IMPACTS OF POLICY OPTIONS RELATING TO EMISSIONS ABATEMENT IN THE STATIONARY ENERGY SECTOR

Report by the Centre of Policy Studies to support a project undertaken by the Allen Consulting Group for the COAG energy market review

20 October 2002 (this draft)

Centre of Policy Studies

PO Box 11E
Monash University
Victoria 3800
Australia

ABN No 12 377 614 012

Contact person: Dr. Philip Adams

Telephone:	(61-3) 9905 5094
Facsimile:	(61-3) 9905 2426
Email:	philip.adams@buseco.monash.edu.au
Web address:	http://www.monash.edu.au/policy/

1. INTRODUCTION

This report deals with the national and regional effects of policy options relating to emissions abatement in the stationary energy sector. The analysis is conducted using the MMRF-Green model.

Projections for the following four scenarios are reported:

- Scenario 1: Baseline (no measures);
- Scenario 2: Baseline (with measures);
- Scenario 3: Baseline (with a national stationary energy emissions intensity requirement); and
- Scenario 4: Baseline (with emissions trading).

Scenario 1 excludes all current measures affecting the stationary energy sector[1]. Scenario 2 includes all current measures. The measures that are included in Scenario 2, but not in Scenario 1 are:

Supply-side

1. QLD cleaner energy strategy;
2. Generator efficiency standards (GES);
3. Mandatory renewable energy targets (MRET) and extension to greenpower;
4. Greenhouse gas abatement program and greenhouse friendly certification program;
5. NSW electricity retailer benchmark scheme;

Demand-side

6. Greenhouse challenge program (GCP);
7. Energy efficiency standards and for residential and commercial buildings (PM 1997 statement);
8. Energy performance codes and standards for domestic appliances and commercial and industrial equipment (PM 1997 statement); and
9. Energy efficiency best practice program (PM 1997 statement).

Our explanation of Scenario 2 concentrates on highlighting the main differences between it and Scenario 1. In Scenario 3, the measures included in Scenario 2 are replaced by a single new measure – the national stationary energy emissions intensity requirement (SEEIR). This is directed at the electricity generation segment of the stationary energy sector and targets the same level of abatement as achieved by the measures in Scenario 2. Comparing the third scenario with the first shows the effects of the new measure. Finally, Scenario 4 excludes the measures embodied in Scenarios 2 and 3, in favour of a national emissions trading scheme applied to the electricity sector only. Again, the measure is targeted to achieve the same level of abatement as achieved by the measure(s) in Scenarios 2 and 3. Comparing variables in Scenario 4 with variables in Scenario 1 shows the effects of the trading regime.

2. THE MODEL

MMRF-Green is a multi-sector dynamic model of the Australian economy covering the six states and two territories. It models each region as an economy in its own right, with region-specific prices, region-specific consumers, region-specific industries, and so on. Since MMRF-Green is dynamic, it is able to produce sequences of annual solutions connected by dynamic relationships. The model also includes enhanced capabilities for environmental analysis.

---

[1] We do not class Energy Market Reform (EMR) as a current measure.

As each state and territory is modelled as a mini-economy, MMRF-Green is ideally suited to determining the impact of region-specific economic shocks. It has already been used to address a wide range of issues, including the economic impacts of large export-oriented projects, the effects of global trading in greenhouse emission permits, and the effects of changes in state and federal tax rates.

Capability for environmental analysis

MMRF-Green has been enhanced in a number of areas to improve its capability for environmental analysis. These enhancements include:

1. an energy and gas emission accounting module, which accounts explicitly for each of the 49 industries (see Table A) and eight regions recognised in the model;
2. equations that allow for inter-fuel substitution in electricity generation by region; and
3. a detailed treatment of renewable generation possibilities.

Emissions accounting

MMRF-Green tracks emissions of greenhouse gases at a detailed level. It breaks down emissions according to:

1. emitting agent (49 industries and residential);
2. emitting state or territory (8); and
3. emitting activity (5).

Most of the emitting activities are the burning of fuels (black coal, natural gas, brown coal or petroleum products[2]). A residual category, named Activity, covers emissions such as fugitives and agricultural emissions not arising from fuel burning.

The resulting 49 x 8 x 5 matrix of emissions is designed to include all emissions except those arising from land clearing. Emissions are measured in terms of carbon dioxide equivalents, $C0_2$-e. The main source of data for the matrix of emissions is the 1999 National Greenhouse Gas Inventory published by AGO.

Inter-fuel substitution

Inter-fuel substitution in electricity generated is handled using the "technology bundle" approach developed at the Australian Bureau of Agricultural and Resource Economics (ABARE). A variety of power-generating industries are distinguished based on the type of fuel used (see Table A). There is also an end-use supplier (*Electricity Supply*). The electricity generated in each state/territory flows directly to the local end-use supplier, which then distributes electricity to local and inter-state users. The end-use supplier can substitute between the different generation technologies in response to changes in their production costs. For example, the Electricity supply industry in NSW might reduce the amount of power sourced from coal-using generators and increase the amount sourced from gas-fired plants. Such substitution is price-induced; the elasticity of substitution between the various types of electricity used by the Electricity supply industry in each state is set to 5.

