Grandfathering and greenhouse: the role of compensation and adjustment assistance in the introduction of a carbon emissions trading scheme for Australia

Flavio Menezes

John Quiggin

And

Liam Wagner

A Contributed Paper to the Australian Agricultural & Resource Economics Society's Annual Conference,
Cairns, February 11-13, 2009.

Grandfathering and greenhouse: the role of compensation and adjustment assistance in the introduction of a carbon emissions trading scheme for Australia

Flavio Menezes, John Quiggin, and Liam Wagner

University of Queensland, School of Economics

Jan 2009

Abstract: The terms 'grandfather clause' and 'grandfathering' describe elements of a policy program in which existing participants in an activity are protected from the impact of regulations, restrictions or charges applied to new entrants. In this paper, the role of grandfathering in the design of a carbon emissions trading scheme in Australia is assessed. It is argued that adjustment assistance policies such as those adopted in conjunction with previous microeconomic reform programs are preferable to policies based on the free issue of emissions permits.

JEL Classification: Q52; Q58.

Key-words: grandfathering; emissions trading; compensation; adjustment assistance.

1. Introduction

The introduction of a carbon emissions trading scheme, such as the proposed Australian Carbon Pollution Reduction Scheme (Commonwealth Department of Climate Change 2008), will involve significant costs to households, employees and businesses, while yielding long term net benefits to Australia and the world. In this respect, the Scheme is similar to previous microeconomic policy reforms in Australia, such as the restructuring of industry assistance policy from the early 1970s to the 1990s (Quiggin 1996).

The distributional consequences of previous reforms in Australia have been dealt with following two main principles. First, where reforms have generated additional revenue, this revenue has been redistributed to households in a way designed to ensure that most households, and particularly those on low incomes, are no worse off, on balance.

Second, where reforms involve structural adjustment, workers, firms and communities have been given adjustment assistance to find new sources of employment and to offset the costs of structural change. However, owners of capital have not, in general, been compensated for the loss of future profits arising from policy changes.

The current policy debate in Australia signals a possible departure from these long-standing principles by contemplating compensation to investors in industries such as brown coal generation, which are likely to be severely affected by the introduction of a carbon emissions trading scheme. These proposals are described in the Green Paper on a Carbon Pollution Reduction Scheme (Commonwealth Department of Climate Change 2008). The aim of this paper is to provide an analysis of the costs and benefits of departing from established practice by compensating investors in affected industries.

This paper is organised as follows. The general principles of compensation for changes in policy are discussed in Section 2. Section 3 focuses both on the international experience and on the current policy debate in Australia regarding the allocation of free permits to compensate industries for the introduction of a carbon emissions trading scheme. Section 4 deals with the treatment of emissions-intensive tradeable goods. In Section 5, estimates are presented of the effects of the introduction of an emissions trading scheme and a cap on emissions (with a range of implicit carbon prices) on the profitability of electricity generators.

2. General principles of adjustment assistance

In considering whether the proposed carbon emissions trading scheme should constitute an exception to established principles regarding adjustment to changes in Australian public policy, it is important to consider whether reasonable investors should have anticipated the introduction of an emissions trading scheme, or similar measures aimed at reducing emissions of greenhouse gases.

The physics of the greenhouse effect have been understood since the work of Arrhenius (1896) around the turn of the 20th century. The possibility of human-caused global warming was discussed by the US National Academy of Sciences in the 1970s (United States Committee for the Global Atmospheric Research Program 1975), but it was unclear at this time whether warming would be outweighed by natural or anthropogenic cooling associated with such factors as the emission of aerosols from industrial processes.

By 1988, concern about human-caused climate change had become sufficient to justify the establishment of the Intergovernmental Panel on Climate Change (IPCC) by the United Nations and the World Meteorological Organization. From this point onwards, standard business practice required that reasonable investors should have taken account of the possible implications of global warming and measures proposed to mitigate it. Early Australian studies of the issue included an analysis by the Industry Commission (1991).

The IPCC issued its first assessment report in 1990 (Houghton, Jenkins and Ephraum 1990), and a second assessment report in 1995 (Intergovernmental Panel on Climate Change 1995). The second IPCC report found that climate had changed over the past century and while many uncertainties remained, ‘the balance of evidence suggests a discernible human impact on climate’.

The first international policy response was the United Nations Framework Convention on Climate Change signed by Australia in 1992, which, despite carefully flexible language, was generally understood as embodying a commitment to reduce greenhouse gas emissions. The general language of the Framework Convention was converted to more specific comments in the Kyoto Protocol to the Convention, which was agreed to in 1997, and came into force in 2005 following ratification by all major emitters except the United States and Australia.

