GREENHOUSE AND LA TROBE VALLEY ENERGY

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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 this paper is the electricity industry which is responsible for over 20 per cent 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.

Results are derived using the MONASH computable general equilibrium (CGE) model of the Australian economy. The MONASH model has been modified to include an additional statistical division to produce results for the La Trobe Valley region of Victoria.

1. INTRODUCTION

The La Trobe Valley is a region located in the State of Victoria in south-east Australia. The La Trobe Valley is situated approximately 150 kilometres east of Melbourne, Victoria's capital. A population of just over 70,000 resides mainly in the region's urban centres of Traralgon, Moe and Morwell. One of the most significant features of the La Trobe Valley is the electricity power stations which 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. The states currently use the national grid in a limited capacity as it will not be fully operational until late 2000. At that time most commercial and some domestic electricity consumers will be able to choose their supplier.

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. In 1997, at the Kyoto Climate Change Conference, the Australian government agreed to reduce its greenhouse gas emissions. Although the Australian government has not set a firm policy agenda to date, most of the discussion is focused on market-based instruments, such as a tax on carbon dioxide. One thing is certain, at least part of any increase in costs to the electricity industry as a result of greenhouse policy will be passed onto consumers as an increase in the price of electricity.

This paper is the first step in a series of studies designed to assess the impact of a greenhouse policy upon the La Trobe Valley region. Stage one involves simulating the effect of a tax on electricity and evaluating the effects on the La Trobe Valley region.

Section 2 of the paper outlines the agreement entered into by developed nations at the Kyoto Climate Change Conference. The current position of the Australian government's greenhouse policy is also discussed in Section 2. Section 3 gives an overview of the Victorian ESI and the La Trobe Valley.

The methodology used is discussed in Section 4. The results are derived using the MONASH computable general equilibrium (CGE) model of the Australian economy, developed by the Centre of Policy Studies at Monash University. 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. A tops-down modelling approach is employed.

The simulation results are presented in Section 5. Section 6 discusses further model modifications to disaggregate the electricity supply industry.

Section 7 outlines areas for further research required for completion of the project.

2. GREENHOUSE POLICY

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% by 2008-2012. 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 per cent on the 1990 base year level (Department of Foreign Affairs and Trade 1998). Australia's original projection of emissions growth was 43% above 1990 levels by 2008-2012 (Ibid, p.3). According to Australia's second national communication to the FCCC Australia's business-as-usual emissions in 1990 were 380Mt (Sturgiss 1998).

Other industrialised nations such as Japan and the United States face more stringent reductions and have agreed to reduce their emissions by 6 and 7 per cent respectively. Australia, which is the 16th largest emitter by volume of carbon dioxide (CO_2) and the 2nd 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 Australia would be disadvantaged by a uniform target relative to other developed nations such as those in the European Community. The Australian government's strong opposition to the uniform targets at Kyoto was based on the fact that as the world's largest coal exporter, the third largest aluminum exporter, and one of the largest energy exporters amongst OECD countries, it would incur a higher cost as these areas of export strength are CO_2 emission intensive.

Whilst the Australian government is in the process of developing its greenhouse policy, a market-based instrument such as a carbon tax is the most likely option for meeting the Kyoto target. Market-based instruments are generally more cost-effective as the burden of reducing emissions is shared across those polluters who are able to reduce emissions at the least cost (Cornwell, Travis and Gunasekera 1997). One likely consequence of a market-based policy on CO_2 emitters is that the price of electricity will rise.

3. VICTORIAN ELECTRICITY SUPPLY INDUSTRY AND THE LA TROBE VALLEY

The Victorian ESI is almost entirely located in the La Trobe Valley region in Eastern Victoria. The La Trobe region is part of greater Gippsland, which relies on its wealth of natural resources for its economic foundation. Natural-resource based industries fostering economic growth in Gippsland include electricity supply, forestry, paper manufacturing, and agriculture. Despite significant restructuring during this decade, the ESI remains to be one of the most important industries in the region, although it is no longer the largest employer.

Almost all of Victoria's electricity supply comes from the La Trobe Valley brown coal generators. The five brown coal generators in the region are Loy Yang Power, Hazelwood Power, Edison Mission Energy, Yallourn Energy and Energy Brix Australia. Collectively the generators supply 90 per cent of Victoria's total power needs (Latrobe Valley Task Force 1996). Based on current demand, the La Trobe Valley has enough brown coal reserves to supply the whole of Victoria for at least another 400 years (Ibid).

In the original version of the MONASH-MRES model (discussed in Section 4), 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. This paper involved a modification to the regional component of the MONASH-MRES model. 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. Data sources used to disaggregate the existing Gippsland region in the MONASH model into two separate statistical divisions included: Employed persons in Local Government Area La Trobe Shire – 1996 Census; Statistical Profile La Trobe Shire 1997; and ABS Regional Statistics Victoria 1314.2. With the addition of the La Trobe Valley, there are currently 56 Statistical divisions in the model.

The main difference between the La Trobe Valley and the Rest of Gippsland is the importance of the electricity industry. As Table 1 shows, over 11% of total employment in the La Trobe Valley region is in the Electricity, Gas and Water Supply sector. Whereas only 2% of total employment in the Rest of Gippsland is found in this sector. Hence, the impact of a greenhouse policy upon the electricity industry will have a greater economic bearing on the La Trobe Valley.

Table 1. Industry Shares in Total Employment[1]

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

4. MONASH MODEL

The research uses computable general equilibrium modelling (CGE) to analyse the economic impact of a greenhouse policy upon the electricity industry and the La Trobe Valley. The CGE model employed is the MONASH model of the Australian economy. The MONASH model is a dynamic model which has been developed by the Centre of Policy Studies at Monash University.

[1] Occupation and Industry Statistics – ABS Regional Statistics Victoria 1314.2.

Each MONASH simulation produces year-by-year projections for the economy over the period to 2010 under a particular set of assumptions. First we compute a base forecast which excludes the policy shock. Typically the base case includes a number of economic forecasts from external sources.[2] Further inclusions in the base case 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.[3] 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 we can deduce the effects on the economy of the policy shock (Dixon, Parmenter and Rimmer 1999 p.1). We report the differences between the two runs as explicit percentage deviations from the base case.

The policy shock reported in Section 5, is an increase in the power of the tax on electricity sales. 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 (Ibid). The electricity tax is placed on commodity *C86 Electricity*.

There are shortcomings of the current MONASH model which affect the results for a simulation involving the electricity industry. One of the limitations is that the current model does not have a mechanism for dealing with fuel substitution. The electricity industry is prevented from substituting between fuels, and therefore faces a fixed bundle of inputs. The fact that there is no fuel substitution is the reason for placing a tax on electricity in the first stage of modelling the impact of greenhouse upon the La Trobe Valley region, rather than on CO_2.