For other energy-intensive commodities used in industry, MMRF-Green allows for substitution possibilities by including a weak form of input-substitution specification. If the price of say, Cement, rises by 10 per cent relative to other inputs to construction, the Construction industry will use 1 per cent less Cement and, to compensate, a little more of labour, capital and other materials. In most cases, as in the Cement example, we have imposed a substitution elasticity of 0.1.

---

[2] Each of these fuels is identified as a separate commodity within the model.

For important energy goods, Petroleum products, Electricity supply, and Urban gas distribution, the substitution elasticity in industrial use is 0.25. This input substitution is driven by price changes, and so is especially important in emission-policy scenarios, which makes outputs of emitting industries more expensive.

Renewable generation

Up to recent times, MMRF-Green had just one renewable generating industry in each state. The cost structure of this generic industry was modelled on the cost structure of the average hydro plant. Accordingly, sales of this industry were concentrated in the states in which hydro generation was present (TAS, VIC, NSW and to a small extent QLD).

Recently, we have incorporated a more detailed treatment of renewable technologies. Instead of one industry, we now have five separate industries each producing electricity from a specific renewable source. The five sources are hydro, biomass, biogas, solar and wind. In broad terms, the production technologies for biomass and biogas generation are more labour intensive than for solar and wind generation, and less intensive in the usage of machinery and equipment. The production technology for hydro generation is about halfway between each of these extremes.

The regional distribution of renewable generation is shown in the table below. Also shown, for sake of comparison, is the regional pattern of fossil-fuel generation.

Electricity Generation by Fuel (PJ) in 1999*

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Electricity generated by:								
Black coal	233.8	0.0	113.7	17.0	34.4	0.0	0.0	0.0
Brown coal	0.0	178.8	0.0	0.0	0.0	0.0	0.0	0.0
Natural gas	7.0	2.8	10.3	17.3	32.7	0.0	7.7	0.0
Oil products	0.6	0.1	1.6	0.2	4.1	0.0	1.6	0.0
Hydro	24.2	3.3	1.4	0.0	0.0	29.8	0.0	0.0
Biomass	1.5	1.3	1.7	0.0	0.0	0.3	0.0	0.0
Biogas	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0
Solar	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Wind	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Total	268.3	187.4	128.9	34.6	71.3	30.0	9.3	0.0

Source: MMRF-Green database for 1999.

Enhancements for this project

The NSW electricity retailer benchmark scheme and the SEEIR allow electricity retailers to comply with their benchmark obligations by:

1. reducing the greenhouse intensity of electricity purchased from generators;
2. improving the energy efficiency of their customers through the promotion of demand management; and
3. offsetting emissions through the purchase of forest sequestration credits.

In our modelling, we make allowance for reductions in the greenhouse intensity of electricity via changes in the mix of generation towards relatively clean forms of power. Subsidising renewable and gas generation, while taxing coal generation induces these changes. The tax fully pays for the subsidy. Retailers in each state pay a common price for electricity, after making allowance for transmission costs, but the final price is higher than otherwise because 1Pj of electricity generated from renewables and gas is assumed to be more expensive than 1Pj of electricity from coal generation.

To model abatement via increased demand management and increased forestry sequestration requires new mechanisms in the model that relate such abatement to the unit cost. At this stage our modelling of these mechanisms is highly speculative, due to data limitations. In both cases, we assume fixed proportionate relationships. The constants of proportionality are derived from point estimates of the extent of abatement that might arise at a particular level of abatement cost [3] In particular, we assume that if the cost reached $10 per tonne of CO2-equivalent, then the following would be available:

1. twenty per cent additional forestry sequestration (equivalent at present national levels to 5 Mt of C02-e); and
2. additional demand management allowing a reduction of two per cent in emissions from the electricity sector (equivalent at present national levels to a reduction of 4 Mt of C02-e).

3. Baseline (no measures)

In forecasting with MMRF-Green, we impose on the model a large amount of information from specialist external forecasting agencies. The model is then used to trace out the implications of the external forecasts and policies changes at a level of detail consistent with the requirements of the user.

This section has two parts. In Section 3.1, we describe the key inputs to the baseline (no measures) projection. Model-generated forecasts are discussed in Section 3.2.

3.1 Assumptions Used in the Baseline (no measures)

In generating the Baseline (no measures) forecasts, we use:

1. State/territory macroeconomic forecasts from Access Economics;
2. National-level assumptions for changes in industry production technologies and in household preferences from CoPS; and
3. Forecasts for the quantities of agricultural and mineral exports, and estimates of capital expenditure on major minerals and energy projects from various sources, such as state government agencies, the Australian Bureau of Agricultural and Resource Economics (ABARE), and the National Electricity Market Management Company (NEMCO).

Macroeconomic Inputs (Table 2)

Table 2 shows the assumptions for selected macroeconomic variables in terms of average annual growth rates over the period 1999 to 2012. These are discussed more fully in Section 3.2.