In negotiations leading up to the drafting of the Kyoto Protocol, a clear preference became evident for market-based approaches such as emissions trading schemes, as opposed to direct regulatory controls on production processes (the ‘command and control’ approach). The Australian delegation played a central role in this process, reflecting extensive analysis of the policy implications of emissions trading undertaken by the Australian government and its research agencies including the Australian Bureau of Agricultural and Resource Economics (1995, 1997, 1998), the Bureau of Transport Economics (1998) and the Industry Commission (1991).

Investors have had 20 years’ warning of the possibility that action would be taken to mitigate global warming. It has been at least 10 years since the Australian government indicated its willingness to meet specific targets for reductions in carbon emissions, with a preference for market-based policies such as emissions trading schemes. Few policy changes in Australian history have come with such lengthy advance notice.

To assess the adequacy of information for investors in the electricity industry, it is useful to examine the history of investment in the industry. Electricity generation assets in Victoria and South Australia, the two states most reliant on brown coal, were privatised in the 1990s. Most of the Victorian assets were later resold by the initial buyers. Hazelwood power station, among the power stations most likely to close as a result of the introduction of an emissions trading scheme, was expected to close in the 1990s, but was extensively refurbished following its privatisation. Thus, it is, in effect a new asset. Assuming due diligence, the existing owners of brown coal power stations acquired these assets in full knowledge that they might be subject to restrictions on carbon dioxide (CO_2) emissions.

It might be argued that the sale value of assets was reduced when, around 1988, the possibility of climate change mitigation policies became evident, and that the owners of the assets at that time (namely, state governments) deserve compensation. On standard assumptions about commercial discount rates and depreciation however, the proportion of asset value accounted for by earnings over 20 years in the future is modest. Assuming, say, a real discount rate of 8 per cent and depreciation of 5 per cent, the residual value of an asset 20 years in the future is about 6 per cent of its current value. Such losses are small in relation to those associated with normal commercial risks.

Furthermore, one needs to consider the effects of compensation on dynamic efficiency. More specifically, a decision to compensate investors who chose the 'wrong bet' might treat unfairly those investors who, understanding the risks involved, decided not to invest in brown coal generation. It is well known that moral hazard might emerge when investors do not face the full cost of their decisions.

The case of tariff policy: a comparison

One of the most important processes of industry adjustment in Australia has been the reform of industry assistance policy and, in particular, tariff policy. In 1972, tariff protection had been a central element of Australian industry policy for more than 60 years. Although some academic debate on the topic had emerged in the late 1960s, the policy was barely debated in public (Quiggin 1996).

In 1973, the Whitlam Labor government cut tariffs by 25 cent and initiated a process of tariff reform, converting the Tariff Board into the Industries Assistance

Commission, the predecessor of the Productivity Commission. The process slowed down under the Fraser Coalition government, but by the early 1990s, the policy of tariff protection had been effectively abolished.

In the course of this process, the share of import-competing manufacturing in the Australian economy declined dramatically. Large numbers of firms closed down or relocated production overseas. Governments undertook a wide range of adjustment policies to assist displaced workers, and to facilitate movement into alternative sources of employment. Adversely affected communities also received assistance in the development of new industries.

Although adjustment policy was the subject of wide-ranging debate, the idea of compensating owners of capital for foregone profits was not even raised, let alone implemented. (See, for example, Productivity Commission 1998). Where firms received adjustment assistance, the aim was to encourage the transition to new and more socially productive activities, not to maintain existing production patterns.

3. Free emissions permits and grandfathering

The term 'grandfather clause' arose in the Southern United States after the Civil War and Reconstruction eras, when resurgent white elites sought to exclude blacks (and sometimes poor whites) from voting, by restricting the franchise to men whose grandfathers had been entitled to vote before the War. Such clauses were eventually ruled unconstitutional (BlackPast.org 2008).

Despite these unsavory origins, the terms 'grandfather clause' and 'grandfathering' have come to be used as a neutral description of any element of a policy program in which existing participants in an activity are protected from the impact of regulations, restrictions or charges applied to new entrants. Grandfathering has been particularly common in the development of policies to control pollution in the United States, where the *Clean Air Act Extension* of 1970 drew a sharp distinction between new and existing sources of pollution.

Two main forms of grandfathering have been used, depending in part on the form of regulation applied to pollution. Where point sources of pollution are required to adopt particular control technologies, or to limit the volume of emissions, existing sources may be exempted from the requirement, or subjected to less stringent restrictions than new sources. Where an aggregate limit is applied to pollution or some other environmentally damaging activity, existing sources may be granted permits, while new entrants may be required to buy permits, or to undertake offsetting activity.

