greenhouse response of individual countries in a national model such as MONASH-Electricity, this could be achieved by global models such as those discussed in Chapter two.

Size of the Statistical Division

One consideration when interpreting the results for the statistical divisions is the size of the region itself. Many of the statistical divisions cover a significant geographical area which may embody a number of different industry structures. This lack of concentration is particularly prevalent in Western Australia and South Australia. For instance, there is a significant amount of non-ferrous industry activity confined to a relatively small area of the Pilbura statistical division.

One method of alleviating this possible inconsistency is to perform further disaggregations of the initial database. As mentioned in Section 5.3.1, an earlier modification to facilitate the accurate placement of employees in a statistical division involved the disaggregation of the Gippsland region into two separate statistical divisions – La Trobe Valley and the rest of Gippsland. In light of greenhouse policy implications, the disaggregation was considered to be essential to analyse the economic impact upon that region where the electricity industry is based. Further disaggregations of this nature could be performed.

Further Industry Knowledge

The exposure of the modified database to key industry players such as the ESAA enabled inconsistencies to be identified prior to simulation analysis. For instance, although it is still included as part of the generation capacity of the State, the Geraldton Power Station in WA has not been operational for a number of years.

It is evident throughout the thesis that the introduction of greenhouse policy in the Australian economy will foster further reform in the NEM. A further extension of this work is to regularly update the MONASH-Electricity model and its database to incorporate such change. Industry knowledge and participation will assist in ensuring that the data is accurate.

BIBLIOGRAPHY

ABARE (1997), EU Climate Change Policies, ABARE Research Report 97.9, Appendix B, Canberra.

ABARE, (1992), Greenhouse Policies and the Australian Aluminium Industry, Canberra.

ABARE, (1996), The MEGABARE Model: Interim Documentation, Canberra, Australia.

ABARE, (1997), International Climate Change Policy: Economic Implications for Australia, Canberra, Australia.

ABARE, (1998), Australian Commodities, Canberra, Australia.

ABARE, (2000), The Australian Electricity Industry, ABARE Research Report 2000.7, Canberra.

ABS (1996), Census.

ABS (2000), Demography, Catalogue No. 3311.2.

ACIL Consulting, (2000), Aluminium and the Australian Economy – A Report to the Australian Aluminium Council, June.

Adams, P. and B.R. Parmenter, (1998), The Australian Coal Industry from 1997-98 to 2009-10: Analysis Using the MONASH Model, Centre of Policy Studies, Monash University, Melbourne.

Adams, P. and Dixon, P., (1995), Prospects for Australian Industries, States and Regions: 1993-94 to 2001-02, *Australian Bulletin of Labour*, Vol. 21, No. 2, South Australia, June.

Adams, P. and Parmenter, B.R., (1998), *Use of Computable General Equilibrium Models for Analysing the Impacts of Tourism.*, in *What is Tourism*, report published jointly by Tourism NSW and the Bureau of Tourism Research; August 10.

Adams, P.D., Horridge, J.M., and Parmenter, B.R. (2000a) Analysis of Greenhouse Policy using MMRF-Green, Working Paper, Centre of Policy Studies, Monash University, Melbourne.

Adams, P.D., Horridge, J.M., and Parmenter, B.R. (2000b) MMRF-Green: A Dynamic, Multi-sectoral, Multi-regional Model of Australia, Centre of Policy Studies, Monash University, Melbourne.

Adams, P.D., Horridge, J.M., and Parmenter, B.R. (2000c) Report on Modelling for a Consultancy Examining the Microeconomic Impacts of an Efficiency Standards Measure, Report for Allen Consulting and the AGO, Centre of Policy Studies, Monash University, Melbourne.

Allen Consulting Group, (2000) Greenhouse Emissions Trading, Report to the Victorian Department of Premier and Cabinet, Melbourne.

Allen, Ian., (1997), *Carbon Realities*, Australian Broadcasting Corporation.