Assumptions for Changes in Technology and Tastes (Table 3)

Table 3 shows our assumptions for changes in the preferences of households and for changes in the production technologies of industries. These are applied uniformly across regions. The numbers are based on extrapolated trends calculated from a MONASH simulation for the period 1986-87 to 1996-97.

---

[3] These estimates are based on data supplied by NSW State Forests, and data reported in *Greenhouse-related licence conditions for electricity retailers*, NSW Government Position Paper, December 2001.

Our assumptions for household tastes are summarised in the first column of numbers in Table 3. The second column of numbers shows our initial assumptions for the average annual rates of change in the usage of commodities as intermediate inputs per unit of production in industries, and as inputs per unit of capital creation. The assumptions in the second column for energy commodities are of special importance to this study. They show that through the forecast period industries will become more intensive in their use of natural gas and less intensive in their use of black and brown coal.[4] The intensity with which industries use crude oil is assumed not to change. For derived fuels, industries will become more intensive in their use of LPG, and less intensive in their use of other petroleum products. We assume zero change in the intensity of use of electricity supply: increased electricity efficiency for electrical equipment is offset by more intensive usage of electrical equipment. To understand the numbers for the electricity-generator products, note that these products are sold only to the electricity supply industry. Thus our assumptions for the generator products are indicative of historical trends in the fuel mix of electricity supply.

Table 3a summarises our technical assumptions for the usage of fuels per unit of industrial output and for the usage of fuels per unit of electricity generation in terms of two commonly used measures of efficiency – energy technical efficiency and supply efficiency. We define energy technical efficiency as minus a weighted average of the use of primary and derived fuels per unit of output in all industries using those fuels other than the electricity generators. For Australia as a whole, we assume a value of 0.5 per cent per annum, implying that in each year industries other than electricity generators will use 0.5 per cent less fuel (primary and derived) per unit of output. We define supply efficiency as minus a weighted average of the use of primary fuels per unit of electricity generation. For Australia as a whole, we assume a value of 0.6 per cent per annum, implying that in each year electricity-generating industries will use 0.6 per cent less primary fuels per unit of output.

Our initial assumptions for each industry concerning average annual changes in primary-factor usage per unit of output are shown in the final column of Table 3. Primary-factor inputs in MMRF-Green comprise labour, capital and agricultural land. For the electricity industries, we assume annual improvements in the rate of factor-saving technological change of 1.0 per cent for the fossil fuel generators and of 2.0 per cent for the renewable generators.

Assumptions for Exports (Table 4), and for Large Resource and Electricity Projects

Table 4 shows assumptions for the quantities of agricultural and mineral exports. These reflect ABARE projections to 2006, and exogenously imposed long-term trends for the remaining years to 2012.

MMRF-Green's theory of investment relates year-to-year changes in capital expenditure to year-to-year changes in rates of return. This is appropriate for most industries where the evolution of investment through time is relatively smooth. However, for industries in the resource and electricity sectors, investment is seldom smooth. Accordingly, in forecasting we complement the standard MMRF-Green investment theory with extraneous information relating to incremental investment changes in the resource and electricity industries. Currently, our primary source of information for planned projects in the resource sector is ABARE. Our primary source of information for future electricity investments is NEMCO, which provides data via personal communication.

3.2 Baseline (no measures) Projections

We report four tables of projections:

Table 5.1: Macroeconomic indicators (repeat of Table 2, included for sake of completeness)

---

[4] We assume that there is more scope for improved efficiency in the use of black coal than for brown coal based on improvements already achieved.

Table 5.2: Output by industry

Table 5.3: Greenhouse gas emissions by state and major source category

Table 5.4: Electricity generation by fuel and state.

Macroeconomic variables (Table 5.1)

Our baseline (no measures) projection for the years 1999 to 2012 features:

- robust growth in real GDP of 3.0 per cent per annum, with NT, QLD and WA the fastest growing states, and SA and TAS the slowest growing;
- average annual growth for real private consumption and for real investment in line with growth in real GDP;
- international trade expanding strongly relative to GDP; and
- aggregate employment growth of 1.3 per cent per annum.

Industry outputs (Table 5.2)

- The fastest growing industries typically are favoured by technological and taste changes, and/or are export-oriented, and/or have strong connections to international tourism.
- The slowest growing industries typically face unfavourable technological and taste trends, and/or face strong competition from international imports.
- Gas-fired electricity generation has better prospects than coal-fired generation, while growth in renewable-generation is generally static.
- Electricity supply is forecast to increase at an annual rate of 2.4 per cent, 0.6 percentage points less than forecast GDP growth.

Emissions of $C0_2$-e (Table 5.3)

- Australia-wide, emissions of $C0_2$-e are forecast to increase at an average annual rate of 1.6 per cent (cf. growth in real GDP of 3.0 per cent). Emissions rise from 461 Mt in 1999 to 564 Mt in 2012.
- Emissions from electricity generation increase at an average annual rate of 1.2 per cent, from 181.8 Mt in 1999 to 210.2 Mt in 2012.