International experience of grandfathering in emissions trading schemes

The first emissions trading schemes were mandated by the 1990 amendments to the US *Clean Air Act* (first passed in 1963) and covered the emission of sulphur dioxide (SO_2) (US Environmental Protection Authority 2008). Title IV of the Act set a goal of reducing annual SO_2 emissions by 10 million tons below 1980 levels. To achieve these reductions, the law required a tightening of the restrictions placed on power plants that relied on fossil fuels.

Phase I began in 1995 and affected 263 units at 110 mostly coal-burning electric utility plants located in 21 eastern and Midwestern states. An additional 182 units joined Phase I of the program as substituting or compensating units. Emissions data indicate that, under Phase I, SO_2 emissions at these units were reduced by almost 40 percent below their required level.

Phase II started in 2000. Annual emissions limits imposed on these large, higher emitting plants were tightened. In addition, restrictions were imposed on smaller, cleaner plants fired by coal, oil, and gas. The program now covers all new generating units and existing units with an output capacity of greater than 25 megawatts.

The US SO_2 emissions permit trading system evolved from more limited forms of offsets, which in turn evolved from a fixed regulation. The starting point implied 100 per cent grandfathering, since companies did not have to pay anything to emit their regulated quantity. To establish an auction market, the US Environmental

Protection Authority withdrew around 3 per cent of allowable emissions permits, and sold these at auction.

Under the cost-based regulatory system that prevailed when the SO_2 emissions trading scheme was introduced, electricity prices were adjusted in line with costs, so that they would be unlikely to change as a result of the issue of free permits. However, with deregulation, market prices would be expected to incorporate the opportunity cost of permits, whether they were issued freely or bought in the market. Thus, the allocation of free permits represented an effective transfer from consumers to generators. However, because the permit program evolved gradually from a system of regulatory controls, with allocation of permits to generators being the default choice, this issue did not raise significant concern.

The European experience with CO_2 emissions trading is more directly relevant to the choices faced in Australia. In the first trading period, from 2005 to 2007, emissions permits were required for the power and heat generation industry and in selected energy-intensive industrial sectors. As in the US SO_2 emissions trading system, generators were allocated free permits in the first phase of the European emissions trading scheme (European Commission 2008).

Unlike the US case, the free issue of permits has been the subject of intense controversy. Critics such as Grubb (2006) focused attention on electricity sector profits from the combination of free allowances and the passing through of increased costs to final consumers. The second phase of the scheme maintained the practice of issuing free permits. However, the European Commission has proposed auctioning 60 per cent of permits in the Third Phase, beginning in 2013, and an increasing proportion thereafter.

The policy of auctioning permits is gaining increased acceptance. The Regional Greenhouse Gas Initiative is a co-operative effort to reduce CO_2 emissions from power plants by ten north-eastern and Mid-Atlantic States in the United States. Under this scheme, which starts in 2009, there will be no free allocation of permits to electricity generators (Regional Greenhouse Gas Initiative 2008).

In summary, international experience with grandfathering pollution permits cautions against a generous free allocation, which can lead to an increase in profits in the electricity industry given the ability of generators to pass the increased costs on to consumers.

Current policy discussions

In recent discussions of the design of an emissions trading scheme for Australia, grandfathering has been a central issue. Different forms of grandfathering have been proposed in different cases.

Exemptions from participation in the scheme have been proposed for some sectors, both on grounds of practicality (such as the difficulty of assessing and monitoring emissions from agriculture) and on the grounds that trade-exposed, energy intensive industries should not be required to reduce emissions in the absence of a more comprehensive international agreement. It has also been suggested that the impact of the scheme on motor transport should be offset by reductions in fuel taxes.

Garnaut (2008) argues that current emitters should not receive free permits and offers a number of supporting arguments. First, the costs of emissions permits, like other costs of production, will ultimately be passed on to consumers, so there is no need to compensate producers through the allocation of free permits. This argument will be formalised below.

Second, Australian governments have not, in general, compensated asset owners for losses associated with economic reforms or resulting from the internalisation of externalities. In general, it has been assumed that such losses are similar in character to those arising from adverse changes in demand patterns or from the entry of new competitors, and that firms and investors should use their own judgement.

Third, structural adjustment measures would be more appropriate than compensation. Structural assistance includes measures to help displaced workers to find new jobs, and to encourage the establishment of new industries in communities affected by structural change. In addition, such assistance could include incentives for investment in lower emissions technologies such as carbon capture and storage. In Garnaut's view, these alternative structural adjustment assistance measures are likely to yield greater benefits than compensation to owners of electricity generating plants.

Analysis

Where pollution control takes the form of specific technological requirements, or plant-level restrictions on emissions, grandfathering may be technologically efficient, at least in the 'static' case where the policy is implemented, and the firm's responses are determined in a one-shot game. This is because the cost of complying with new requirements will generally be greater for old plants than for newer ones, a point that may be made formally in terms of putty–clay technology.