Another limitation is that those industries which use electricity as an input to production cannot substitute away from it when the tax increases the cost of purchasing electricity. As a consequence, the results reported in Section 5 of this paper are more conservative for the electricity industry than they would be if fuel substitution was incorporated into the MONASH model. The household sector can substitute away from electricity as the price rises, however the low elasticity of substitution in the model limits this. Section 6 discusses how these limitations are overcome.

The mechanisms included in the model allow the electricity tax to raise the price of electricity intensive commodities relative to other commodities. This has ramifications for international trade and the household sectors of the economy, as will be shown in Section 5.

4.1 Regional Modelling Methodology

"MONASH-MRES is a tops-down regional disaggregation facility based on the ORANI regional equation system described in Dixon, Parmenter, Sutton and Vincent. 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 p.90).

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[2] Sources for Australian economic modelling include:

- Macroeconomic forecasts from Access Economics;
- Forecasts of foreign-currency prices and volumes of agricultural and mineral exports from the Australian Bureau of Agricultural and Resource Economics (ABARE);
- Forecasts of international tourist arrivals from the Bureau of Tourism Research (BTR); and
- Forecasts of industry-policy change from the Industry Commission. (Dixon, Parmenter and Rimmer 1999)

3 Assumptions relating to the electricity industry included in the base case are: coal-saving technical change in the electricity generation at an average annual rate of about 1.9 per cent; and primary-factor-saving technical change in electricity generation at an average annual rate of about 4.15 per cent. Partly offsetting the saving of primary factors is an increase in the usage (per unit of electricity generated) of services such as communication and financial 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).

At both the State and Statistical division level, the 115 commodities used in the MONASH 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 (Ibid). 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 (Ibid).

Electricity is currently classified as a *local* commodity at the State level.[4] Hence, the model assumes that all of Victoria's demand for electricity is satisfied from Victoria's supply of electricity. The incorporation of the National Electricity GRID in the MONASH model will change this classification for future simulations. 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 exports electricity to most other regions, which are large importers of the commodity.

5. **SIMULATION: Electricity Tax**

To analyse the impact of the type of measures likely to be included in the Australian government's greenhouse policy, a generic simulation was performed. Section 5 discusses the results of an illustrative experiment to predict how a broad greenhouse policy implemented at the macro level impacts upon the electricity sector of the economy, and then upon the La Trobe region. The simulation involves a tax on electricity sales which is representative of a carbon tax.

The simulation introduced a uniform 50% increase in the powers of taxes applying to all domestic sales of electricity. The imposition of the tax increase on *C86 Electricity* means that all users of this commodity face an increase in its price. Consumers of electricity include the household sector, as well as industries who use it as an intermediate input.

The simulation is revenue neutralised by a decrease in the aggregate income tax collected by the government.[5]

The mechanisms resulting from the increase in the price of electricity are:

- exports of electricity-intensive commodities fall as their price rises;
- imports of electricity-intensive commodities rise as domestic consumers opt for the cheaper alternative; and
- households substitute away from electricity-intensive goods.

The implication of this policy shock is a contraction of *I84 Electricity* at the national level which filters down to the state and regional levels.

There were two main factors which determine the macroeconomic results for this simulation. The first is the electricity tax which restricts the growth of many sectors of the economy. Electricity intensive

4 The classification of electricity as a local commodity at the State level will be altered in future simulations. In forthcoming simulations the existence of the national electricity grid will be taken into consideration by classifying electricity as a national commodity. The full operation of the national grid will allow both domestic and commercial consumers to purchase electricity from across state borders.

5 One possibility is that the government collects the electricity tax and then redistributes it to compensate those industries which have been most affected. Such compensation could be in the form of payments to the electricity sector, or funding research projects into renewable technology. Later modifications to the model may encompass these scenarios.

industries such as non-ferrous metals, experience an increase in their costs of production and consequently become less competitive, especially on the international market.

The second influence on the macroeconomic story is that the closure is set up so that movements in the balance of trade reconcile model-determined movements in Gross National Expenditure (GNE) with Gross Domestic Product (GDP), (Dixon, Parmenter and Rimmer 1999). The results shown on Chart 1 indicate that the model driven percentage changes in GDP and GNE are different. The model reconciles this difference with a balance of trade surplus, which is depicted as a rise in the Balance of Trade (BT) to GDP ratio. Chart 1 further shows the real devaluation in the Australian dollar which stimulates exports and lowers the volume of imports.

i *Employment results are a reflection of the areas of the economy which are being stimulated.*

Chart 2 shows the deviation-from-base path of employment. Employment falls in the first five years of the policy shock due to the factor intensity of the industries which gain/lose from the electricity tax.

The employment results are driven largely by the factor intensity of the expanding and contracting industries in the economy. Chart 4 shows the percentage-deviation-from-base output results for those industries who contract after the increase in the tax on electricity. Many of these industries, such as *I105 Public Administration* and *I88 Other Buildings*, are labour-intensive. Chart 5 shows the percentage-deviation-from-base output results for those industries who are expanding. Industries in this group are generally capital-intensive. The contraction in the labour-intensive industries decreases employment relatively more than the expanding industries increase employment.

In 2001 employment increases toward control as the wage-adjustment mechanism in MONASH alleviates the impact of the tax shock. In the closure we assume that workers respond to the real after-tax wage rates. According to the labour-market specification in MONASH, if a deviation shock moves employment below its base-case value, real wage rates gradually decrease, eliminating the initial employment response after about five years (Ibid). We see the wage-mechanism in place in Chart 2. The slight fall in employment is followed by a slight fall in the real post-tax wage. As employment falls, employees are willing to take a reduction in their wage to increase employment back toward control.

Whilst employees concentrate on the post-tax wage, employers are concerned with the pre-tax real wage. Chart 2 shows a large decrease in the pre-tax real wage, due to the revenue neutralising reduction in income tax imposed on the model.

ii *Results for real GDP are driven largely by the capital stock*

Chart 3 shows the deviation-from-base paths for real GDP, aggregate employment and the aggregate capital stock. In the first year, GDP is determined by employment because the capital stock is fixed. The industries being stimulated are capital intensive (point *i* above), but in the first year if industries want to expand they are forced to use more labour.

The electricity tax contracts investment in most industry sectors of the economy, therefore reducing the capital stock after the first year. The capital-labour ratio decreases as labour becomes more attractive as the real wage falls (point *i* above). Demand for capital declines as labour becomes relatively cheaper due to the fall in the real wage rate (Chart 2). The decline in the capital stock is responsible for the fall in GDP.