Electricity generation (Table 5.4)

- According to our projections, generation of electricity in Australia will increase from 729.8 PJ in 1999 to 1,009.5 PJ in 2012, implying an average annual growth rate of 2.5 per cent.
  - Generation from black coal is forecast to grow at an average annual rate of 2.5 per cent, while gas generation is forecast to grow by 3.8 per cent per year.
- A notable feature of the forecasts is the declining share of renewable generation across the county. In 1999, renewable energy contributed just over 9 per cent of total generation in Australia. According to our projections, this share will fall to 7.7 per cent in 2010 and to 7.5 per cent in 2012.
  - The change in generation mix over the forecast period favours gas, with gas's share in total generation forecast to rise from 10.7 per cent in 1999 to 12.5 per cent in 2012.

4. Alternative Scenarios

4.1 Methodology for producing alternative scenarios

In computing the Baseline (no measures) scenario, we took on board forecasts and information available from outside sources, such as Access Economics. To accommodate this information, numerous naturally endogenous variables were exogenised. These included the volumes of agricultural exports and most macro variables.

To allow such naturally endogenous variables to be exogenous, an equal number of naturally exogenous variables were made endogenous. For example, to accommodate forecasts for the volumes of agricultural exports we made endogenous variables that locate the positions of foreign demand curves. To accommodate forecasts for macro variables, we made endogenous various macro coefficients such as the average propensity to consume.

However, when accommodating the effects of the shocks embodied in Scenarios 2, 3 and 4, the naturally endogenous variables, such as the volumes of agricultural exports and macro variables, which were exogenous in the baseline (no measures) scenario must be made endogenous. This allows them to respond to the exogenous changes under consideration. Correspondingly, naturally exogenous variables, such as the positions of foreign demand curves and macro coefficients, which were endogenous in the baseline (no measures) scenario must be exogenous. They are set at the values revealed in the baseline (no measures) case.

In making these closure changes we make the following assumptions regarding important aspects of the economy.

Labour markets

At the national level, we assume that the deviation in the consumer's real wage rate (i.e., the nominal wage rate deflated by the CPI) from its baseline (no measures) level increases in proportion to the deviation in employment from its baseline (no measures) level. The coefficient of proportionality is chosen so that the employment effects of a shock to the economy are largely eliminated after five years. In other words, after about five years, the costs of an unfavourable shock are realised almost entirely as a fall in the national real wage rate, rather than a fall in employment.

At the regional level, we assume that labour is mobile between state economies. Labour is assumed to move between regions so as to maintain inter-state wage and unemployment rate differentials at their levels in the baseline (no measures) case. Accordingly, regions that are favourably affected by a shock will experience increased employment and population at the expense of regions that are less favourably affected.

Private consumption and investment

Consumption expenditure of the regional household is determined by Household Disposable Income (HDI) Since budget constraints are not imposed on the business sector or on governments, regional economies' will run trade deficits/ surpluses to the extent that aggregate regional expenditure levels are greater than/less than aggregate regional incomes. The deficits or surpluses can be held with other agents in other regions, with foreigners or with both regional agents and foreigners.

We assume that in each year, investment in each regional industry will deviate from its value in the baseline (no measures) in line with the deviation in the expected rate of return on the industry's capital stock. Investors are assumed to be myopic, implying that expected rates of return move with contemporaneously observed rates of return.

Rates of return on capital

In deviation simulations, MMRF-Green allows for short-run divergences in rates of return on industry capital stocks from their levels in the baseline (no measures) forecasts. Such divergences cause divergences in investment and hence capital stocks. The divergences in capital stocks gradually erode the divergences in rates of return, so that in the long-run rates of return on capital over all regional industries return to their baseline (no measures) levels.

Production technologies

MMRF-Green contains many types of technical change variables. In the deviation simulation we assume that all technology variables, other than those used in the implementation of shocks, have the same values as in the baseline (no measures) simulation.

4.2 Scenario 2 – Baseline (with measures)

Nine policy measures are included in the with-measures scenario. The following is a list of these measures along with a description of how they were modelled.