Australian Aluminium Council, (1994), *Energy Efficiency, Greenhouse Policies and the Australian Aluminium Industry*, Canberra.

Australian Aluminium Council, (1994), *The Australian Aluminium Industry*, Canberra.

Australian Aluminium Council, (1997), *Greenhouse: What it means for the Australian Aluminium Industry*, Canberra.

Australian and New Zealand Standard Industrial Classification 1993 ANZSIC

Australian Greenhouse Office, (1998a), *Greenhouse Challenge Vegetation Sinks Workbook, Quantifying Carbon Sequestration in Vegetation Management Projects, Version 1.0,* Appendix B.

Australian Greenhouse Office, (1998b), AGO Website http://www.ago.gov.au

Australian Greenhouse Office, (1999a), National Emissions Trading: Issuing the permits, Discussion paper No. 2, Commonwealth of Australia, Canberra.

Australian Greenhouse Office, (1999b), National Emissions Trading: Crediting the carbon, Discussion paper No. 3, Commonwealth of Australia, Canberra.

Australian Greenhouse Office, (1999c), National Emissions Trading: Designing the market, Discussion paper No. 4, Commonwealth of Australia, Canberra.

Australian Greenhouse Office, (2000) Greenhouse Sinks and the Kyoto Protocol – An Issues Paper, Commonwealth of Australia, Canberra.

Babiker, M.H., Maskus, K.E., and Rutherford, T.F. (1997), Carbon Taxes and the Global Trading System, International Energy Workshop and Energy Modeling Forum Meeting at IIASA, June 23-25.

Balistreri, E.J. and Rutherford, T.F. (2000), Dynamic General Equilibrium Analysis At the state Level: Assessing the Economic Implications of the Kyoto Protocol, Economics Department Working Paper, University of Colorado.

Ballard, C., Goddeeris, J., and Kim, SK. (2001), Non-Homothetic Preferences and the Non-Environmental Effects of Environmental Taxes, Submitted to American Economic Review, Unpublished.

Birrell, B., (2001), Population Movement and Social Well Being in Gippsland, Paper for 'The Region Strikes Back' collection, Department of Geography and Environmental Science, Monash University, Melbourne.

Birrell, B., Dibden, J., and Wainer, J. (2000), Regional Victoria: Why the Bush is Hurting, Monash Regional Australia Project, Centre for Population and Urban Research, Monash University, Melbourne.

Blitzer, C.R., and Eckaus, R.S. (1986), Modeling Energy-Economy Interactions in Small Developing Countries: A Case Study of Sri Lanka, Journal of Policy Modeling, Vol. 8, No. 4.

Böhringer, C. (1999), Cooling down hot air: A global CGE analysis of Post-Kyoto carbon abatement strategies, Centre for European Economic Research, Discussion Paper No. 99-43.

Böhringer, C., and Rutherford, T.F., (1998), The Efficiency Costs of Voluntary Agreements in Environmental Policy, Unpublished.

Böhringer, C., Jensen, J., and Rutherford, T.F. (1999), Energy Market Projections and Differentiated Carbon Abatement in the European Union, Discussion Paper No. 99-11, ZEW Centre for European Economic Research.

Böhringer, C., Rutherford, T.F., and Vo, A. (1999), Global CO2 Emissions and Unilateral Action: Policy Implications of Induced Trade Effects, The International Journal of Global Energy Issues, 11(1-4), 18-22.

Bollen, J. Manders, T. and Timmer, H. (2000), Decomposing Carbon Leakage – an Analysis of the Kyoto Protocol, Paper presented to the Global Economic Analysis conference, Melbourne, June.

Boone, L. Hall, S. and Kemball-Cook, D. (1996), Endogenous Technical Progress in Fossil Fuel Demand: The Case of France, Journal of Policy Modelling, North Holland, Vol. 18, No. 2, April.

