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Understanding the effect of an emissions trading scheme on electricity generator investment and retirement behaviour: the proposed Carbon Pollution Reduction Scheme

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The objective of a greenhouse gas (GHG) emissions trading scheme (ETS) is to reduce emissions by transitioning the economy away from the production and consumption of goods and services that are GHG intensive. A GHG ETS has been a public policy issue in Australia for over a decade. The latest policy initiative on an ETS is the proposed Carbon Pollution Reduction Scheme (CPRS). A substantial share of Australia's total GHG reduction under the CPRS is expected to come from the electricity generation sector. This paper surveys the literature on investment behaviour under an ETS. It specifically focuses on the relationship between the design of an ETS and a generator's decisions to invest in low emissions plant and retire high emissions plant. The proposed CPRS provides the context for presenting key findings along with the implications for the electricity generation sector's transition to lower emissions plant. The literature shows that design features such as the method of allocating permits, the stringency of the emissions cap along with permit price uncertainty, provisions for banking, borrowing and internationally trading permits, and the credibility of emissions caps and policy uncertainty may all significantly impact on the investment and retirement behaviour of generators.

Key words: cap-and-trade, climate change, emissions trading, investment.

1. Introduction

Concerns over the possible harmful effects of global climate change arising from the accumulation of anthropogenic emissions of greenhouse gases (GHGs) in the atmosphere have led to proposals for, and in some countries the implementation of, a cap-and-trade GHG emissions trading scheme (ETS). An advantage of using an ETS is that it can theoretically achieve emissions reductions at minimum cost by equalising the marginal abatement costs across emitters (Baumol and Oates 1988). Countries with national cap-and-trade schemes either operating or proposed include the members of the European Union, New Zealand, Australia, Canada, Japan, Switzerland and the United States (Nielson 2008).

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A GHG ETS has been a public policy issue in Australia for over a decade. The latest policy initiative on an ETS is the government's proposed Carbon Pollution Reduction Scheme (CPRS).[1] The CPRS's objective is to reduce Australia's GHG emissions by transitioning the economy away from the production and consumption of goods and services that are GHG intensive. An important question concerning both the efficiency and effectiveness of the CPRS is how will it affect the transition to less GHG intensive technologies in energy-intensive industries? As the Stern review on the economics of climate change stresses, capital investment decisions made over the next two decades will have major implications for our climate during the second half of this century and into the next (Stern *et al.* 2006).

Economic modelling of various ETS scenarios by Treasury (2008) show a substantial share of Australia's total GHG reduction is expected to come from the electricity generation sector. This presents a major challenge for the sector. In 2007 electricity generation accounted for 36.9 per cent of Australia's total emissions, and 84.4 per cent of these were from black and brown coal-fired generation plants (Department of Climate Change 2009c). The amount of new and replacement investment in electricity generation plant needed in Australia over the next few decades is substantial. Recent estimates of investment required from 2011 to 2020 range from A$13 billion under business as usual, to A$36.5 billion under an ETS that reduces GHG emissions by 20 per cent of 2000 levels (ACIL Tasman 2008a). The effect of the CPRS on the transition of the sector to lower emissions generation plant will therefore have major implications for future levels of emissions and the dynamic efficiency of the scheme. This underscores the importance for policy makers to comprehensively understand how generators are likely to respond through their plant investment and retirement decisions to the design of the CPRS.

This paper surveys the literature on investment behaviour under an ETS. It specifically focuses on the relationship between the design of an ETS and a generator's decisions to invest in low emissions plant and retire high emissions plant. The proposed CPRS provides the context for presenting key findings along with the implications for the electricity generation sector's transition to lower emissions plant. Details of the CPRS that are relevant to the electricity generation sector are initially presented. This is followed by insights from the literature on significant design features affecting the investment and retirement behaviour of generators. These comprise the method of allocating permits; the stringency of the emissions cap along with permit price uncertainty; provisions for banking, borrowing and internationally trading permits; and the credibility of emissions caps and policy uncertainty.

[1] Unless otherwise stated, details relating to the CPRS refer to the proposed Carbon Pollution Reduction Scheme Bill No.2 2009 and the proposed measures to safeguard the security of electricity supplies (Department of Climate Change 2009a,b).

2. The Carbon Pollution Reduction Scheme's impact on electricity generators

In a cap-and-trade ETS the total amount of GHG emissions allowed from specified sources over a set period are capped. Compliance with the emissions cap is achieved by requiring firms in specific sectors to surrender a permit for each unit of GHGs they emit. The CPRS requires electricity generators that emit over 25 000 tonnes of CO_2-equivalent GHGs (CO_2-e) annually to surrender an amount of permits equal to their actual emissions each year. Permits are available for purchase either through monthly 'ascending clock' auctions or the secondary market.[2] Four vintages of permits comprising the current and three subsequent years are offered at each auction. In addition, during the scheme's first 10 years free permits are given to coal-fired electricity generators that satisfy specific criteria discussed below. Once permits are initially allocated, the secondary market establishes a price for permits and they flow to where they are most valued. Although the total amount of emissions is capped, each generator's decision regarding the amount of CO_2-e emissions it abates becomes an operational decision, which depends on the marginal cost incurred from abating emissions (through changes in its production technology and/or inputs) compared to the marginal cost of purchasing permits.