In the case of tradeable emissions permits, a static analysis suggests that the consequences of grandfathering, in the form of free allocation of permits, are purely distributional. Trade should ensure that the final allocation of permits is consistent with efficiency in reducing emissions to the aggregate target level.

In a dynamic analysis however, it is necessary to take account of the incentive effects on investment choices that arise if grandfathering is anticipated as a feature of future policy changes. In the presence of fully anticipated grandfathering, firms will not invest in emissions-reducing technology even if they expect policy changes that will increase the cost of emissions.

It follows that grandfathering should be considered as a last resort. In general, owners of capital should not be compensated for policy changes that might reasonably be anticipated. Any form of compensation to owners of capital distorts investment decisions.

4. Treatment of emissions-intensive tradeable goods

In the absence of a global agreement on reducing emissions of greenhouse gases, the adoption of measures to reduce emissions in individual countries can have perverse effects.

Currently the international framework governing the emission of greenhouse gases is the United Nations Framework Convention on Climate Change, operationalised in the Kyoto Protocol to the Convention, which was adopted in 1997 and came into force in 2005. All major emitters, with the exception of the United States have ratified the Kyoto Protocol. However, following a change of government in 2006, Canada indicated that it would not fulfil its obligations under the Protocol. Thus, until the first commitment period under the Protocol ends in 2012, the only significant competition from non-compliant firms is that from the United States and Canada. Australian policymakers should seek to encourage these countries to return to compliance with the commitments made in Kyoto.

In the discussion leading up to the drafting of the Kyoto Protocol in 1997, it was envisaged that an initial phase in which developed countries would reduce their emissions would be followed by a global agreement encompassing emissions from both developed and developing countries. Subsequent discussion has produced widespread acceptance of a 'contract and converge' model. In this model, all countries would agree to move, over the period between the present and 2050, to a common level of per capita emissions consistent with stabilisation of global atmospheric concentrations of greenhouse gases at levels leading to warming of 2 degrees Celsius relative to pre-industrial levels.

Adoption of this, or any other comprehensive agreement, will require agreement from developing countries, most importantly China and India, to limit growth in emissions of greenhouse gases and, if the agreed final level is below current emissions, ultimately to reduce emissions levels.

At this stage it is unclear whether major emitters such as China and India will agree to accept quantitative emissions targets. Even assuming successful negotiation of an agreement with these countries, it is necessary to consider the possibility that other countries will remain outside a new agreement, or will fail to comply with their obligations.

A global agreement to reduce emissions will be undermined if emissions-intensive industrial activities are relocated to countries that decline to participate in such an agreement. It is desirable that Australian industries should not be disadvantaged in competition with firms located in non-compliant countries. However, this should not be regarded as the basis for an open-ended commitment to assist emissions-intensive industries, and should not reward the adoption of emissions-intensive technologies.

Assistance to emissions-intensive industries should be treated as a precautionary response to the possibility that no satisfactory successor to the Kyoto Protocol will emerge. It should be made clear in international negotiations that, in markets where all major participants are compliant, Australian firms will be required to participate in the emissions trading scheme and will not receive any special assistance. In particular, this policy should be applied even where, as in the Kyoto Protocol, an international agreement allows for differentiated emissions targets based on the circumstances of particular countries.

Any measure to assist export-oriented industries should be matched by assistance to import-competing industries in competition with competitors located in non-compliant industries, preferably in the form of taxes or quotas on imports from non-compliant countries. Since failure to comply with a global agreement is an unfair subsidy, such measures are consistent with the spirit of the agreements establishing the World Trade Organisation (WTO). In the event that any technical difficulties arise in relation to the WTO, Australia should support renegotiation of the WTO agreement to make explicit the right of compliant countries to respond to the unfair practices in non-compliant countries.

5. Grandfathering: a market analysis

This section provides a conceptual framework to determine the level of compensation, in terms of free carbon emissions permits that would make a representative firm in a given market indifferent between being included in, or excluded from, an emissions trading scheme. In this simple framework we consider a representative firm that is subject to perfect competition in the output market.

We assume that the supply of electricity is given by $S(p,p_e)$, where p and p_e denote, respectively, output and emission permit prices and demand for electricity is given by $D(p)$. We abstract from distribution and transmission charges and consider a vertically integrated generator/retailer who faces perfect competition downstream.

In this setting, if the target quantity of emissions is q^*_e , then the equilibrium output price p^*, the equilibrium output quantity q^*, and the equilibrium price of emissions p^*_e satisfy the following:

$$q_e(p,p_e) = q^*_e,$$

$$S(p^*,p^*_e) = D(p^*) = q^*$$

where $q_e(p,p_e)$ is input demand for emissions. Let

$$s_e = (p_e q_e)/pq$$

be the cost share of emissions, assuming competitive pricing so that pq is equal to the total cost of producing q units of output.