We can see the trend in Chart 3 that when the capital stock is weak relative to employment, the path of real GDP tends to be below the path of employment.

iii *Consumption and Government Expenditure Results determined by the Closure*

The consumption function operates so that nominal consumption moves with nominal GDP. The increase in the tax on electricity pushes up the Consumer Price Index (CPI) relative to the price of GDP. The price of GDP falls by more than the price of the CPI because the electricity tax impacts heavily upon household consumption goods, such as retail trade, indirectly. Even though consumers' electricity costs are rising, they do not demand a wage rise as they are concerned with the post-tax wage which has remained relatively strong due to the income tax cut. In short, we have not allowed consumers to spend more even though the price of household goods and services have risen.

Government expenditure has also been tied to real GNE. Both consumption and government expenditure show declines in their deviation-from-base paths.

iv Gains and Losses for Industry Sectors are Consistent with the Macroeconomic Results

There are both direct and indirect impacts of the electricity tax upon industries. The industry results depend upon whether:

- Electricity is an important part of an industry's costs,
- The industry is price sensitive.

Domestic industries who compete on the international market are price sensitive. If the electricity tax raises the domestic price of a commodity, imports will be used as a cheaper substitute. Likewise, exports will increase if a depreciation in the Australian dollar makes them more competitive. Those industries which sell to the household sector will also be price sensitive as households can substitute between domestic goods.

v Industry Losers

Electricity intensive industries tend to experience a decline in their activity levels in the deviation-from-base paths. Chart 4 shows the deviation-from-base paths for those industries who reduce their output levels after the electricity tax. 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 depreciation of the Australian dollar stimulated exports and prevented the results for this group of industries from being worse.

The electricity industry itself contracts as demand for its commodity *C86 Electricity* falls. Further, the costs of the electricity industry rise as it is uses a considerable amount of electricity as an intermediate input (52% of its total costs). In Chart 4, the output of *I84 Electricity* does not fall to the same level as *I64 Non-ferrous* metals as the limitations of the model provide a low elasticity of demand for electricity.

Additional industry losers include *I65 Structural, I85 Gas and I88 Other Buildings*. *I85 Gas* is town gas which mainly sells to the household sector. As aggregate consumption is falling, demand for town gas will fall. *C87 Gas* is also sold to the electricity industry and the non-ferrous industry, both of which are contracting.

I65 Structural is an important component of electricity investment (14% of *I84 Electricity's* total domestic investment). Investment in *I84 Electricity* collapses in line with the reduction in the industry's activity level. As investment in electricity falls, industries such as *I65 Structural* face a reduction in demand for their commodity, and consequently reduce their output.

I88 Other Building is also used as an input to investment in electricity (67% of *I84 Electricity's* total domestic investment). Chart 4 shows a reduction in the activity level for this industry. The result for this industry is not as negative as may have been expected as it sells its output to the expanding hotel and rail transport industries.

Service based industries such as *I105 Public Administration* contract in response to the decrease in domestic demand at the macro level.

vi Industry Gainers

The industries which gain from an increase in the power of the tax on electricity are all exposed to international competition. Export orientated and import competing industries benefit from the balance of trade surplus and the real exchange-rate depreciation. Chart 5 shows the deviation-from-base paths of those traditional export orientated industries who are being stimulated by the tax shock. These industries are not electricity intensive and therefore do not have to incur the burden of the increased costs.

vii Results for the Statistical Division – La Trobe Valley

As mentioned above, the main compositional difference between the Gippsland and La Trobe Statistical divisions in the MONASH model is the importance of the electricity industry. Chart 6 shows the deviation-from-base paths of Gross State Product (GSP) for Victoria, and Gross Regional Product (GRP) for Gippsland and the La Trobe Valley. The result for Gippsland shows a slight fall in deviation-from-base GRP whereas the result for La Trobe Valley is considerably worse. As the simulation uses a tops-down model, the La Trobe Valley's economy contracts following the collapse of the electricity industry at the national level. Relative to Gippsland, the La Trobe Valley has a higher percentage of its workforce employed in the electricity sector. This reiterates the importance of separating the La Trobe Valley region from greater Gippsland.

The industry results at the Statistical division level mirror those found at the macro level. The industry gainers were the non-electricity intensive exporters, whilst the losers included electricity intensive industries such as *I64 Non-ferrous metals, I88 Other Buildings*, and *I84 Electricity*.

The main industry base in the La Trobe Valley region experienced a decline in its deviation-from-base output. Chart 7 shows the main industries of *I84 Electricity, I90 Retail Trade, I103 Other Finance, I107 Health, and I108 Education*. Apart from *I84 Electricity*, the rest of these industries were classified as *local-region* at the Statistical division level. The collapse of the *national-region* electricity industry was multiplied through the regional economy, reducing the growth rates of the *local-region* industries.

The conclusion drawn from this simulation is that the imposition of a greenhouse policy such as a carbon tax upon the electricity sector of the economy will be detrimental to the La Trobe Valley region. The results indicate that the tax 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.

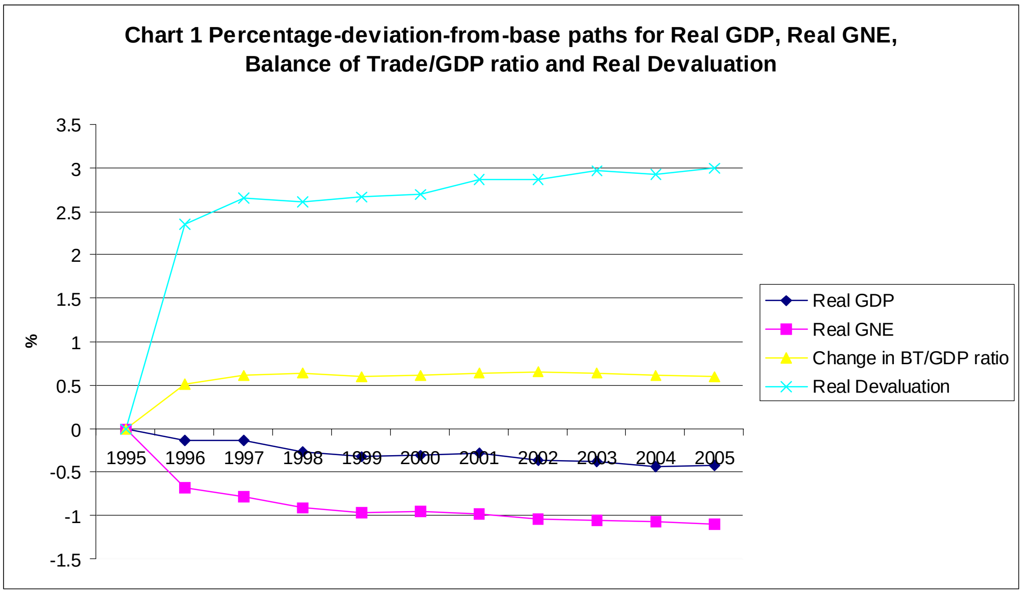


Chart 1 Percentage-deviation-from-base paths for Real GDP, Real GNE, Balance of Trade/GDP ratio and Real Devaluation
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Real GDP
Real GNE
Change in BT/GDP ratio
Real Devaluation