Supply-side

1. *QLD cleaner energy strategy*. This is modelled as autonomous annual shifts towards gas-fired electricity generation and away from coal-fired generation in QLD sufficient to increase the share of gas-fired generation in total generation in QLD to 13.1 per cent by 2010 and to keep it at that level through to 2012.
2. *Generator efficiency standards (GES)*. We assume that efforts in updating generators will result in a reduction (relative to baseline (no measures) levels) in 2010 of 2 Mt of emissions from black coal generation, of 2 Mt from brown coal generation, and of 1 Mt from gas generation. These reductions are achieved by cost-neutral increases (relative to baseline (no measures) levels) in the annual-rate of fuel-saving technological progress in fossil-fuel generation. For the period 2010 to 2012, we assume that the increases in the annual-rate of fuel saving technological progress deduced for the period 1999 to 2010 continue.
3. *Mandatory renewable energy targets (MRET) and extension to greenpower*. The MRET target obliges wholesale purchasers of electricity to proportionately contribute towards the generation of an additional 9.500 GWh of renewable energy per year by 2010. This translates to an additional 34.2 PJ of generated electricity. We implement the scheme via autonomous annual shifts towards renewable electricity generation and away from fossil-fuel generation, sufficient to hit the renewable target in 2010. These shifts are quantity neutral – one PJ increase in renewable generation is matched by one PJ decrease in fossil generation. However, they are not cost neutral since renewables are assumed to be a more costly form of generation. For the years 2010 to 2012, we assume that the renewable share in total generation is maintained at its level achieved in 2010 with the MRET in place.
4. *Greenhouse gas abatement program (GGAP) and greenhouse friendly certification program*. This program provides support to activities that are likely to result in substantial emission reductions or substantial sink enhancement up to 2012. We assume that the GGAP will lead to reductions (relative to baseline (no measures) levels) in emissions from the stationary energy sector in each state as listed in the GGAP spreadsheet provided by AGO.
5. *NSW electricity retailer benchmark scheme*. Under the benchmarks, NSW electricity retailers are required to reduce per capita C02-e emissions to 7.27 tonnes by 2007. As noted in Section 2 of this report, the scheme allows electricity retailers to comply with their benchmark obligations by: reducing the greenhouse intensity of electricity purchased from generators; improving the energy efficiency of their customers through the promotion of demand management; and offsetting emissions through the purchase of forest sequestration credits. We implement the scheme via a combination of autonomous annual shifts towards gas-fired and renewable

electricity generation and away from coal generation, combined with allowance for increased demand management and increased forestry sequestration. The shifts in generator mix are quantity neutral – one PJ increase in gas and renewable generation is matched by one PJ decrease in coal generation. However, the shifts are not cost neutral since gas-fired power and renewable generation are more costly forms of generation. The additional demand management and sequestration occurs in line with mechanisms that relate these forms of abatement to the cost of abatement (see Section 2).

Demand-side

6. *Greenhouse challenge program (GCP).* This is described as a co-operative program between industry and government whereby companies undertake action to abate their greenhouse gas emissions through no regrets energy efficiency and other measures. It is modelled as a combination of improved (relative to baseline (no measures) levels) generation efficiency and improved energy efficiency in industrial usage targeted to achieve an Australia-wide reduction in emissions of 5.8 Mt. This is the estimate of the measure's impact based on data provided by GCP participants and published in the Greenhouse Challenge, February 2002. For the period 2010 to 2012, we assume that the increases in the annual-rate of generation efficiency and industrial energy efficiency deduced for the period 1999 to 2010 continue.
7. *Energy efficiency standards for residential and commercial buildings (PM 1997 statement).* The measure has a technical effect that increases the energy of residential and commercial buildings. The AGO estimates that the measure will reduce total emissions by 1.6 Mt in 2010. It is modelled as cost-neutral annual increases in the efficiency with which energy is used in buildings.
8. *Energy performance codes and standards for domestic appliances and commercial and industrial equipment (PM 1997 statement).* The measure increased the effectiveness of existing energy labelling by developing minimum energy performance standards for a broad range of new appliances and equipment. The AGO estimates that the measure will reduce total emissions by 6.1 Mt in 2010. The measure is modelled as a combination of cost-neutral annual shifts in industry technologies and consumer tastes against the usage of electricity and gas.
9. *Energy efficiency best practice program (PM 1997 statement).*This measure encourages industries to become more efficient in the use of energy via innovative investments and changes in technologies. The AGO estimates that the measure will reduce total emissions by 1.5 Mt in 2020. It is modelled via cost-neutral annual shifts in industry technologies against the usage of electricity and gas.

The main effects of the measures are shown in Tables 6.1 to 6.5. These show, for the period 2000 to 2012, deviations of a range of variables in the Baseline (with measures) simulation from their values in the Baseline (no measures) simulation.

Below is a listing of the tables and their titles.

Effects of measures already in place

Macroeconomic variables

- The policy measures have a negative impact on national macroeconomic variables.
- The measures are projected to reduce real GDP in an average year by 0.19 per cent (or $1,475 million) relative to its level without measures.

- This decline is due to two measures – MRET and the NSW benchmark scheme. These measures have a negative impact because they increase costs through forced adoption of more expensive renewable and gas generated electricity.
- The other measures combined have a neutral effect on the national macro economy.
- NSW, Victoria and SA are projected to experience falls in real GSP, while QLD and WA are projected to experience relatively large percentage gains.
- NSW bears the largest costs because of an over-representation in its economy of expensive renewable generation.
- QLD and WA gain, in part, because of strong real devaluation of the currency. These states are favored by real devaluation because of their strong trade orientation. Real devaluation is required to offset the falls in electricity-intensive exports – aluminium and other refined metals.

* On the expenditure side, in the average year national real private consumption (C) and real investment (I) fall relative to real GDP.
    - The decline in investment reflects falls in investment in fossil-fuel generating industries and in fossil-fuel mining industries. These falls more than offset increased investment in renewable generation.
* Overall, real gross expenditure (C+I+G) falls by more than real GDP, implying an improvement in the in the balance between aggregate export and import volumes (X-M).