Coal-fired electricity generation is deemed a strongly-affected industry requiring transitional assistance through the Electricity Sector Adjustment Scheme (ESAS). The total assistance provided under the ESAS during the first 10 years of the CPRS is capped at 228 700 000 free permits (an estimated A$7 300 000 000). Permits are given to each eligible generation asset (referred to from here on as 'plant') to compensate generators to some extent for financial distress incurred in the short-term, and reduce adverse impacts on investment in the sector in the longer-term. A generation plant's eligibility for free permits depends on either its operational or project status at specific times prior to July 2007, together with the requirement that at least 95 per cent of the electricity it produced came from or was intended to come from the combustion of coal, and the plant was connected or intended to be connected to a grid with a capacity of at least 100 megawatts. The amount of assistance provided to eligible coal-fired generation plants each year is based on their historical energy and emission intensities, which are used to calculate an 'annual assistance factor'. Only plants with energy intensities greater than the threshold level of 0.86 tonnes of CO_2-e per megawatt hour are given an assistance factor. The number of free permits a plant receives depends on the amount by which its emissions intensity exceeds the threshold level, the plant's share of the total assistance factors for all eligible plants, and the share of total permits available for that year.

There are two tests that eligible plants must satisfy in order to receive free permits under the ESAS for all 10 years. These are a 'power system reliability

[2] For details of an ascending clock auction see chapter 9 in Commonwealth of Australia (2008).

test' that applies to each of the 10 years and a 'windfall gain test' that takes place in the last 3 years. Allocations of free permits to a plant may cease or be reduced depending on which test it fails. The power system reliability test aims to avoid adverse impacts on the supply of electricity. A plant will fail this test if its registered nameplate rating (maximum continuous electrical output) is reduced or it ceases registration as a generator, and there is either no replacement investment compliant with The Low Emissions Transition Incentive, or there is likely to be a breach of reliability standards within 2 years of either event occurring. The Low Emissions Transition Incentive allows a generator to continue receiving permits if it retires an emission-intensive plant and replaces it with new low emission generation capacity.

The objective of the windfall gain test is to minimise the prospect of a plant obtaining a windfall gain from free permits. Plants are assessed for the possibility of windfall gains over the 15 year period from the introduction of the CPRS. If a windfall gain declaration is made the plant concerned will only receive 50 per cent of the permits allocated to it over the last 3 years of the ESAS. In the event of a generator disputing a windfall gain declaration there is a comprehensive review process available that includes merit review, judicial review and Ministerial discretion.

The CPRS also provides direct and indirect financial assistance to generators through the availability of deferred payment arrangements for permits purchased at auctions and the Energy Security Assurance Mechanism, respectively. The deferred payment arrangements allow generators to pay a 10 per cent deposit to secure the rights to permits of future vintage years successfully bid on in auctions held before the end of 2013. The Energy Security Assurance Mechanism aims to protect against systemic risks to energy supply. It facilitates the provision of limited and conditional financial indemnities, or loan guarantees, by the Government for financially stressed generators to prevent them from abruptly exiting the market and creating supply disruptions.

Policy modelling of the impact of the CPRS on the electricity generation sector shows the transition to lower emissions plants is very responsive to the affect of the scheme on the net returns available from plants of different emissions intensities (ACIL Tasman 2008b; Treasury 2008; McLennan Magasanik Associates 2008). The literature provides many additional insights on how the design of an ETS is likely to affect the net returns of these plants. It shows that design features such as the method of allocating permits, the stringency of the emissions cap along with permit price uncertainty, provisions for banking, borrowing and internationally trading permits, and the credibility of emissions caps and policy uncertainty may all impact on the investment and retirement behaviour of generators.

3. The method of allocating permits

The allocation of emissions permits is regarded as the most critical design feature of a GHG cap-and-trade ETS due to its significance in determining both the efficiency and distributional outcomes of a scheme (Burtraw and Evans 2009). An important distinction between permits received through an auction and those received for free is that under perfectly competitive conditions the latter provide recipients with a subsidy if they are given on the condition that either the firms receiving them continue to produce output, or the allocation is not restricted to a closed class of firms (Kling and Zhao 2000; Pezzey 2003). The decision to keep an existing high emissions plant or retire it and invest in lower emissions plant depends on which alternative provides the largest expected net returns after accounting for any subsidy. If conditional allocations of free permits are a long-term feature of an ETS and the quantity received is dependent on a specific attribute of the plant being considered for investment or retirement then it is likely to affect the generator's decision (Grubb and Neuhoff 2006; Sijm *et al*. 2008).