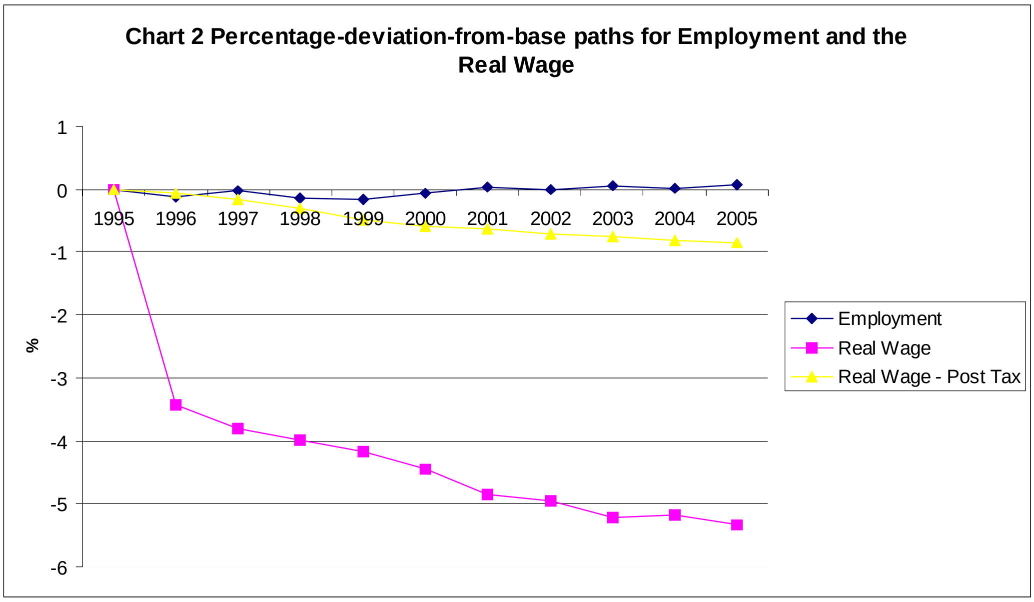


Chart 2 Percentage-deviation-from-base paths for Employment and the Real Wage
1
0
-1
-2
-3
-4
-5
-6
%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Employment
Real Wage
Real Wage - Post Tax

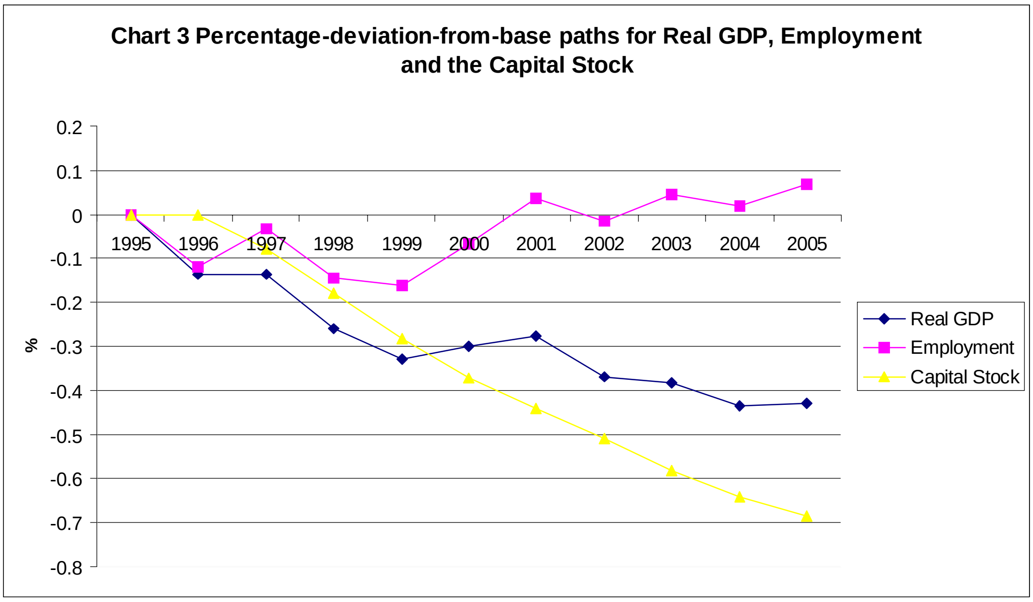


Chart 3 Percentage-deviation-from-base paths for Real GDP, Employment and the Capital Stock
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
%
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Real GDP
Employment
Capital Stock

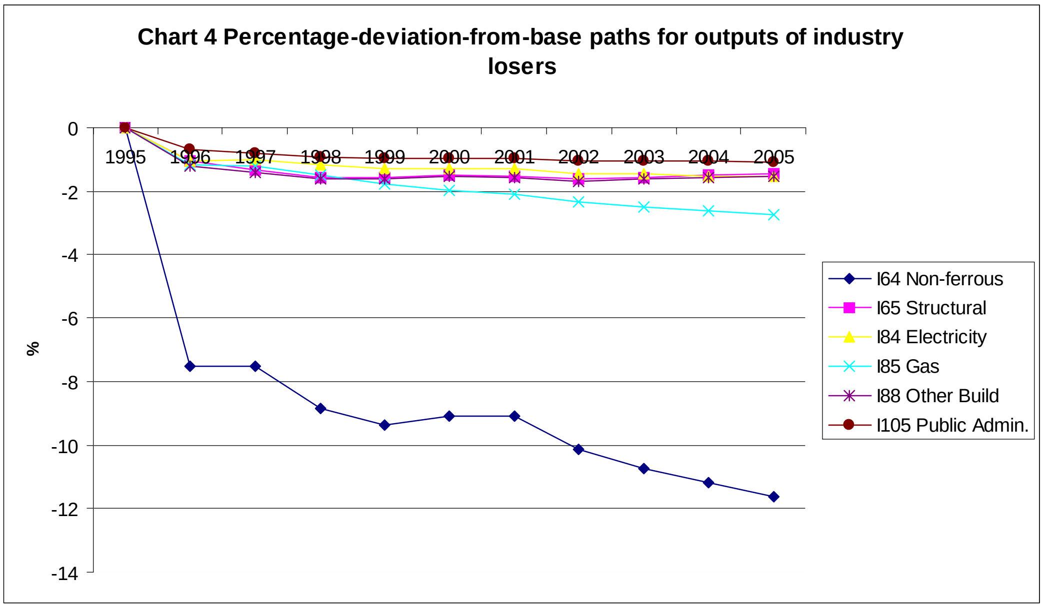


Chart 4 Percentage-deviation-from-base paths for outputs of industry losers
%
0
-2
-4
-6
-8
-10
-12
-14
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
I64 Non-ferrous
I65 Structural
I84 Electricity
I85 Gas
I88 Other Build
I105 Public Admin.