Industry output

* The measures significantly alter the industrial structure of the national and state economies. In terms of percentage deviations, in the average year the industries that suffer the greatest declines are:
    - *Electricity – black coal* (down 15.1 per cent)
    - Electricity – brown coal (down 5.4 per cent) and
    - *Electricity – supply* (down 4.5 per cent).

Offsetting these declines are expansions in renewable generating industries:

- *Electricity – wind* (up 164 per cent)
- *Electricity – biomass* (300 per cent)
- *Electricity – biogas* (300 per cent)
- *Electricity – solar* (74 per cent) and
- *Electricity – gas* (29 per cent)

* Not included in the list of industries that are expected to achieve significant gains in output is *Electricity – hydro*. The reason is that hydro capacity is tightly constrained by a lack of additional water resources. In our projections we assume that hydro generation can expand, but by no more than 1 per cent of its basecase level.

$C0_2$-e Emissions by Major Source Category

* Total emissions are projected to fall by 5.2 per cent in 2012 as a result of the measures. This is equivalent to a fall of 29.5 Mt. In 2010, emissions are down by 27.1 Mt. Nearly all of these falls can be attributed to reductions in emissions from electricity generation, which fall by 23.4 Mt in 2010 and by 25.6 Mt in 2012.

Electricity Generation by Fuel

* As a result of the measures, total electricity generation in 2012 is projected to fall by 3.5 per cent (or 35.5 PJ) relative to its no-measures level.

4.3 Scenario 3 – Baseline (with SEEIR)

In this scenario, the measures embodied in Scenario 2 are replaced by a nation-wide version of the NSW benchmark scheme. The scheme begins operation in 2003 and targets in each year the same level of abatement as was achieved by the measures in Scenario 2.

The main effects of the new measure are shown in Tables 7.1 to 7.5. These show, for the period 2000 to 2012, deviations for variables in the simulation of Scenario 3 from their values in the Basecase (no measures) simulation.

Effects of the SEEIR

We find that most of the abatement task is achieved through changes in the generation mix towards gas generation and away from coal generation. Sequestration credits are used, but only in relatively small numbers. In 2010, credits covering 1.6 Mt of C02-e are purchased. Some demand management options are also taken up. In 2010, these options lead to 0.6 per cent less electricity generation (equivalent to 6 PJ).

Macroeconomic and industry variables

- The SEEIR has a milder negative impact on national macroeconomic variables than do the measures in Scenario 2.
  - In an average year, real GDP is 0.09 per cent (or $696 million) below its basecase level. This compares to a fall of 0.19 per cent (or $1,475 million) in Scenario 2.
  - The SEEIR is less costly than existing measures because it encourages less of the most costly renewable generation options.
- Overall, relative to Scenario 2, in Scenario 3
  - less demand side management options become available causing production of electricity-supply to decline by less;
  - gas generation increases by significantly more; and
  - renewable generation increases by significantly less.

$C0_2$-e Emissions by Major Source Category

- The total of emissions is projected to fall by 5.3 per cent in 2012 as a result of the SEEIR. This is equivalent to a fall of 29.7 Mt. In 2010, emissions are down by 25.6 Mt. Emissions from electricity generation are down by 22 Mt in 2010 and by 25.8 Mt in 2012. Sequestration increases by 1.6 Mt in each of the two years.

Electricity Generation by Fuel

- As a result of the measures, total electricity generation in 2012 is projected to fall by 0.9 per cent (or 9.4 PJ) relative to its no-measures level.

4.4 Scenario 4 – Baseline (with carbon trading scheme)

In this scenario, the measures embodied in Scenario 2 are replaced by a national emissions trading scheme, which begins operation in 2003, and is applied only to the electricity sector. Again, the measure is targeted to achieve the same level of abatement as achieved by the measure(s) in Scenarios 2 and 3. Annual proceeds from the sale of credits are handed back via cuts in the GST and in state payroll taxes. For comparison purposes, we assume that the trading scheme leads to the same levels of abatement from sequestration and demand management as was achieved in Scenario 3.

The main effects of the new measure are shown in Tables 8.1 to 8.5. These show, for the period 2000 to 2012, deviations for variables in the simulation of Scenario 4 from their values in the Basecase (no measures) simulation.

Effects of the carbon trading scheme

Of the three options, carbon trading is significantly less costly in terms of its impacts on real GDP. To meet the annual targets, the price of emission permits progressively rises to $10.20 per tonne of C02-e in 2010.

Macroeconomic and industry effects

- Real GDP and employment fall significantly less with the carbon trading scheme than with the SEEIR and existing measures. In an average year, real GDP falls by 0.3 per cent due to the carbon trading scheme, whereas it fell by 0.19 per cent and 0.09 per cent in each of the other scenarios.
- Overall, relative to Scenario 3, in Scenario 4
  - (by assumption) the same amount demand side management options become available, however production of electricity-supply falls by significantly more because of a larger increase in price and hence larger deleterious price-induced substitution effects[5]; and
  - the take up of gas and renewable generation is significantly less.