Allocations contingent on either the operating level of the plant or solely on it remaining operational will lower a generator's variable or fixed costs, respectively (Neuhoff *et al*. 2006). The impact of a subsidy on the relative differences between both the operating and capital costs of alternative technologies are shown to influence a generator's choice (Lundmark and Pettersson 2008; Sijm *et al*. 2008). The size of a subsidy can be large as demonstrated in the Nordic electricity generation sector where the permits received by generators for investment in new low emissions plant ranged from 35 to 51 per cent of annualised fixed costs during phase I of the European Union emission trading system (EU ETS), and 14 to 56 per cent for phase II (Åhman and Holmgren 2006). The decision to retire existing high emissions plant may be delayed if allocations of free permits are contingent on the plant remaining operational, as is the case under a closure rule where permit allocations cannot be transferred to new plant, or the criteria for receiving allocations favour GHG emitting technologies (Neuhoff *et al*. 2006; Sijm *et al*. 2008). A closure rule was found to have extended the life of high emissions generation plants in the EU ETS (Åhman and Holmgren 2006; Åhman *et al*. 2007).

The CPRS provides free permits under the ESAS based on criteria designed to minimise a generator's incentive to alter the future production decisions of high emissions plant in order to increase the value of assistance received. Although the power system reliability test provides an incentive to maintain high emissions plant for the 10 years over which free permits are allocated, the Low Emissions Transition Incentive allows the subsidy to be applied to investment in replacement lower emissions plant. Whether generators are likely to commit to lower emissions plant is difficult to determine as the windfall gains test does little to encourage them to retire high emissions plant with low variable operating costs.

However, the effect of an allocation method on a generator's investment and retirement decisions may be more complex than the direct effect on expected net returns alone suggests. There is empirical evidence that the relationship between investment by firms and the level to which they are leveraged is negative (Lin *et al.* 2008).[3] The allocation can also have financial implications that may indirectly affect the generator's financing arrangements if there are imperfections in the capital market. A key issue is whether the method of allocating permits is likely to have an impact on the external financing of a plant. While the difference in cash flows arising from auctioned and free permits may impact on a generator's financing costs and in turn affect the decision to invest or retire plant (Koutstaal 1997; Åhman and Holmgren 2006; IEA 2007), it should not affect the availability of capital to a generator (Burtraw and Evans 2009).

Electricity generation plants owned by the private sector in Australia typically have debt levels of between 60 and 80 per cent of their investment cost, due to owners leveraging scarce capital across a portfolio of plants to take advantage of economies of scale and scope (Simshauser 2009). If the method of allocating permits results in large reductions in the asset values of existing high emissions plants, then the adverse impact on owner equity may impair the ability of generators to allocate capital to new investments in lower emissions plant (Simshauser 2008). The potential for financial considerations to adversely impact on investment and retirement decisions under the CPRS is low given both the opportunity for plants to earn windfall gains from free permits with minimum penalty, and the possibility of receiving some form of Government guarantee should they become financially distressed.

4. Stringency of scheme caps and permit price uncertainty

The stringency of the scheme's cap on the total quantity of permits issued through allocations each period (usually a year) is a key determinant of the expected prices of permits in the absence of international trade in permits or price caps and floors. Unless the scheme's caps result in sufficiently high expected prices of permits, an ETS alone is unlikely to provide the appropriate cost incentive for firms to invest in research and development, or in lower emissions technologies (Driesen 2007; Gonzalez 2008; Kumbaroğlu *et al.* 2008). Low levels of investment in energy efficiency and emissions abatement by UK firms prior to phase II of the EU ETS are attributed to weak emissions pricing (Sijm *et al.* 2008; Bailey and Ditty 2009).

Scheme caps for the CPRS are set for a minimum period of 5 years in advance and are extended by 1 year each year. During the first 5 years of the scheme an unlimited number of additional permits are available for purchase at capped prices.[4] The price of permits is capped at A$10 per tonne of CO_2-e in the initial year of the scheme (2011–2012) followed by a higher price cap of A$46 per tonne CO_2-e beginning in 2012–2013 and increasing at a real rate of 5 per cent for each following year up to and including 2015–2016.

[3] Leverage is defined in this study as the ratio of total long term debt, which includes the current portion of long term debt, to total assets.

[4] These permits may not be banked and can therefore only be surrendered in the year that they are issued.