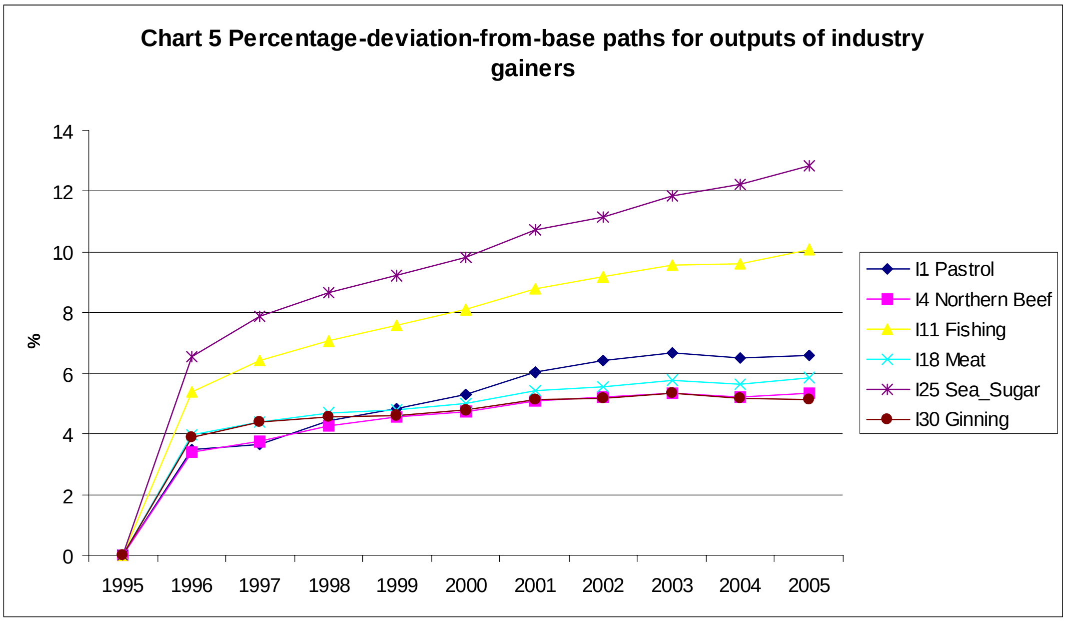


Chart 5 Percentage-deviation-from-base paths for outputs of industry gainers
%
14
12
10
8
6
4
2
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
I1 Pastrol
I4 Northern Beef
I11 Fishing
I18 Meat
I25 Sea_Sugar
I30 Ginning

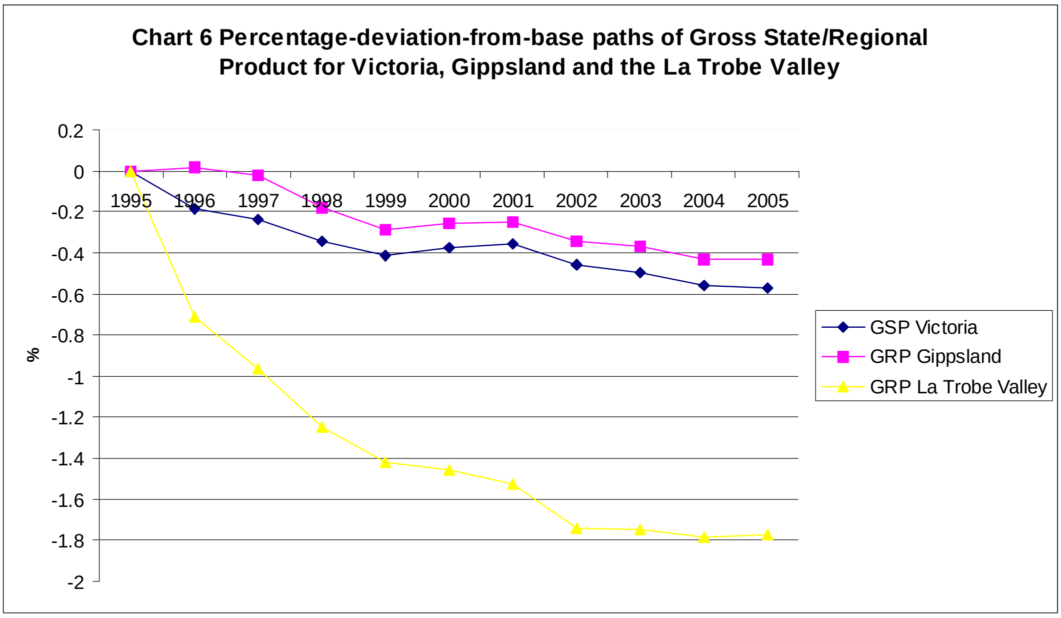
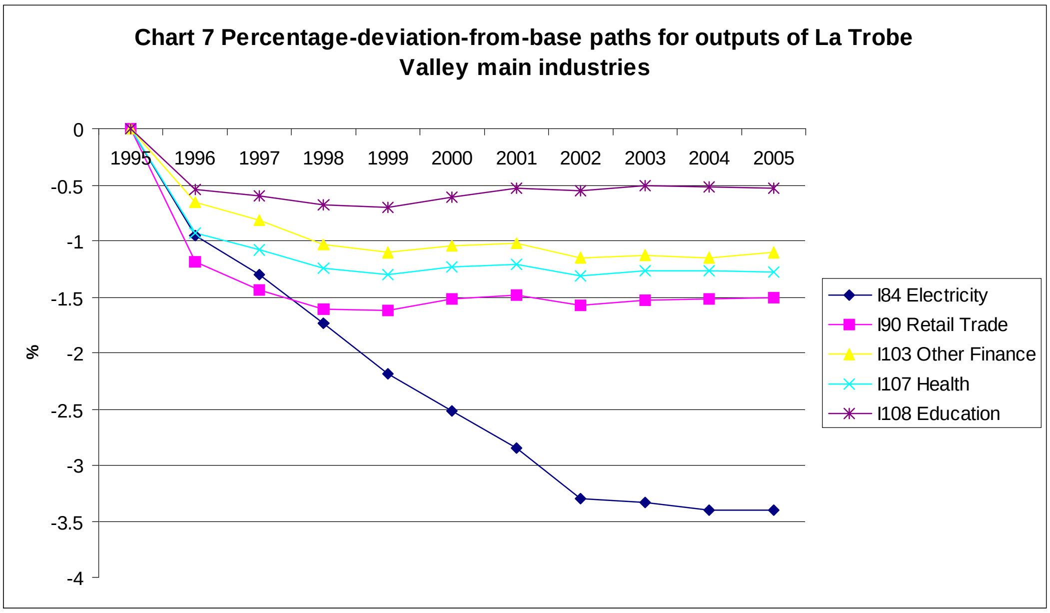