Letting p_0 be the equilibrium price when $p_e = 0$, we have, for small changes in emissions around p_0,

$$(p^* - p_0)/ s_e p_0 = \rho /(\rho + \varepsilon) = \gamma,$$

where ρ is the (price) elasticity of supply and ε is the (price) elasticity of demand.

In the case where emissions intensity cannot be adjusted, therefore, a representative firm will have profit unchanged if $g = (1-\gamma)\ q^*_e$ permits are issued.

It is generally assumed that the elasticity of supply greatly exceeds the elasticity of demand, both in the short run and in the long run.

In the short run, the elasticity of supply in the electricity market is determined by the bidding behaviour of market participants. Observations on the bid curve suggest that the short-run elasticity of supply is likely to be in the range 0.5 to 1. The short-run elasticity of demand for electricity is close to zero, perhaps 0.1. In the long run, estimates of the elasticity of demand are close to 1, while under standard assumptions the elasticity of supply is very large (with constant returns to scale at the industry level, the elasticity of supply is infinite). In both cases, supply is substantially more elastic than demand.

It follows that, in a homogenous industry, if the policy objective were to leave the welfare of industry participants unchanged, g, the optimal proportion of permits to be allocated freely, would be small, since most cost increases will be passed on to consumers. With a short-run elasticity of supply equal to 0.5 and elasticity of demand equal to 0.2 (assumptions that are respectively conservative and optimistic), the optimal proportion of freely allocated permits would be below 30 per cent. More plausible parameter values would suggest that free permits should be no more than 15 per cent of the total.

5. Treatment of Electricity Generators

The Green Paper on a Carbon Pollution Reduction Scheme (Commonwealth Department of Climate Change 2008) indicates that assistance to deal with the effects of a carbon emissions trading scheme should be provided to generators of coal-fired electricity, but does not nominate a preferred delivery mechanism. The latter perspective is consistent with long-standing practice in adjustment assistance policy. Governments have long provided assistance to enable firms to reorient production activities and avoid or reduce redundancies, and to assist workers and communities in the adjustment to changing patterns of employment. By contrast, as noted above, the suggestion that owners of capital assets should be compensated for changes in government policy that reduce the expected flow of income from those assets represents a radical innovation.

It may be argued, however, that as coverage will initially be partial, particular groups of emitters, would seek to delay their inclusion in an emissions trading scheme if compensation were not provided. An appropriate compensation mechanism would reduce the incentive to lobby for exemptions from the scheme. This argument raises the question of how to estimate the appropriate level of compensation. One possible response to this question is to estimate the volume of free permits that would leave existing emitters no worse off than in the absence of the scheme.

Simulation analysis

The theoretical analysis presented in Section 5 incorporates a number of simplifying assumptions. Most notably, the electricity supply industry is treated as homogenous, allowing the derivation of effects on a representative firm. In reality, electricity generation is undertaken using a variety of technologies and fuels. The most emissions-intensive plants are those fired by brown coal (primarily in Victoria), followed by black coal-fired plants. With the exception of hydro-electric generation , where there is little scope for expansion, and renewable sources such as wind energy (still a very small share of the total), the least emissions-intensive generators are those fired by natural gas. Closed-cycle natural gas plants have lower emissions, but higher capital costs, than open-cycle plants.

In addition, the vertically separated structure of the electricity supply industry means that the price paid by consumers is not equal to the price received by generators. Transmission and distribution costs contribute around $0.03–0.05/kWh ($30–$50/MWh) to the retail price of electricity (National Electricity Code Administrator 2002), and retailers' margins increase the price by around 10 per cent.

The spot price received by electricity generators is determined by the operations of the National Electricity Market (NEM) established in 1998 Under the NEM, the electricity price is set in a pool market at intervals of 30 minutes by matching bids, submitted by generators with demand from electricity users and retailers (National

Electricity Market Management Company 2008). Prices in peak periods are significantly higher than in off-peak periods. In periods of high demand and when significant generators are off-line due to breakdowns or maintenance, prices can reach very high levels, capped under the NEM at $10 000/MWh.

Because of capacity constraints on interstate connections, the price of electricity differs between states, although prices tend to move together. For the purposes of this study, we will focus attention on the price in New South Wales, using data for 2007 derived from *Liam can you supply details here, please*

This simplification is based on the implicit assumption that the effects of transmission interconnector constraints do not vary significantly over time, and therefore that the price in one state can be treated as representative of the market as a whole. Additional simplifications include the exclusion from consideration of the current state-based emissions abatement and technology enhancement schemes.

More importantly we simplify by considering the market as having only two components: peak and off-peak, and we treat the observed distribution of market outcomes in 2007 (referred to as the Base Case) as representative of market behaviour in the absence of a carbon emissions trading scheme. Table 1 shows the average electricity price for New South Wales for all periods, for peak and for off-peak, expressed in $/MWh.