Born, P. (1996), Input-Output Analysis: Input of Energy, CO2, and Work to Produce Goods, Journal of Policy Modelling, North Holland, Vol. 18, No. 2, April.

Breuss, F. and Steininger, K. (1998), Biomass Energy Use to Reduce Climate Change: A General Equilibrium Analysis for Austria, Journal of Policy Modelling, North Holland, Vol. 20, No. 4, August.

Brockway, D. and Simpson, M. (1999), Potential Greenhouse Gas Emission Reductions from Future Lignite-Fired Power Generation in Victoria and South Australia, CRC Clean Power.

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

Bureau of Transport Economics, (1998), *Trading Greenhouse Emission: Some Australian Perspectives*, Canberra.

Commonwealth of Australia, (1992), National Greenhouse Response Strategy, *AGPS*, Canberra.

Commonwealth of Australia, (1997), *Future Directions for Australia's National Greenhouse Strategy*, Department of the Environment, Sport and Territories, for the Intergovernmental Committee for Ecologically Sustainable Development, Australia.

Conconi, P. (2001), Green and Producer Lobbies: Enemies or Allies?, Working Paper, Department of Economics, University of Warwick, UK.

Condon, T., Dahl, H., and Devarajan, S. (1986), Implementing a Computable General Equilibrium Model on GAMS: The Cameroon Model, DRD Discussion Paper, Report No. DRD290, The World Bank.

Conrad, K. and Henseler-Unger, I. (1986), Applied General Equilibrium Modeling for Long-Term Energy Policy in Germany, Journal of Policy Modeling, Vol. 8, No. 4.

Cornwell, A., Travis, J. and Gunasekera, D., (1997), *Framework for Greenhouse Emission Trading in Australia*, Industry Commission Staff Research Paper, AGPS, Canberra, December.

Cornwell, A., Travis, J. and Gunasekera, D., (1998) Essential Elements of Tradable Permit Schemes, Trading Greenhouse Emission: Some Australian Perspectives, Bureau of Transport Economics, Canberra.

CPB Netherlands Bureau for Economic Policy Analysis (1999), WorldScan, the Core Version, The Hague.

Cramton, P. (2000), A Review of Markets for Clean Air: The US Acid Rain Program, Journal of Economic Literature, Vol. 38, September, pp. 627-633.

CRC Clean Power, (2000), Cooperative Research Centre for Clean Power from Lignite, June.

Danoher, Edward. (1997), *Coal Can Maintain its Special Position*, Electricity Supply Magazine, Canberra.

Danoher, Edward. (1997), *Green Energy Deals Becoming the Vogue*, Electricity Supply Magazine, Canberra

Dellink, R. (2000), Dynamics in an Applied General Equilibrium Model with Pollution and Abatement, Paper presented to the Global Economic Analysis conference, Melbourne, June.

Department of Employment, Workplace Relations and Small Business, (2000), Small Area Labour Markets – Unemployment Rates, Economic and Labour Market Analysis Branch, Australia.

Department of Foreign Affairs and Trade, (1998),*Climate Change*, Canberra.

Devarajan, S., Lewis, J.D., and Robinson, S. (1991), From Stylied to Applied Models: Building Multisector CGE Models for Policy Analysis, Cambridge University Press.

Dixon, P.B., and Rimmer, M.T. (2000), Forecasting, Policy, History and Decomposition: The MONASH Model of the Australian Economy, Centre of Policy Studies, Monash University, Australia. Unpublished.

Dixon, P.B., B.R. Parmenter, and Rimmer, M., (1999), Macro-Economic and Industrial Impacts of Achieving a 2% Renewables Target financed by a Surcharge on the Price of Electricity, Centre of Policy Studies, Monash University.

Dixon, P.B., B.R. Parmenter, J. Sutton and D. Vincent, (1982), ORANI: A Multi-Sectoral Model of the Australian Economy, *North-Holland Publishing Company*, Amsterdam.