$C0_2$-e Emissions by Major Source Category

- The total of emissions is projected to fall by 5.0 per cent in 2012 as a result of the carbon trading scheme. This is equivalent to a fall of 27.9 Mt. In 2010, emissions are down by 25.0 Mt. Emissions from electricity generation are down by 21.9 Mt in 2010 and by 24.4 Mt in 2012. Sequestration increases by 1.6 Mt in each of the two years.

Electricity Generation by Fuel

- As a result of the measures, total electricity generation in 2012 is projected to fall by 5.5 per cent (or 55.3 PJ) relative to its no-measures level.

Real GDP effects.

Real GDP falls relative to base in Scenarios 2 and 3, in the main, because of forced adoption of more expensive forms of electricity generation. Forced adoption of relatively expensive generation imposes a cost on the economy in the same way that a technological deterioration does. The cost increase directly reduces real GDP because it reduces the real income available to the factors of production – labour, capital and agricultural land. It also reduces real GDP in an indirect way because it increases the real cost of the variable factor of production – labour in the short run, capital in the long run. Increasing the real cost of the variable factor forces the economy to increase use of the fixed factor relative to use of the variable factor . The only way this can be achieved is via a reduction in the variable factor. Thus in Scenario 2 and 3, real GDP falls throughout the period, with short-run declines in employment progressively being replaced by reduced capital.

In Scenario 3, the reduction in real GDP is driven by a different mechanism. We assume that the revenue raised by the carbon "tax" is matched by falls in consumption and payroll taxes. In the short-run, the switch in tax burden leaves the real cost of the variable factor

[5] In Scenario 4, the national price of electricity increases by 11.8 per cent relative to base in 2012. In Scenario 2, the price increase is 2.6 per cent. In Scenario 3, the price increase is 2.1 per cent.

(labour) more-or-less unaffected. Thus there is little pressure on the economy-wide factor ratio and little adjustment in real GDP. In the long-run, however, the reductions in consumption and payroll taxes do little to offset the effects of the carbon tax on the real cost of the variable factor (capital). This means that the real cost of capital rises, leading to less capital and hence less real GDP.

Effects on the national wholesale price of electricity

The table below shows percentage deviations from base in the national wholesale price of electricity in each of the deviation scenarios. Deviations are reported for each year through to 2010, which is the end year for many of the measures included in Scenario 2. The average deviation for Scenario 2 is the average of annual deviations between 2001 and 2010. The average deviations for Scenarios 3 and 4 are the averages of deviations between 2003 and 2010.

Percentage deviations from base in the national wholesale price of electricity

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Average
Scenario 2	-0.5	-0.9	-0.9	-1.0	-1.1	-1.1	-1.0	-0.8	-0.4	0.4	-0.7
Scenario 3	0.0	0.0	-0.3	0.1	0.3	0.4	0.5	0.6	0.8	0.9	0.4
Scenario 4	0.0	0.0	1.0	2.2	3.5	4.8	6.1	7.4	8.8	10.1	5.5

The table clearly shows that, on average, the measures in Scenario 2 reduce the national wholesale price of electricity. By contrast, the SEEIR leads to a mild increase, while the carbon trading scheme results in a significant increase.

The measures embodied in Scenario 2 comprise a mixture of demand-side and supply-side initiatives (see Section 4.2). The demand-side measures suppress demand for electricity, causing the demand schedule faced by electricity wholesalers to shift to the left. The supply-side measures have differing impacts on the wholesaler's supply schedule. GES and GGAP tend to shift the schedule to the left because they encourage greater efficiency in use of fossil fuels. The other supply-side measures encourage the use of more costly forms of generation. Hence, they tend to shift the supply schedule to the right. On balance, the price suppressing measures more than offset the price increasing ones, leading to an overall price reduction. This is reinforced by a reduction in electricity demand caused by the general contraction in economic activity. Note that a back of the envelope calculation shows that demand-side measures plus GES and GGAP contribute to around 60 per cent of the total abatement in Scenario 2.

Scenario 3 achieves annually the same level of abatement as in Scenario 2 primarily by encouraging the use of gas-fired electricity at the expense of coal-fired electricity. Also included is a moderate (relative to Scenario 2) level of demand management which reduces electricity demand. According to our modelling, at the start of the period on average gas-fired electricity is around 0.8 $m/PJ dearer than coal fired electricity. This gap progressively widens through the period as demand for gas-fired power rises, and demand for coal-fired power falls. The average price (effectively the wholesale price), however, is relatively stable. In the first year, most of the targeted abatement is achieved via demand management. Hence the price of electricity falls relative to basecase levels. Thereafter, the share of abatement achieved via demand management declines, and we see mild rises (relative to base) in the wholesale price of electricity as gas-power replaces coal-power. Note that the price gap between gas and coal does not become large enough to encourage big increases in use of the very expensive non-hydro renewable options.