When the generator's investment decision can be delayed, both expectations and uncertainties relating to future permit prices jointly play a significant role. The value of an opportunity to delay the investment decision and wait for more information about the future price of permits is positively correlated with uncertainty (represented as volatility) about the permit price (Fuss *et al.* 2009). Uncertainty in the expected price of permits is acknowledged as a significant reason for firms delaying investment under the EU ETS (Grubb and Neuhoff 2006). However, if both the expected price of permits and their volatility are sufficiently high, then the potentially higher future cost of emissions facing generators may provide them with an incentive to commit to investing in lower emissions plant sooner than otherwise (Laurikka and Koljonen 2006).

The expected trend in the permit price also affects the value of the opportunity to delay investment. Fuss *et al.* (2008) show that if the generator expects permit prices to increase over time, then price uncertainty may provide an incentive to invest in lower emissions technologies sooner. The change in incentive arises from the generator expecting to be exposed to higher permit costs for both positive and negative variations in the permit price when it is trending upwards. Consequently there is no value gained from delaying the investment decision.

The combination of a trending and volatile permit price may also influence the generator's choice of technology to invest in. While capital requirements per unit of output tend to have a negative effect on the choice of technology (Lundmark and Pettersson 2008), if the generator expects a large upward trend in the permit price then a capital intensive low or zero emissions technology such as nuclear power can become feasible (Kiriyama and Suzuki 2004). Furthermore, a low upward trend in the permit price may still be sufficient to stimulate investment in low emissions plant if volatility in the permit price is large. Under these conditions greater expected costs may be imposed on high emissions plants and expected benefits received by low emissions plants (Szolgayova *et al.* 2008). The significant impact of permit price uncertainty on a generator's investment decision highlights that when strategic necessity is absent and the decision can be delayed, more than just the expected permit price arising from the scheme's cap is involved. Factors giving rise to price uncertainty such as the operational efficiency of the permit market and expectations regarding future emission targets are also important.

When plants can be operated flexibly to take advantage of the cash flow benefits arising from volatile prices, then the investment and retirement decisions may need to account for short-run volatility around the expected value of the permit price (IEA 2007). If operational flexibility is significant in determining a plant's net returns then correlations between the permit price and electricity price, along with the share of the permit price passed through to the electricity price may also affect the decision (Laurikka and Koljonen 2006; IEA 2007).

The significance of the correlation between permit and electricity prices depends on the emissions intensity of the generation technology setting the price of electricity and the extent to which the cost of permits is fully passed through to the electricity price (pass-through rate).[5] In a competitive market the electricity price is set by the plant with the lowest short-run marginal cost, and the marginal cost of permits to this plant is expected to be fully passed through (Chernyavs'ka and Gulli 2008). Volatility in the permit price may affect the operating margin of low emissions plants if high emissions plants determine the electricity price, as it exposes the former to greater risk from changes in the permit price (Yang *et al*. 2008). Simulations by Laurikka and Koljonen (2006) also show that if both permit and electricity prices are highly correlated, and the permit price is sufficiently high, the generator has an incentive to invest in lower emissions plant to take advantage of the high operating margin available. Furthermore, when the correlation between the permit and electricity prices is low, and the volatility of the permit price is low, this incentive disappears and it is optimal for the firm to delay the decision to invest. Therefore, while the expected permit price arising from a scheme's cap affects the expected net returns from a low emissions plant the correlation between the prices of permits and electricity affects the extent to which permit price volatility impacts on the variability of these returns.

The marginal pass-through rate may be less than 100 per cent depending on the structural features affecting both competition and the level of demand in the electricity market (Sijm *et al*. 2006; Chernyavs'ka and Gulli 2008). When the marginal cost of permits is not fully passed through to the electricity price the share of it that is determines not only a plant's expected net returns, but may be another source of uncertainty affecting the variability of net returns (IEA 2007). Previous policies involving indirect taxes in Australia suggest that the final incidence of the costs borne by generators from the CPRS will be high (Freebairn 2007). Short-run simulations show that for pass-through rates ranging from 80 to 100 per cent, reductions in net returns are restricted to relatively high emissions-intensive coal-fired plants that are unable to cover fully the marginal cost of permits when lower emissions plants set the electricity price (Menezes *et al*. 2009).

5. Banking, borrowing and international linking

In addition to the stringency of the emissions cap, three features of an ETS design that may significantly affect the expected price of permits are banking, borrowing and the ability to buy and sell permits internationally. In theory allowing emitters to bank and borrow tradeable emissions permits may result in more efficient use of permits over time (Rubin 1996; Kling and Rubin

[5] The pass-through rate is expressed as the percentage change in the electricity price due to the change in the marginal cost of generating electricity arising from the cost of emissions permits.