Table 1: Average electricity prices for New South Wales in 2007, $/MWh (Base Case).

Average Price	67.07
Peak Average Price	97.95
Off_-Peak Average Price	44.98

Simulation approach

The approach used to simulate the introduction of a carbon emissions trading scheme involves a number of steps. The first step is to simulate the bidding behavior of generators. For each class of generators, we use data from ACIL Tasman (2007) on short-run marginal costs, medium-term variable costs and average availability. We construct a supply curve based on the assumption that firms are willing to supply electricity at prices equal to or greater than their short-run marginal cost, provided that average returns are sufficient to cover medium-term variable costs. This gives rise to an order of merit for peak and off-peak production.

We then construct, from observed market outcomes, the distribution of quantities demanded at market clearing prices for each half-hour period in 2007. For periods when average availability exceeds demand, we assume that supply is allocated according to the merit order, with price being determined by the short-run marginal cost of the marginal supplier. For peak periods when demand exceeds average availability, we assume that the amount supplied increases proportionately for each class of generator, reflecting the capacity to increase availability in periods of high demand. For these periods, the observed market-clearing price is received by all generators.

Next we simulate the introduction of an emissions trading scheme. We assume that all firms increase their bids by an amount given by

$$\Delta = p_e*(q_e/q)*\theta,$$

where Δ is the increase in bids, p_e is the price of emissions permits, q_e/q is the emissions intensity ratio (that is, the quantity of emissions per unit of output) and θ is the pass-through factor.

This formulation requires some simplifying assumptions. First, it is assumed that the scheme gives rise to a market price for permits which is stable over the course of a given year. Depending on the design of the scheme, this market price might be an upper limit, reached under 'safety-valve' arrangements such as those proposed by McKibbin and Wilcoxen (2002). Alternatively, the price may be the equilibrium value reached in the national market for emissions permits.

In addition, it is assumed that prices are not constrained by retail price caps. The introduction of a carbon emissions trading scheme requires that, if such price caps are retained, they should be adjusted to allow generators to pass on the cost of emissions permits.

The emissions permit price p_e is stated in terms of the price for a permit to emit one tonne of CO_2. A range of values for p_e, from $A20 to $A50 is considered. Values for the emissions intensity factor (q_e/q) are given by Table 2.

Table 2: Emissions intensity factors for electricity generation technologies

Generation Technology	Emissions Intensity[1]
Hydro-electricity	0
Closed Cycle Gas Turbine	0.5
Open Cycle Gas Turbine	0.6
Black Coal	1
Brown Coal	1.3

1. Tonnes of CO_2 emitted for each MWh generated

In the simulations reported here, we assume $\theta = 1$ (full pass-through of costs to consumers). Other simulations, available as an Appendix from the authors, show that results are generally robust to the use of values of θ as low as 0.8.

The next step in the modeling process is estimation of the change in equilibrium average prices for peak and off-peak electricity supply, after taking account of demand responses. Assuming that the short-run elasticity of demand is equal to 0.2 for retail electricity, and that approximately half of all costs are associated with the distribution and retail sectors, we estimate the derived short-run elasticity of demand for electricity in the wholesale market to be 0.1.

After taking account of demand responses to the shift in market supply associated with the requirement to buy emissions permits, it is possible to estimate the change in market price, the change in emissions and the changes in revenues and profits for each class of generators.

Results

As noted above, the crucial determinant of supply response is the 'merit order' associated with the market, ranking electricity suppliers from lowest cost to highest cost. Initially, brown coal-fired baseload stations are the least-cost suppliers. However, at an emissions permit price of $26/tonne, the short-run marginal costs of brown coal, black coal and gas-fired power are approximately equal. At higher emissions permit prices, brown coal stations are displaced in the merit order by gas and black coal.

At emissions permit prices of around $30/tonne, brown coal power stations cease to cover their long-run variable costs of operation, and will therefore shut down. The first plants to close will be those with high long-run variable costs of operation, and relatively short remaining lives, such as Hazelwood in Victoria.

Table 3 provides a summary of average electricity prices for the various emissions permit price scenarios, after taking account of the interaction of supply and demand responses.