Chart 6 Percentage-deviation-from-base paths of Gross State/Regional Product for Victoria, Gippsland and the La Trobe Valley
%
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
GSP Victoria
GRP Gippsland
GRP La Trobe Valley



6. ELECTRICITY INDUSTRY DISAGGREGATION

The next phase of the research is to further expand the existing energy sector in the MONASH model. The updated MONASH model will be used to perform simulations of greenhouse policy options.[6]

Further model modifications have been made to analyse the impact of greenhouse policy upon the different electricity generators in the energy sector. This second stage of modelling addresses the main limitations found in the first simulation. The first phase in implementing a mechanism to deal with fuel substitution is the disaggregation of the original electricity industry. The basis for disaggregation is outlined in the following sections which delineates the nature of the Australian ESI and how it has changed over the last decade.

6.1 Australia's Electricity Industry

6.1.1 Reform

During the last decade, the Australian ESI has undergone fundamental reform. Prior to 1990 each State or territory owned and operated a single vertically integrated electricity industry, responsible for the generation, transmission and distribution of electricity within the state. Although each State usually had more than one electricity generation plant, there was no competition in the market. Investment in the industry was driven mainly by 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 State government.

An enquiry was conducted by the Industry Commission into the potential efficiency gains of electricity industry deregulation in each State. The findings of the Commission were released in 1991. The main recommendations were:

- 'restructuring the electricity supply 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'.

[6] In addition to the modifications to the MONASH model, the tax will be placed on CO_2, instead of electricity. This is essential to ensure that the results reflect the impact of greenhouse policy upon all energy sectors, and not just electricity.

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 start with a reduction in employee numbers. [7] During the restructure 4,820 direct electricity-generation jobs were shed.[8] The majority of these positions were located in the La Trobe Valley region.

The next stage in the reform 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.[9] Following the deregulation of the industry, the State government of Victoria privatised each of the brown coal generators. The new capital investment poured into the La Trobe Valley region was almost $11 billion, with Loy Yang Power alone selling for $4.7 billion.[10] The retail arm of the newly deregulated Victorian electricity industry was also privatised shortly after.

Whilst similar industry deregulation occurred throughout Australia, to date no other State has followed the lead of Victoria in 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).

6.1.2 National Electricity Market

The final recommendation of the Industry Commission, to promote the State's interconnected power systems, was enacted soon after the report's release. In 1997, the Victorian Electricity market (VicPool) and the NSW State Electricity Market (SEM) were linked and limited interstate trade of electricity began.

"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 ACT, NSW, QLD, SA and VIC". (NEMMCO, 1998) 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 National Electricity Code Administrator (NECA) is responsible for administering the code.

The main roles of NEMMCO are to centrally coordinate the despatch process and the spot market. The day before despatch the generators all bid for half hour time slots to supply electricity into the pool. NEMMCO receives the confidential bids and decides how much electricity each generator supplies, based on the bid price. The generator with the lowest 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 receive the highest bid price of suppliers operating in that half hour. The generators are informed 24 hours prior to despatch 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 despatch bids to NEMMCO. The demand and supply of electricity is known as the spot market. NEMMCO calculates a spot price that is the clearing price to match supply and demand.[11]

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. Although the average spot price is relatively stable, it has been prone to large fluctuations when the supply of

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[7] Employees were offered Voluntary Departure Packages (VDP) to leave the organisation.
[8] Foster, B., Kazakevitch, G., and Stone, S. (1997), *The Effect of Economic Restructuring on Population Movements*, Department of Immigration, Multicultural and Ethnic Affairs, Canberra.
[9] Such as the Hazelwood Power station and mine
[10] Addition of individual generators sale price.
[11] 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 its source.

electricity is reduced due to generation outages or industrial disputes. 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.[12] It is estimated that 80 –90 % of the electricity produced by the generating businesses is contracted.[13]

The financial nature of the electricity contract was recently exemplified when one of the Victorian generators was not generating any electricity due to industrial relations. Although the generator was unable to produce electricity, its contracted customers were still drawing electricity from the pool. This represents the true magnitude of the financial contract. 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.

6.1.3 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 generation. These generators tend to be the main suppliers in each state in terms of capacity. Base generators do not switch on and off the plant in response to prices in the spot market. For this reason the prices bid to NEMMCO for electricity from these sources are generally 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.[14]

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 economy of scale as the larger base generators. Peak generators are usually despatched in times of electricity supply shortage and tend to bid into the market at much higher prices than base generators.[15]

Whether a base or peak generator supplies to the pool depends in part upon the demand and supply of electricity at the national and state level. Supply of electricity can flow between the states of NSW, VIC and SA but it is restricted by the interconnector capacity of the transmission lines. There exists a transmission line between NSW and VIC, and between VIC and SA. For instance, SA could only export electricity into NSW if VIC was not using all of the available transmission capacity. When the interconnector limit is reached, NEMMCO will despatch the next cheapest electricity from within that region. "NEMMCO 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 despatch prices.[16]

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[12] The financial nature of the electricity contract is best explained with the use of an example. 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 how much electricity they generate. Retailer B still has to pay NEMMCO the pool price for how much 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).

[13] The brown coal generators produce at about $4/MWh. Black coal generators have a higher short run cost than this due to the fact that their mines are not located physically next to the power station, as is the case in Victoria. The long run cost for the Victorian generators including their associated debt is closer to $35/MWh. With a pool price averaging $22/MWh in Victoria, the brown coal generators enter into contracts to ensure they receive revenue closer to their long run cost.

[14] 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.

15 There currently exists a limit on the spot price of electricity per MWh of $5000.

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

Competition is set to intensify when QLD joins the NEM at the end of 2000. This will open up further interstate trade. There are also discussions taking place to construct a transmission line between VIC and TAS.