Scenario 4 achieves annually the same level of abatement as in Scenario 3 primarily by taxing fossil-fuel electricity, causing the wholesale price of electricity to rise and demand to fall. In our modelling, demand for electricity is fairly inelastic, due, in part, to very inelastic residential demand. This is why the percentage increase (relative to base) in the price of electricity necessary to achieve the targeted reduction in use is so large. The increase is much larger than in Scenario 3 because the price paid by wholesalers for coal-fired power, which represents around 85 per cent total generation, rises. In Scenario 3, the price-of coal-fired power falls. In Scenario 4, the price of gas-fired electricity also rises, but by less than in Scenario 3. As in Scenario 3, the tax-induced increases in price for fossil-fuel electricity is not large enough to encourage big increases in the use of very costly renewable options.

The table below summarises the main forces underlying changes in the wholesale price of electricity in the three alternative scenarios.

Forces underlying changes in electricity prices

	Change in electricity price	Key forces
Scenario 2	Down moderately	Demand contraction offsets outward shift in supply.
Scenario 3	Up moderately	Shift towards more expensive gas-fired electricity and away from less expensive coal-fired electricity. Gap in price is initially less than $1m/PJ. Steadily increases, as demand for gas-fired electricity rises and demand for coal-fired electricity falls. The average price (effectively the wholesale price) rises, but not significantly. Some of the upward pressure on the wholesale price of electricity offset by increased demand management.
Scenario 4	Up significantly	All fossil fuel generators are taxed. The tax is made larger because of inelastic demand for electricity by final customers. Incentive to substitute towards gas-fired power is less than in Scenario 3. As in Scenario3, increased demand management offsets some of the upward pressure on the wholesale price of electricity.

Table A: Industries in MMRF-Green[*]

Name	Description of major activity
1. Agriculture	All primary agricultural activities plus fishing
2. Forestry	All forestry activities, including logging and management
3. Iron ore	Mining of iron ore
4. Non-iron ore	Mining of non-iron ores, including gold and base ores
5. Black coal	Mining of black coal – thermal and metallurgical
6. Crude oil	Production of crude oil
7. Natural gas	Production of natural gas at well
8. Brown coal	Mining of brown coal
9. Food, beverages and tobacco	All secondary agricultural activities
10. Textiles, clothing, footwear	Manufacture of textiles, clothing and footwear
11. Wood and paper products	Manufacture of wood (including pulp) and paper products
12. Chemical prods. excl. petrol	Manufacture of basic chemicals and paints
13. Petroleum products	Manufacture of petroleum products
14. Building prods (not cement & metal)	Manufacture of non-metallic building products excl. cement
15. Cement	Manufacture of cement
16. Iron and steel	Manufacture of primary iron and steel.
17. Alumina and aluminium	Alumina refining and aluminium smelting
18. Other metal products	Manufacture of other metal products
19. Motor vehicles and parts	Manufacture of motor vehicles and parts
20. Other manufacturing	Other manufacturing including electronic equipment
21. Electricity – black coal	Electricity generation from black coal thermal plants
22. Electricity – brown coal	Electricity generation from brown coal
23. Electricity – gas	Electricity generation from natural gas
24. Electricity – oil prods.	Electricity generation from oil products thermal plants
25. Electricity – hydro	Electricity generation from renewable sources – hydro
26. Electricity – biomass	Electricity generation from renewable sources – biomass
27. Electricity – biogas	Electricity generation from renewable sources – biogas
28. Electricity – solar	Electricity generation from renewable sources – solar
29. Electricity – wind	Electricity generation from renewable sources – wind
30. Electricity supply	Distribution of electricity from generator to user
31. Urban gas distribution	Urban distribution of natural gas
32. Water and sewerage services	Provision of water and sewerage services
33. Construction services	Residential building and other construction services
34. Trade services	Provision of wholesale and retail trade services
35. Road transport services – direct	Provision of road passenger transport services
36. Road transport services – freight	Provision of road freight transport services
37. Rail transport services – direct	Provision of rail passenger transport services
38. Rail transport services – freight	Provision of rail freight transport services
39. Water transport services – direct	Provision of water transport for international freight and passenger carriage.
40. Water transport services – freight	Provision of water freight transport services within Australia
41. Air transport services – passenger	Provision of air transport services for international freight and passenger carriage.
42. Air transport services – freight	Provision of air freight transport services within Australia
43. Other transport services	Provision of water, air and rail transport services
44. Communication services	Provision of communication services
45. Financial/business services	Provision of financial and business services
46. Dwelling ownership	Services of dwellings
47. Public services	Provision of public services
48. Other services	Provision of all other services
49. Private motor vehicle ownership	Services of private motor vehicles

* For most of the products identified in this table there is an obvious correspondence to one or more standard categories in the Australian and New Zealand Standard Industrial Classification (ANZSIC). The exceptions are: industries 21 to 30, which together comprise ANZSIC 3610 *Electricity Supply*; industry 46, which is equivalent to the *Ownership of dwellings* industry in the industrial classification of the official Input/Output statistics; and industry 49 which is unique to MMRF-Green. Industry 49 produces the services of the stock of private motor vehicles. It is analogous to industry 49, which produces the services of the stock of dwellings.