Dobes, L. Enting, I., and Mitchell, C. (1998), Trading Greenhouse Emission: Some Australian Perspectives, Bureau of Transport Economics, Canberra.

Edmonds, J. Scott, M. Roop, J. and MacCracken, C., (1999), International Emissions Trading and Global Climate Change: Impacts on the costs of greenhouse gas mitigation, Pew Center on Global Climate Change, USA.

Edwards, T.H. (1998), Modelling the Effects of Energy Market Distortions on the Costs of Carbon Abatement: Computable general equilibrium and partial equilibrium assessment, In Fossati, A. and Hutton, J.P. (Eds), Policy Simulations in the European Union, Routledge, Andover, UK.

Edwards, T.H. and Hutton, J.P., (1999), The effects of carbon taxation on carbon, nitrogen and sulphur pollutants in Europe: combining general equilibrium and integrated system approaches, Paper presented to the Policy Evaluation with Computable General Equilibrium Models conference, Genoa, Italy, October 29-30.

Edwards, T.H. and Hutton, J.P., (2001), Allocation of carbon permits within a country: a general equilibrium analysis of the United Kingdom, Energy Economics, Forthcoming publication.

Electricity Supply Association of Australia, *CMS Energy: growing in a world of opportunities, Electricity Supply Magazine*, (1997), Canberra.

Ellerman, D., Joskow, P.L., Schmalensee, R., Montero, J., and Bailey, E.M. (2000), Markets for Clean Air: The US Acid Rain Program, Cambridge University Press, ISBN 0521 660831.

Enzinger, S. (1999), The Australian Government's Greenhouse Policy – A Study of the Economic Impact Upon the La Trobe Valley Region, Paper presented to the Policy Evaluation with Computable General Equilibrium Models conference, Genoa, Italy, October 29-30.

Enzinger, S. and Jeffs, C., (2000), Economics of Forests as Carbon Sinks: An Australian Perspective, Journal of Forest Economics, Vol. 6, No. 3, The Swedish University of Agricultural Sciences, Sweden.

ESAA, (1999), Electricity Australia 1999, Gotham City Press, Sydney.

Fehr, H., Rosenberg, C., and Wiegard, W. (1995), Welfare Effects of Value-Added Tax Harmonisation in Europe, Springer.

Foster, B., and Homes, M. (1998), *Globalisation, Regionalisation and Localism Impacts on the Social and Economic Profile of Gippsland*, Gippsland Research and Information Service, Monash University.

Foster, B., Kazakevitch, G., and Stone, S., (1997), The Effect of Economic Restructuring on Population Movements, *Department of Immigration, Multicultural and Ethnic Affairs*, Canberra.

GenVic, (1994), Annual Report, Generation Victoria, Melbourne.

Gottinger, H.W. (1998), Greenhouse Gas Economics and Computable General Equilibrium, Journal of Policy Modeling, North Holland, Vol. 20, No. 5. Elsevier Science Inc.

Goulder, L.H. (1995), Environmental Taxation and the Double Dividend: A Reader's Guide, International Tax and Public Finance, Vol. 2, pp.157-183.

Goulder, L.H., Parry, W.H., and Burtraw, D. (1997), Revenue-raising versus other approaches to environmental protection: The critical significance of preexisting tax distortions, RAND Journal of Economics, Vol. 28, No. 4, pp. 708-731.

Goulder, L.H., Parry, W.H., Williams, R.C., and Burtraw, D. (1999), The cost-effectiveness of alternative instruments for environmental protection in a second-best setting, Journal of Public Economics, Vol. 72, No. 3, pp. 329-360.

Gray, C.B. and Rivkin, D.B., (1991) A No-Regrets Environmental Policy, *Foreign Policy*, pp. 47-65.

Greenhouse Challenge Office, (1998), *Key Points about Australian Greenhouse Emissions.*

Greenhouse Challenge, *Progress Report*, (1997).