In addition to the promotion of interstate trade, the electricity market will become more competitive as consumers will be able to choose who supplies their electricity. In the future all consumers will be able to enter into contracts with retailers who are not geographically located in their region. The market of contestable customers will further promote competition as these consumers can negotiate to purchase electricity directly from the wholesale NEM.[17]

Given the competitive nature of the NEM, generators will have to monitor the market to evaluate how they can individually pass on the cost of greenhouse compliance to the final consumer of electricity. If black coal passes all of its cost on, brown coal will have to incorporate some of its cost internally so that it can compete.

6.2 Disaggregation

As mentioned in Section 4, one of the main limitations of the existing energy sector in the MONASH model is the sole electricity industry who produces all of the electricity in the economy. 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 greenhouse gas. Thus, a greenhouse policy which increases the cost of one fuel relative to another should lead to the electricity industry substituting away from the more expensive fuel.

To address this limitation the existing electricity industry in the MONASH model was disaggregated into seven new industries. The original industry remains but it no longer produces any electricity itself. Instead it purchases electricity from either of the newly formed Base *I115Base* or Peak *I116Peak* electricity industries, and sells it to end users such as households and industries. The original electricity industry *I84 Electricity*, is based on a similar model to the electricity pool in the NEM. At this stage it is assumed that the generators themselves do not sell electricity directly to final consumers. The market for contestable customers could however be incorporated into a long run model.

The base and peak industries purchase their electricity from the five new electricity generating industries – *I117ElectBr, I118ElectBlk, I119ElectGas, I120ElectHydro*, and *I121ElectOth/Ren*. These industries produce electricity and sell all of their output to either the Base or Peak electricity markets.

As part of the database modification, the single commodity *C17 Oil, gas and brown coal* found in the original version of the MONASH model, was disaggregated. The unique commodities are *C17aOil, C17bGas*, and *C17cBcoal.*

The data requirements were met primarily from existing data files for the electricity industry. Additional information relating to electricity market shares was used to disaggregate down to the new electricity generating industries. The main data sources for the initial construction of the Input-Output table came from the Electricity Supply Association of Australia's 1999 publication 'Electricity Australia 1999'. This provided invaluable information on electricity generation per plant type, and generator shares in total output. The data assisted in the disaggregation of the existing *I84 Electricity* into the newly created industries. The publication also provided load forecasts for the base and peak markets, clearly identifying which generators were selling to each market. In line with industry findings, the model was set up so that *I117ElectBr* and *I118ElectBlk* sell their output solely to *I115Base*. *I120ElectHydro* and *I121ElectOth/Ren* sell their output to *I116Peak*. As *I119ElectGas* was deemed to be selling into both markets, a share weighted allocation was adopted.

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

The modifications to the MONASH model should bring about improvements in modelling policy shocks associated with the electricity sector of the Australian economy. In particular, 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 also has regional modelling implications for the States as fuel type and efficiency of electricity generation varies. Greenhouse policy is likely to have differing ramifications for the electricity industry in each State. *I117ElectBr* which is a relatively high CO_2 emitter is generated in the State of Victoria. Over half of Australia's electricity is generated using black coal (*I118ElectBlk*) in the northern States of New South Wales and Queensland. Most of South Australia's electricity comes from the comparatively low CO_2 emitter, *I119ElectGas*.

In accordance with the NEM, each of the electricity commodities produced by these industries will be classified as a *national* commodity at the State level. In the first simulation the model assumed that all of Victoria's demand for electricity was satisfied from the State's supply. The incorporation of the NEM into the MONASH model recognises that electricity can now be traded between States. Victoria's demand for electricity may be satisfied from any of the new industries, and is not reliant on the supply of electricity from brown coal generation.

6.3 Simulation

Following the disaggregation, a second simulation involving a policy shock to the power of taxes on the new electricity industries was performed. The shock is similar to the first simulation in that it will lead to an increase in the price of electricity sold to households and the industry sector. The main difference between the simulations is that in the first the electricity industry itself was shocked whereas in the latter the shock is placed on industries which sell to the electricity industry.

The shock will cause an increase in the price of electricity produced by the new electricity generating industries (*C119ElectBr, C120ElectBlk, C121ElectGas, C122ElectHyd,* and *C123ElectOth*). The rise in price represents an increase in the input costs to the base and peak electricity industries. It also flows through as an increase in the costs of production to *I84 Electricity* as the price of its intermediate inputs rises. This in turn increases the price of electricity sold to final consumers and industries who use electricity as an input to production. At present the modelling is limited by the fact that the full substitution possibilities are not entirely incorporated into the model.

Although the macroeconomic results vary slightly, the overall trend is the same as that found in the first simulation. Real GNE falls by relatively more than Real GDP which represents a movement towards a balance of trade surplus. There is an accompanying large real devaluation of the dollar making exports relatively cheaper and imports relatively more expensive.

The real wage mechanism ensures that the decrease in aggregate employment is followed by a reduction in the real wage to bring employment back towards control. As employment falls, employees are willing to take a reduction in their wage to increase employment.

The depreciation influences the industry results as export orientated industries expand in response to their output becoming relatively cheaper on overseas markets. The increased level of activity in industries such as *I1Pastoral* represents the expansion of Australia's traditional export market in agriculture.

Industry losers are those electricity intensive industries such as non-ferrous metals.

The regional results show a contraction in gross regional product for the La Trobe Valley region which greatly exceeds that of Gippsland.

6.4 Substitution

The current model does not have a mechanism for dealing with fuel substitution. Three important substitution mechanisms are being added to the model. The first is to allow the electricity industry to substitute between fuels. The second is to introduce substitution between the individual brown coal electricity generators in the La Trobe Valley. The third is to allow users of electricity to substitute between it and other sources of energy such as natural gas.

i Substitution between electricity producers – brown coal, black coal, oil, gas, nuclear, hydro, and renewables.

As described in Section 6.2 the initial industry modification involved modelling the separate sources of electricity generation. Each electricity source emits a different level of CO_2, depending on the type of fuel used. A greenhouse policy aimed at emissions will have different ramifications for each source.

The impact of greenhouse policy will be an increase in the cost of emitting a unit of CO_2 (whether it be via a carbon tax or emission credits). This will increase the cost of producing electricity from some sources more than others. The emergence of the NEM allows substitution between electricity fuel sources in response to changes in relative prices. Brown coal electricity generation emits more CO_2 than other fuel sources per MWh and therefore has to incur a higher cost of abatement. If the price of brown coal electricity increases relative to the price of black coal, consumers will purchase electricity generated by black coal. The ability to pass these taxes onto the consumer will depend on the substitution elasticities.

ii Substitution between brown coal generators in the La Trobe Valley.