1997; Leiby and Rubin 2001). Essentially, the inter-temporal flexibility provided by banking and borrowing has the potential to smooth both the incidence of abatement costs and the price of permits. While banking is usually included in the design of a GHG ETS, borrowing is greatly restricted to maintain the environmental integrity of the scheme (Commonwealth of Australia 2008). The CPRS provides unlimited banking of permits by allowing permits to be surrendered in the year of their vintage or any subsequent year. There are restrictions on banking and borrowing in so far as permits acquired from the government at a fixed price may not be banked, and firms can only borrow permits from the following year's vintage up to an amount no greater than 5 per cent of their current year's emissions liability.

Including banking in an ETS may contribute to reducing the variability of permit prices and the cost of adjusting to changes in the scheme's cap, and promoting liquidity and trading activity in the permit market (Haites 2006). Whether banking provides an incentive to invest in lower emissions plants and retire high emissions plants depends on the amount it increases the expected prices of permits compared to no banking. Laboratory experiments find that when banking is available the average price of permits may be relatively higher than suggested by equilibrium pricing due to overbanking, and firms may overinvest in abatement technologies compared to theoretical predictions (Gangadharan *et al.* 2005). The literature shows that if the costs of complying with a scheme are uncertain and significantly large sunk costs are involved, then firms tend to defer investment in high cost abatement options and rely on banking to reduce compliance costs (Haites 2006). Furthermore, when enforcement is lacking banking may increase noncompliance and thereby lower the expected price of permits (Cason and Gangadharan 2006).

While the domestic trading of emissions permits equates the marginal cost of emission within a country, full international trading in permits is a necessary condition for equalising the marginal cost of emissions among countries (Kerr 2000). When international linking is allowed the level of the domestic scheme cap is no longer the sole determinant of the supply of permits. Whether international linking has a beneficial or adverse impact on the transition to lower emissions generation plant depends on the expected permit price faced by generators being higher or lower, respectively, than without linking. If the international price acts as a binding cap on the permit price both the expected prices of permits and their upside variability become constrained. Consequently, the expected net returns of emission-intensive plant are relatively improved, while those of low emissions plant are diminished.

The CPRS allows for the importing of an unlimited amount of eligible international units by entities deemed liable for compliance with the scheme.[6] Exports of domestically allocated permits (Australian units) are not allowed

[6] Eligible international units are comprised of Kyoto units (certified emission reduction units, emission reduction units and removal units) and non-Kyoto units created by a country or group of countries that are deemed acceptable for surrender by future regulations.

in the 'initial' years of the scheme so there is no floor on the price of permits. Changes to this restriction will be given with a minimum of 5 years' notice. Treasury's (2008) analysis of the CPRS found that Australia has a high marginal cost of abatement compared to many countries, and it is anticipated that a substantial share of annual emissions will need to be off-set against imported permits until a back stop technology such as carbon capture and storage is widely adopted in the electricity generation sector. Australia's low share of global CO_2-e emissions suggests that generators are likely to face a horizontal supply curve for permits at the international price thereby providing the CPRS with a cap (safety valve) on the price of permits. A consequence of banking and linking in the CPRS is the expected price of permits may become too low to provide generators with suitable returns from investment in low emissions plant. To help prevent this occurring it is suggested that a price floor is placed on permits purchased at auction (Hepburn *et al*. 2006).

6. Credibility of scheme caps and policy uncertainty

To provide an incentive to invest in low emissions plant policy settings must ensure the formation of stable long-term expectations about the permit price (Grubb and Neuhoff 2006). Uncertainties over the regulatory settings of an ETS, and climate change policy more broadly, impact on a generator's choice of technology and/or the timing of the investment. Fuss *et al*. (2008) conclude that probably too much focus has been directed towards the effect of price uncertainties rather than the effect of policy uncertainty on the investment decisions of generators. There is some empirical support for this as regulatory uncertainty was found to contribute to the lack of investment in low emission electricity generation in Germany during phase I of the EU ETS (Hoffman 2007).

A key regulatory setting that is shown to significantly impact on a generator's investment decision is the credibility of future scheme caps, as these provide guidance on longer term expected permit prices. If there is uncertainty about the level at which a cap will be set, the value of the generator's option to wait and see whether the government will remain committed to its climate policy increases (Blyth *et al*. 2007; Fuss *et al*. 2008). The risk premium arising from this uncertainty manifests as the additional discounted net returns needed by the generator to off-set the increased value of the option to wait (Yang *et al*. 2008). Furthermore, the nearer the generator's decision to invest is to a change in the emissions cap the greater the effect of uncertainty about its level on the decision (Blyth *et al*. 2007). This is particularly important prior to the introduction of an ETS. The choice of technology to invest in depends on the firm's expectations of the ETS being actually introduced and the subsequent level of the permit price; and importantly the viability of the proposed technology with and without an ETS (Reedman *et al*. 2006). If there is also uncertainty about the cost of the investment, which may become higher as a result of an impending policy change, then the value of delaying investment is reduced and the firm invests sooner than is the case where the investment cost is certain (Pawlina and Kort 2005). As these studies show, the impact on a generator's incentive to invest in low emissions plant depends on whether policy uncertainty dominates the decision.