Greenhouse Response Branch., (1998) A Simple Guide to the Kyoto Protocol and its Implications for the Forestry Sector, Department of Industry, *Science and Resources*, Vol. 10, No. 4, December.

Greenpeace, (1998), UN Framework Convention on Climate Change, Meeting of subsidiary bodies, Position Paper, June, Bonn.

GRIS - Gippsland Research and Information Service, (2000), Statistical Profile – Latrobe City, Monash University, Churchill.

Gunasekera, Don and Mwesigye, Deo., (1998) Prospects For Australian Industry Involvement in the Asia-Pacific Region with Clean Development Mechanisms, *Trading*

Greenhouse Emission: Some Australian Perspectives, Bureau of Transport Economics, Canberra, Chapter Seven, Page 82.

Hagan, Jim., (1998), Emissions Trading - Making It Work, *Trading Greenhouse Emission: Some Australian Perspectives*, Bureau of Transport Economics, Canberra, Chapter Five, Page 53.

Hamilton, Clive., (1998), *The evolution of the global market for greenhouse gas emission allowances*, The Australia Institute, Page 17.

Hancoh, G. (1975) Production and demand models with direct or indirect implicit additivity, Econometrica, Vol. 43, No. 3, pp. 395-420.

Hanoch, G. (1971) CRESH Production Functions, Econometrica, Vol. 39, No. 5, pp. 95-112.

Harris, Paul G., (1998), *The Overlooked Shift in American Policy on Climate Change*, Earth Times.

Harrison, W.J., and K.R. Pearson (1996), Computing Solutions for Large General Equilibrium Models Using GEMPACK, *Computational Economics*, Vol. 9, pp.83-127.

Harrison, W.J., and Pearson, K.R. (2000), An Introduction to GEMPACK, GEMPACK Document No. GPD-1 to GPD-5, Fifth Edition, Centre of Policy Studies and Impact Project, Melbourne.

Hazelwood Power, (1999), Annual Report, Melbourne.

Hertel, T.W. (ed.) (1997), Global Trade Analysis: Modeling and Applications, Cambridge University Press, Massachusetts, USA.

Higgs, Peter J., B.R. Parmenter and R.J. Rimmer, (1983), Modelling the Effects of Economy-Wide Shocks on a State Economy in a Federal System, Preliminary Working Paper No. OP-37, University of Melbourne, Melbourne.

Howard, J., (1997), Safeguarding the Future: Australia's Response to Climate Change, *Commonwealth of Australia,* Canberra.

Industry Commission (1991), Costs and Benefits of Reducing Greenhouse Gas Emissions, Report no. 15, AGPS, Canberra.

Jensen, J. (1998), How Valuable are Delayed Cutbacks in Danish Carbon Emissions?, Ministry of Business and Industry, Government of Denmark, Copenhagen.

Jorgenson, D. Goettle, R. Wilcoxen, P. and Ho, M.S., (2000), The role of Substitution in understanding the costs of Climate Change Policy, Pew Center on Global Climate Change, USA.

Kahn, James R. (1997) The Economic Approach to Environmental and Natural Resources, Second Edition, The Dryden Press, U.S.A.

Kanik, Myron., (1997), *CEPA Disappointed with Kyoto Agreement*, Canadian Energy Pipeline Association.

Latrobe Valley Task Force, (1996), *Meeting the Greenhouse Challenge*, Australia.

Latrobe Valley Task Force, (1998), *The Victorian Brown Coal Generators*, Australia.

Li, P.C., Huang, C.H., and Hsu, S.H. (2000), Energy Substitution in CGE Modeling Using the "Technology Bundle" Approach: The Case of Taiwan, Paper presented to the Global Economic Analysis conference, Melbourne, June.

Liew, L.H. (1982), *Regional Disaggregation of a National Economic Model: The 'Bottoms-Up' Approach*, Preliminary Working Paper No. OP-34, University of Melbourne, Melbourne.