Table 3: Electricity price outcomes with a range of carbon emission permit prices

Emissions permit price ($/tonne of CO_2 emitted)	Average electricity Price ($/MWh)	Peak price ($/MWh)	Off-Peak price ($/MWh)
0	67.07	97.95	44.98
20	84.53	109.95	66.34
25	89.57	112.95	72.84
30	94.61	115.95	79.34
40	104.69	121.95	92.33
50	114.77	127.95	105.33

Two features of Table 3 are particularly notable. First, the average electricity price (expressed in $/MWh) increases by approximately one dollar for each one dollar increase in the emissions permit price, (expressed in $/tonne of CO_2 emitted). This is consistent with the observation, from Table 2 above, that the emissions intensity for most kinds of electricity generation is around 1 tonne/MWh. Second, the increase in off-peak prices is greater than the increase in peak prices. This reflects the fact that the main fuel used in baseload generation (that is, in both peak and off-peak periods) is coal, while gas-fired generation is used only in peak periods, except when emissions permit prices are high enough to displace brown coal.

The change in CO_2 emissions associated with a given emissions permit price may now be estimated. The change in emissions is determined by the change in the mix of generation technologies arising from the change in merit order caused by the introduction of emissions trading and by the reduction in demand for electricity associated with higher electricity prices. Table 4 shows the relationship between emissions permit prices, electricity demand, and emissions of CO_2 from electricity generation.

Table 4: Effects of carbon emissions permit prices on electricity demand and CO2 emissions

Emissions permit price ($/tonne of CO2 emitted)	Reduction in electricity demand (per cent)	Reduction in CO2 emissions (per cent)	CO2 emissions (million tonnes)
0	0	0	184
20	2.9	2.9	179
25	3.6	8.1	169
30	4.3	10.1	165
40	5.7	11.8	162
50	6.9	13.4	159

When reading Table 4, it is important to note that, under an emissions trading scheme, the volume of permits issued determines the market-clearing price for emissions permits, and not vice versa. The final column of Table 4 shows the reduction in the volume of allowable carbon emissions for the electricity industry that would be associated with the market-clearing prices for emissions permits presented in the first column.

The final stage of the simulation consists of calculating the changes in the profits of electricity generators after the introduction of a carbon emissions trading scheme compared to the benchmark where no permit is required and the implied price for CO_2 emissions is zero. In this calculation we assume that generators only sell in the spot market and there is no hedging.

Table 5 summarises the results of this calculation. Only brown coal generators are made worse off by the introduction of an emissions trading scheme. The profits of black coal generators are broadly unchanged, reflecting the fact that the emissions intensity of black coal generation is about equal to that for the electricity industry as a whole. Gas generators gain substantially, since their emissions intensity is below that for the industry as a whole. As a result, the increase in electricity prices paid by consumers when the cost emissions permits is passed on to them more than compensates gas generators for the permits they are required to purchase.

Table 5: Changes in profits for electricity generators resulting from a carbon emissions trading scheme

Carbon emissions permit price ($/t)	Change in generators' profits (per cent)			
	Brown coal	Black coal	Closed cycle gas turbine	Open cycle gas turbine
20	-31	2	53	66
25	-29	3	57	72
30	-28	4	60	-
35	-27	5	63	79
40	-27	5	64	81
50	-26	6	67	84

Additional modeling, not reported here, shows that this conclusion is robust to changes in assumptions about the extent to which generators pass on cost increases to consumers through changes in their bids. Even with 80 per cent pass through, which implies either restrictions on retail price increase or a substantial divergence from competitive behaviour, the main loss falls on brown coal generators, though black coal generators suffer modest losses.

The analysis supports the conclusion that policy attention should be focused on generators using brown coal. However, it does not support the view that the main concern should of policy should be to mitigate losses incurred by the owners of such generators.

The primary implication of the analysis is that substantial reductions in emissions will be achieved only when existing brown coal generators are replaced by other sources of electricity or by electricity conservation. In the short run adjustment modeled here, this would be achieved by increasing the availability and output of existing gas-fired plants, and by the demand-reducing effects of higher electricity prices.

In the longer term, adjustment will include the construction of new low-emissions electricity generating plants, and, if technological difficulties can be overcome, the adoption of carbon capture and sequestration technology. Cost-effective carbon capture would probably require the construction of new plants, although retrofitting remains a possibility.

The process of adjustment is usually a difficult and painful one for the workers and communities affected. The primary focus of government policy should be on assisting workers to find new jobs and assisting communities to expand alternative sources of employment. In the context of the La Trobe valley in Victoria, where most brown coal generators are located, this might include assistance with the adoption and implementation of carbon capture and sequestration technology.

Resources diverted to compensating the owners of existing capital for reductions in the value of capital assets are not available to support the adjustment of workers and communities. Any payments made to owners of existing assets should be used to assist this adjustment process, for example by assisting owners of coal-fired plants to implement emission-reducing technologies such as coal-drying, or to develop methods for carbon capture and sequestration.

6. Conclusions

Adjustment assistance policies associated with the introduction of a carbon emissions trading scheme should be based on the established policy framework developed in previous processes of microeconomic reform. In this framework, policy effort is focused primarily on mitigating the adverse impacts of reform on workers and communities, rather than on seeking to compensate owners of capital. In particular, suggestions that investors in assets affected by the scheme require special treatment to maintain confidence are without merit. In fact, such investors have had much more time to prepare for policy change than have those affected by earlier rounds of microeconomic reform.