In the La Trobe Valley the level of CO_2 emissions from generators varies with the age of the station and the fuel type used. The newer plants such as Loy Yang A and B operate with technology which is far more advanced than that of the older plants such as Yallourn and Hazelwood. This technology facilitates electricity generation with a lower level of CO_2 per MWh. There is also a variance in CO_2 emissions due to the grade of brown coal available in the mines. The revised model will incorporate the substitution possibilities between the La Trobe Valley generators.

Consideration needs to be given to the ability of the La Trobe Valley generators to cope with the additional financial encumbrance imposed by a greenhouse policy. Whilst competing against public entities in a somewhat fickle pricing environment, the generators carry the burden of enormous debt.[18]

iii Substitution between different sources of energy – electricity, gas, petrol.

Modifications to the MONASH model include substitution between energy suppliers. If one energy source becomes more expensive relative to another, the cheaper supply will be substituted for its more expensive counterpart. Substitution between sources is important as greenhouse policy has different cost ramifications for different sectors of the energy market.

Energy substitution has particular ramifications for the household sector of the economy. There will exist a degree of change in consumer tastes away from CO_2 emission intensive energy sources. The substitution elasticity will probably be low in the short term but may become higher over time. Consumers will potentially reduce their consumption of emission intensive goods in favour of ‘clean’ goods. Consumers are being encouraged to buy ‘green electricity’ sourced from renewable energy[19]. There may consequently be a substitution away from electricity generated by steam, towards gas-fired turbines or hydro. Household appliances and heating can be readily interchanged between electricity and gas if the cost of one energy source rises relative to another.[20]

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[18] The Victorian ESI shareholders are on the most part foreign owned companies. This is in contrast to government shareholders in other States.

[19] Sold by retailers such as United Energy.

[20] Households can also substitute away from using petrol in their automobiles if the relative price of gas falls significantly.

Simulation results for some of these modifications are not available at the time of writing. However data on greenhouse emissions in Australia has been collected, and work is in progress on the construction of equations that will facilitate substitution.

7. AREAS FOR FURTHER RESEARCH

7.1 Developing Countries

The project needs to take into consideration the effect of world prices on electricity intensive commodities. As the above results indicate, industries such as non ferrous metals collapse in response to an increase in the price of electricity. This is based on the assumption that the price of the Australian commodity increased relative to the world price.

The assumptions surrounding the export markets of the domestic commodity are important. Only developed countries became signatories to the Kyoto Protocol, with developing countries such as India allowed to continue emitting CO_2 without constraint. If the Australian industry is competing with developed countries, it may retain its position in the international market as the world price of the commodity rises in line with the domestic good. If however the industry is competing with commodities produced in developing countries the Australian commodity will become relatively more expensive on the global market. An industry collapse similar to that found in the results of this simulation would therefore seem probable.

7.2 Carbon Sinks

Another policy option currently under review by the Australian government is the introduction of carbon sinks which can be used to offset CO_2 emissions. Carbon sinks have direct bearings on both CO_2 emitting industry's and the forestry sector of the Australian economy. Commercial forestry plantations are part of the La Trobe Valley's economy and should be taken into consideration when modelling the regional impact of greenhouse policy.

A carbon sink is a naturally occurring mechanism that removes carbon dioxide from the atmosphere. (Kahn 1997, p171) Carbon sinks can be used by the government and/or private organisations to sequester carbon dioxide. The creation of carbon sinks through new forest plantations reduces the amount of carbon dioxide stored in the air. Whilst a forest is growing, CO_2 is absorbed into the trees. (Gunasekera and Cornwell, 1998, p.20) A mature plantation has a zero net effect on the level of CO_2 in the atmosphere because of its slow growth rate and degeneration. It is therefore the rate of tree growth and the resultant carbon sequestration that is important, not the total carbon stored in trees.

It has been scientifically proven that different trees have different storage values of carbon and sequester CO_2 at different rates over time. (Kahn 1997, p171) When forests are cut down, all the carbon except that which is preserved in wood products (construction materials, furniture, paper in books) eventually breaks down, and is released as carbon dioxide into the atmosphere. (Kahn 1997, p171) Forestry carbon sinks act both as a source and a sink of CO_2 depending on the forest life-cycle.

The recognition and acceptance of carbon sinks is encompassed by a number of regulatory rules, which were outlined by the UNFCCC at Kyoto. "The Kyoto Protocol as it now stands 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." (Department of Industry, 1998) This has important ramifications for forest plantations as CO_2 absorbed by 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 important to forest owners and other parties who are interested in reducing overall emissions.

According to the Protocol, 'greenhouse gas emissions from sources and removal by sinks resulting from direct human-induced land-use change and forestry activities limited to afforestation, reforestation and deforestation since 1990' can be included as part of the measurement toward Australia's target. (Department of Industry, 1998) Managed native forests and plantations established before 1990 are not included. (Department of Industry, 1998) Provided that they are established after 1990, activities such as commercial plantations, environmental plantings, windbreaks and shelter belts will be recognised as carbon sinks provided they are of sufficient scale to qualify as a forest. (Australian Greenhouse Office, 2000)

Plantations created after 1990 will only be counted against the target if they have not been harvested. Trees harvested and deemed to have generated carbon emissions greater than the carbon they have sequestered from the atmosphere during that period will actually incur a carbon penalty. (Department of Industry, 1998) This acts as a positive incentive to refrain from harvesting during the commitment period. This also raises one of the inconsistencies in the measurement of the carbon sequestered in the sink as parties that plant trees post-1990 will only be entitled to credits for sequestration that has occurred during the five-year commitment period. In contrast, if those same trees are harvested during the commitment period, the Party would be liable for debits equal to the entire growth of the tree. (Australian Greenhouse Office, 2000)

Carbon sinks can be used in conjunction with other policy measures such as emission trading to lower the cost of abatement. For each tonne of CO_2 sequestered by the carbon sink, a carbon credit could be issued, allowing the polluter to emit one tonne of CO_2 in its production process.

Carbon sink shocks to the forestry and energy sectors can be simulated using the MONASH model. In the short run carbon sinks will impact on the forestry sector by increasing the number of timber plantations. This would coincide with a reduction in the availability of timber as Kyoto increases the optimal rotation period for a stand of trees. (Enzinger and Jeffs, 1999) We would expect to see an increase in the price of timber. In the long run, the availability of timber will increase as plantations are harvested. We would expect to see a decrease in the price of timber at this time.

The impact of carbon sinks on the energy sector is a reduction in the cost of abatement. Carbon sinks are not a stand-alone solution to CO_2 emissions, however they can be used in conjunction with other abatement measures.

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