Policy uncertainty may be reduced through features of a scheme's design such as: greater transparency of climate change policy along with better structured and regular disclosure of information (Betz and Sato 2006); establishing an independent institution for operating and regulating the scheme (Grubb and Neuhoff 2006); and imposing price constraints such as caps and floors (IEA, 2007). Longer commitment periods for the scheme's caps are also suggested to encourage investment in lower emissions plants (Buchner 2007). They provide generators with more certainty about the expected price of permits and greater flexibility in responding to short term variations in emissions, while shorter commitment periods provide more frequent opportunities to evaluate new information. Other things being equal, a longer commitment period may reduce permit price uncertainty and therefore lower the expected value of the option to delay the investment (Fuss *et al*. 2009). The effect of permit price uncertainty on the investment option's value, however, may depend on the timing of the investment decision. If the decision involves non-renewable plant then fuel price uncertainty dominates the value of the option to delay investment when it is made towards the beginning of a commitment period, but as the decision moves closer to a policy setting date permit price uncertainty becomes relatively more important (Yang *et al*. 2008).

Under the CPRS the Minister is responsible for setting the scheme caps and gateways. Criteria or triggers for cap adjustments are not provided in the Bill. Annual caps for at least 5 years in advance are prescribed by regulation and gateways within which future emission caps are expected to be bounded are provided for a further 10 years. Gateways are extended by 5 years every fifth year. Generators therefore have up to 15 years of guidance for the scheme's cap which should assist them in formulating an expected price of permits over a significant proportion of a plant's operating life. However, uncertainty about these prices will be greater than otherwise due to the dependence of cap settings on the political process.

7. Conclusion

This survey considered the effects of four significant design features of an ETS on the decision of generators to invest in new low emissions plant or retire existing high emissions plant, and presented them in the context of the CPRS. Allocations of free emissions permits that provide generators with a subsidy distort investment and retirement decisions. The specific effects depend on the criteria used to allocate permits and the choices relating to each decision that allows a generator to increase the expected value of the permits received. It is unclear how allocations under the ESAS and associated Low Emissions Transition Incentive will impact on a generator's decisions.

The effect of the scheme caps is complex. Key factors include the expected price of permits together with its trend and volatility, as these influence the generator's willingness to either commit to investing in low emissions plant or wait and see how price uncertainty is resolved. When the generator also has flexibility concerning how the plant is operated, additional factors need to be accounted for. Significant factors affecting a plant's operating margin include the correlation between the permit price and electricity price, and the 'pass-through' rate for the permit price. The emissions intensity of the plant setting the electricity price has a significant affect on expected net returns when the pass-through rate is high, as is likely to be the case under the CPRS.

Given sufficiently high expected permit prices, the more confidence a generator is about them and therefore expected net returns the greater the incentive to invest in low emissions plant. Borrowing of permits is limited under the CPRS. Banking provides generators with a means to hedge themselves against future price and policy uncertainties. International linking in the CPRS is likely to provide generators with a safety valve on the price of permits. A potential problem is that the expected price of permits may become too low to provide generators with suitable returns from investment in low emissions plant.

The credibility of scheme caps and policy certainty are critical to achieving a transition to low emissions technologies. Policy uncertainty adds to other price uncertainties and may significantly increase the value of a generator's option to delay investing in low emissions plant. While there are features of a scheme's design that may reduce policy uncertainty, longer commitment periods are seen as an effective way of achieving it. The failure to separate the setting of scheme caps from the political process in the CPRS is a major weakness.

Research has provided many insights on the effects of ETS design on firm investment and retirement behaviour and possible implications arising from the CPRS. As this survey demonstrates these are far from complete. Many of the relationships concerning the retirement decision are still unknown and there are complex interrelationships between each of the design features focused on that are yet to be fully understood.

References

ACIL Tasman (2008a). *The Impact of an ETS on the Energy Supply Industry*. Report prepared for the Energy Supply Association of Australia, July 2008, Melbourne.

ACIL Tasman (2008b). *Impacts of the Carbon Pollution Reduction Scheme and RET: Modelling of Impacts on Generator Profitability*. Report to Department of Climate Change, December 2008. Available from URL: http://www.climatechange.gov.au/government/initiatives/cprs/esas/~/media/publications/esas/acil-report.ashx [accessed 23 Feb 2010].

Åhman, M. and Holmgren, K. (2006). New entrant allocation in the Nordic energy sectors: incentives and options in the EU ETS, *Climate Policy* 6, 423–440.

Åhman, M., Burtraw, D., Kruger, J. and Zetterberg, L. (2007). A Ten-Year Rule to guide the allocation of EU emission allowances, *Energy Policy* 35, 1718–1730.