Assistance to energy-intense trade-exposed industries should only be provided to the extent that Australian firms face competition from non-compliant countries. In particular, exporting and input-competing emissions intensive industries should receive comparable assistance. Assistance to input-competing emissions intensive industries should take the firm of countervailing duties applied to imports from non-compliant countries rather than subsidies to Australian producers.

For the electricity sector as a whole, assuming competitive pricing, most of the costs of an emissions trading scheme will be borne by consumers. Retail price caps, if retained, should be adjusted to ensure that consumers receive an appropriate price signal. Our estimates indicate that adverse effects on producers will be confined to brown coal generators. Any effective scheme to reduce carbon emissions is likely to require the closure of some brown coal generators. However, adjustment assistance should be directly primarily towards enabling workers, firms and communities to deal with the consequences of plant closures rather than towards compensating investors.

References

ACIL Tasman (2007), *Fuel Resource, New Entry & Generation Costs in the NEM: Report 2 - Data & Documentation*, Report to NEMMCO, http://www.nemmco.com.au/psplanning/410-0090.pdf

Arrhenius, S. (1896), 'On the influence of carbonic acid in the air upon the temperature of the ground', *London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science (fifth series)*, 41, 237–75.

Australian Bureau of Agricultural and Resource Economics (1995), *Global Climate Change: Economic Dimensions of a Cooperative International Policy Reponse beyond 2000*, Commonwealth of Australia, Canberra.

Australian Bureau of Agricultural and Resource Economics (1997), *The Economic Impact of International Climate Change Policy*, Commonwealth of Australia, Canberra.

Australian Bureau of Agricultural and Resource Economics (ABARE) (1998), 'Greenhouse gas emissions trading', *ABARE Update*, April, 6–9.

BlackPast.org (2008), 'Grandfather Clause, The (1898–1915)', http://www.blackpast.org/?q=aah/grandfather-clause-1898-1915, visited 17 Nov 2008.

Bureau of Transport Economics (1998), *Trading Greenhouse Emissions: Some Australian Perspectives*, Occasional Paper 115, ed. Leo Dobes, Bureau of Transport Economics, Canberra.

Commonwealth Department of Climate Change (2008), *Carbon Pollution Reduction Scheme: Green Paper*, July,, http://www.greenhouse.gov.au/greenpaper/report/pubs/greenpaper.pdf.

European Commission (2008), 'Emission Trading Scheme (EU ETS)', http://ec.europa.eu/environment/climat/emission/index_en.htm,

Garnaut, R. (2008), *Garnaut Climate Change Review*, Cambridge University Press, Melbourne.

Grubb, M. (2006), 'The EU Emissions Trading Scheme -- present lessons, future evolution', 2nd Annual Conference of the Centre for Energy and Environmental Markets (CEEM), Sydney. http://www.ceem.unsw.edu.au/content/userDocs/10-06EUETSCEEMpresentation_001.pdf.

Hinchy, M., Fisher, B. and Graham, B. (1998), 'Emissions Trading in Australia: Developing a Framework', ABARE Research Report 98.1, Canberra.

Houghton, J., Jenkins, G. and Ephraums, J. (eds) (1990) *Climate Change: The IPCC Scientific Assessment,* Cambridge University Press, Cambridge.

Industry Commission (1991), *Costs and benefits of reducing greenhouse gas emissions: Volume 1*, Report No. 15, Australian Government Publishing Service.

Intergovernmental Panel on Climate Change (1995), *IPCC Second Assessment Report: Climate Change*, IPCC, Geneva.

National Electricity Code Administrator (NECA) (2002), 'The performance of the national electricity market: Final report', NECA, Adelaide.

National Electricity Market Management Company Limited (NEMMCO) (2008), *An Introduction to Australia's National Electricity Market*, NEMMCO, Melbourne. http://www.nemmco.com.au/about/000-0283.pdf

Productivity Commission (1998), *Annual Report 1997-98*, Productivity Commission, Melbourne.

Quiggin, J. (1996) *Great Expectations: Microeconomic Reform and Australia,* Allen & Unwin, St. Leonards, NSW.

Regional Greenhouse Gas Initiative (2008), 'Regional Greenhouse Gas Initiative CO2 budget trading program', http://www.rggi.org/home.

United States Environmental Protection Authority, (2008), 'Allowance Trading Basics', http://www.epa.gov/airmarkets/trading/basics.html, visited 17 Nov 2008.

United States Committee for the Global Atmospheric Research Program (1975) *Understanding Climatic Change: A Program for Action,* National Academy of Sciences, Washington DC.