GRIB (1999), LRC/GRIB Latrobe Region Industry and Employment Survey, Churchill, Australia.

Maclaren, Piers., (1996) Plantation Forestry: Its Role as a Carbon Sink, in CSIRO Greenhouse Coping with Climate Change, pp. 417-436.

Manne, A.S., and Richels, R.G. (1992), Buying Greenhouse Insurance: The Economic Cost of CO2 Emission Levels, Cambridge: MIT Press.

Mathiesen, L. and Håkonsen, L. (1999), Comparing the cost of emission reductions in first and second-best economies, Department of Economics working paper, University of California.

McDonald, Meg., (1997), The International Emission Trading System: Australia's Perspective.

McDougall, R.A., (1993a), Energy Taxes and Greenhouse Gas Emissions in Australia, Centre of Policy Studies, *General Paper No. G-104*, Monash University.

McDougall, R.A., (1993b), Short-Run Effects of a Carbon Tax, Centre of Policy Studies, *General Paper No. G-100*, Monash University.

McKibbin Software Group 2000, The G-Cubed Multi-country Model: Specification, Parameters, Data and Variable Definitions, http://www.msgpl.com.au/msgpl/msghome.htm

McKibbin, W.J. (2001), Moving Beyond Kyoto, Policy Brief No. 66, Brookings Institution, http://www.brook.edu/comm/policybriefs/pb066/pb66.htm

McKibbin, W.J. and Wilcoxen, P.J. (1997a), A Better Way to Slow Global Climate Change, Brookings Policy Brief No. 17, The Brookings Institution, Washington D.C., June.

McKibbin, W.J. and Wilcoxen, P.J. (1997b), Salvaging the Kyoto Climate Change Negotiations, Brookings Policy Brief No. 27, The Brookings Institution, Washington D.C., November.

McKibbin, W.J. and Wilcoxen, P.J. (1999), The theoretical and empirical structure of the G-Cubed model, Economic Modelling, Vol. 16, No. 1, pp.123-48.

McKibbin, W.J. and Wilcoxen, P.J. (2000), Beyond the Kyoto Protocol, CRUGE International Symposium and UN University Workshop, Japan, March.

McKibbin, W.J. and Wilcoxen, P.J. (2000b), Designing a Realistic Climate Change Policy that includes Developing Countries, The Brookings Institution, Washington D.C.

McKibbin, Warwick J., (1998), The McKibbin-Wilcoxen Proposal for Global Greenhouse Abatement, *Trading Greenhouse Emission: Some Australian Perspectives*, Bureau of Transport Economics, Canberra, Chapter Four.

Meagher, G.A. and B.R. Parmenter, (1990), ORANI-NT: A Multisectoral Model of the Northern Territory Economy, Australian National University, *North Australia Research Unit*, Australia.

Meagher, G.A., (1988), The Input-Output Database for the ORANI-NT Model: Sources and Methods, *Research Paper No.4/1988*, Institute of Applied Economic and Social Research, University of Melbourne, Melbourne.

Mitchell, Chris., (1997), *Greenhouse and the Science of Uncertainty*, Australian Broadcasting Corporation.

National Resources and Defence Council, (1998), *Global Warming: The Kyoto Protocol.*

NEMMCO, (1998), An Introduction to Australia's National Electricity Market, Canberra.

NEMMCO, (2001), Australia's National Electricity Market Prices, http://www.nemmco.com.au/.

O'Sullivan, (1997), *The Costs of Kyoto: The Implications of Climate Change Policy*

Parmenter, B.R., (1982), Inter-Industry Analysis: The ORANI Model of Australia's Industrial Structure, Chapter Five in Webb, L.R. and Allan, R.H. eds., *Industrial Economics - Australian Studies*, George Allen & Unwin Australia, North Sydney.

Parmenter, B.R., K.R. Pearson and R. Jagielski, (1985) Bottoms-up, Tops-down and Hybrid Methods for Regionalizing Computable General Equilibrium Models: Some Comparisons, in R. Glass, ed., *Papers of the Australia and New Zealand Section of the Regional Science Association*, Melbourne.