Bailey, I. and Ditty, C. (2009). Energy markets, capital inertia and economic instrument impacts, *Climate Policy* 9, 22–39.

Baumol, W.J. and Oates, W.E. (1988). *The Theory of Environmental Policy*, 2nd edn. Cambridge University Press, New York.

Betz, R. and Sato, M. (2006). Emissions trading: lessons learnt from the 1st phase of the EU ETS and prospects for the 2nd phase, *Climate Policy* 6, 351–359.

Blyth, W., Bradley, R., Bunn, D., Clarke, C., Wilson, T. and Yang, M. (2007). Investment risk under uncertain climate change policy, *Energy Policy* 35, 5766–5773.

Buchner, B. (2007). *Policy Uncertainty, Investment and Commitment Periods*. IEA information paper COM/ENV/EPOC/IEA/SLT(2007)8, IEA/OECD, Paris.

Burtraw, D. and Evans, D.A. (2009). Tradable rights to emit air pollution, *Australian Journal of Agricultural and Resource Economics* 53, 59–84.

Cason, T.N. and Gangadharan, L. (2006). Emissions variability in tradable permit markets with imperfect enforcement and banking, *Journal of Economic Behavior & Organization* 61, 199–216.

Chernyavs'ka, L. and Gulli, F. (2008). Marginal CO_2 cost pass-through under imperfect competition in power markets, *Ecological Economics* 68, 408–421.

Commonwealth of Australia (2008). *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future, Volume 1, White Paper*. Bluestar Print, Canberra.

Department of Climate Change (2009a). *Proposed Measures to Safeguard the Security of Electricity Supplies*. Available from URL: http://www.climatechange.gov.au/government/initiatives/cprs/Proposed-CPRS-Negotiation.aspx [accessed 28 Nov 2009].

Department of Climate Change (2009b). *Details of Proposed CPRS Changes*. Available from URL: http://www.climatechange.gov.au/~/media/publications/cprs/CPRS_ESAS/091124%20Details_proposed_CPRS_changes.ashx [accessed 22 Feb 2010].

Department of Climate Change (2009c). *National Inventory 2007: Accounting for the Kyoto Target May 2009*. Available from URL: http://pandora.nla.gov.au/pan/102841/20090717-1556/ http://www.climatechange.gov.au/inventory/2007/pubs/nggi_2007.pdf [accessed 10 Aug 2009].

Driesen, D.M. (2007). Design, trading, and innovation, in Freeman, J. and Kolstad, C.D. (eds), *Moving to Markets in Environmental Regulation: Lessons from Twenty Years of Experience*. Oxford University Press, New York, pp. 436–469.

Freebairn, J. (2007). Economic issues with climate change, *Australian Economic Review* 40, 402–409.

Fuss, S., Szolgayova, J., Obersteiner, M. and Gusti, M. (2008). Investment under market and climate policy uncertainty, *Applied Energy* 85, 708–721.

Fuss, S., Johansson, D.J., Szolgayova, J. and Obertsteiner, M. (2009). Impact of climate policy uncertainty on the adoption of electricity generating technologies, *Energy Policy* 37, 733–743.

Gangadharan, L., Farrell, A. and Croson, R. (2005). Investment decisions and emissions reductions: results from experiments in emissions trading, Research Paper Number 42, Department of Economics, The University of Melbourne, Australia.

Gonzalez, P. (2008). Policy implications of potential conflicts between short-term and long-term efficiency in CO_2 emissions abatement, *Ecological Economics* 65, 292–303.

Grubb, M. and Neuhoff, K. (2006). Allocation and competitiveness in the EU emissions trading scheme: policy overview, *Climate Policy* 6, 7–30.

Haites, E. (2006). *Allowance Banking in Emissions Trading Schemes: Theory and Parctice*. MARGAREE Consultants Inc., Toronto.

Hepburn, C., Grubb, M., Neuhoff, K., Matthes, F. and Tse, M. (2006). Auctioning of EU ETS phase II allowances: how and why? *Climate Policy* 6, 137–160.

Hoffman, V.H. (2007). EU ETS and investment decisions: the case of the German electricity industry, *European Management Journal* 6, 464–474.

IEA (2007). *Climate Policy Uncertainty and Investment Risk*. International Energy Agency, Paris.

Kerr, S. (2000). Fair Competition and Annex B Trading, in Kerr, S. (ed.), *Global Emissions Trading: Key Issues for Industrialized Countries*. Edward Elgar, Cheltenham UK, pp. 157–184.

Kiriyama, E. and Suzuki, A. (2004). Use of real options in nuclear power plant valuation in the presence of uncertainty with CO_2 emission credit, *Journal of Nuclear Science and Technology* 41, 756–764.

Kling, C. and Rubin, J. (1997). Bankable permits for the control of environmental pollution, *Journal of Public Economics* 64, 101–115.

Kling, C.L. and Zhao, J. (2000). On the long-run efficiency of auctioned vs. free permits, *Economic Letters* 69, 235–238.

Koutstaal, P. (1997). *Economic Policy and Climate Change: Tradable Permits for Reducing Carbon Emissions*. Edward and Elgar, Aldershot.

Kumbaroğlu, G., Madlener, R. and Demirel, M. (2008). A real options evaluation model for the diffusion prospects of new renewable power generation technologies, *Energy Economics* 30, 1882–1908.

Laurikka, H. and Koljonen, T. (2006). Emissions trading and investment decisions in the power sector – a case study in Finland, *Energy Policy* 34, 1063–1074.

Leiby, P. and Rubin, J. (2001). Intertemporal permit trading for the control of greenhouse gas emissions, *Environmental and Resource Economics* 19, 229–256.

Lin, C-M., Phillips, R.D. and Smith, D.D. (2008). Hedging, financing, and investment decisions, *Journal of Banking and Finance* 32, 1566–1582.

Lundmark, R. and Pettersson, F. (2008). Investment decisions and uncertainty in the power generation sector, Paper presented at the 31st IAEE International Energy Conference, 18–20 June 2008, Istanbul, Turkey.

McLennan Maganasik Associates (2008). *Impacts of the Carbon Pollution Reduction Scheme on Australia's Electricity Markets*. Report to the Federal Treasury. Available from URL: http://www.treasury.gov.au/lowpollutionfuture/consultants_report/downloads/Electricity_Sector_Modelling_Report_updated.pdf [accessed 22 Feb 2010].

Menezes, F., Quiggin, J. and Wagner, L. (2009). Grandfathering and greenhouse: the role of compensation and adjustment assistance in the introduction of a carbon emissions trading scheme in Australia, *Economic Papers* 28, 82–92.

Neuhoff, K., Martinez, K.K. and Sato, M. (2006). Allocation, incentives and distortions: the impact of EU ETS emission allowance allocations to the electricity sector, *Climate Policy* 6, 73–91.

Nielson, L. (2008). *Emissions – who is trading what?* Background note, 15 August 2008, Parliamentary Library, Canberra. Available from URL: http://www.aph.gov.au/Library/pubs/BN/2008-09/emissions.htm [accessed 9 Nov 2009].

Pawlina, G. and Kort, P.M. (2005). Investment under uncertainty and policy change, *Journal of Economic Dynamics & Control* 29, 1193–1209.

Pezzey, J.C.V. (2003). Emission taxes and tradeable permits, *Environmental and Resource Economics* 26, 329–342.

Reedman, L., Graham, P. and Coombes, P. (2006). Using a real-options approach to model technology adoption under carbon price uncertainty: an application to the Australian electricity generation sector, *The Economic Record* 82, S64–S73.

Rubin, J.D. (1996). A model of intertemporal emission trading, banking, and borrowing, *Journal of Environmental Economics and Management* 31, 269–286.

Sijm, J., Neuhoff, K. and Chen, Y. (2006). CO_2 cost pass-through and windfall profits in the power sector, *Climate Policy* 6, 49–72.

Sijm, J., Hers, J. and Lise, W. (2008). *The Implications of Free Allocation versus Auctioning of EU ETS Allowances for the Power Sector in the Netherlands*. Report of the Energy Research Centre of the Netherlands, ECN-E-08-056, Amsterdam.

Simshauser, P. (2008). On emissions permit auction vs. allocation and the structural adjustment of incumbent power generators in Australia, *The Electricity Journal* 21, 30–41.

Simshauser, P. (2009). On emissions trading, toxic debt and the Australian power market, *The Electricity Journal* 22, 9–29.

Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., Crane, D., Cruickshank, S., Dietz, S., Edmondson, N., Garbett, S., Hamid, L., Hoffman, G., Ingram, D., Jones, B., Patmore, N., Radcliffe, H., Sathiyarajah, R., Stock, M., Taylor, C., Vernon, T., Wanjie, H. and Zenghelis, D. (2006). *Stern Review on the Economics of Climate Change*. Cambridge University Press, Cambridge.

Szolgayova, J., Fuss, S. and Obersteiner, M. (2008). Assessing the effects of CO_2 price caps on electricity investments – a real options analysis, *Energy Policy* 36, 3974–3981.

Treasury (2008). *Australia's Low Pollution Future: The Economics of Climate Change Mitigation*. Commonwealth of Australia, Canberra: Available from URL: http://www.treasury.gov.au/lowpollutionfuture/default.asp [accessed 7 May 2009].

Yang, M., Blyth, W., Bradley, R., Bunn, D., Clarke, C. and Wilson, T. (2008). Evaluating the power investment options with uncertainty in climate policy, *Energy Economics* 30, 1933–1950.