Parry, I., Williams, R., and Goulder, L. (1997), When can carbon abatement policies increase welfare? The fundamental role of distorted factor markets, NBER Working Paper No. W5967.

Pearce, D.W. (1991), The role of carbon taxes in adjusting to global warming, Economic Journal, 101, pp. 938-948.

Pears, Alan., (1997), *Forward Thinking*, Australian Broadcasting Corporation.

Pench, A. (1999), Ecotaxes in Italy: Evidence from a Multi Country Model of the European Union, Paper presented to the Policy Evaluation with Computable General Equilibrium Models conference, Genoa, Italy, October 29-30.

Pezzey, J.C.V. and Lambie, N.R. (2001), Computable general equilibrium models for evaluating domestic greenhouse policies in Australia: A comparative analysis, Report to the Productivity Commission, AusInfo, Canberra.

PowerGen, (1998), *Energy 2020.*

Proost, S. and Van Regemorter, D. (1993), Policy Modelling and the Interactions Environment - Economy in the field of energy in Europe – past experience and skeleton for new models, Center for Economic Studies, Belgium.

Rutherford, T., Montgomery, D. and Bernstein, P. (1998), Carbon Abatement, Permit Trading and International Trade: Comparative Statics Results for 2010, Paper presented to the First World Congress of Environmental Economists, Italy, June 25-27.

Rutherford, T.F., Böhringer, C., and Pahlke, A. (1997), Environmental Tax Reforms and the Prospects for a Double Dividend: An Intertemporal General Equilibrium Analysis for Germany, http://nash.colorado.edu/tomruth/germany/ecotax.html, Accessed March 2001.

Rutherford, T.F., Böhringer, C., and Pahlke, A. (1999), Carbon Abatement, Revenue Recycling and Intergenerational Burden Sharing, Proceedings of the KNAW colloquium, P.J.J. Herings, G. van der Laan and A.J.J. Talman, eds., North-Holland, Amsterdam, pp. 305-326.

SECV, (1985-1992), Annual Reports, Melbourne.

Sturgiss, Robert., (1988), Department of Foreign Affairs, Australian Government, pers. comm. May.

Tate, Alan., (1997), *Kyoto Diary*, Australian Broadcasting Corporation.

U.S. Department of Energy, (1994), *Carbon Emitters*, Trends.

UNFCCC (1997), United Nations Convention on Climate Change, Kyoto Protocol to the United Nations Framework Convention on Climate Change, Kyoto.

UNFCCC (2001), UNFCCC Website http://www.unfccc.de/, Accessed frequently between 1998 and 2001.

Uri, N.D. and Boyd, R. (1999), A note on the Economic Impact of Higher Gasoline and Electricity Prices in Mexico, Journal of Policy Modelling, North Holland, Vol. 21, No. 4, July.

Victorian Department of Infrastructure, (2000), *Victorian Future*

Vlachou, A., Vassos, S. and Andrikopoulos, A. (1996), Energy and Environment: Reducing CO2 Emissions from the Electric Power Industry, Journal of Policy Modelling, North Holland, Vol. 18, No. 4, August.

Weyant, J.P., (2000), An Introduction to the Economics of Climate Change Policy, The Pew Center on Global Climate Change, US.

Weyant, J.P., and Hill, J.N. (1999), Introduction and Overview to Special Issue of The Energy Journal, Weyant, J.P. eds.

Wooders, M. and Zissimos, B., (2001), The efficiency, equity and politics of emissions permit trading, Working Paper, Department of Economics, University of Warwick, UK.

Xie, J. and Saltzman, S. (2000), Environmental Policy Analysis: An Environmental Computable General-Equilibrium Approach for Developing Countries, Journal of Policy Modeling, Vol. 22, No. 4, pp. 453-489.