CLIMATE CHANGE AND THE ENERGY SECTOR

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There has been much sound and fury over climate science and the Copenhagen UNFCCC meeting since just before Christmas. So much that we may need a reminder that the noise and fury have not changed the risks of dangerous climate change. On a balance of probabilities, if there were no effective global effort to reduce emissions of greenhouse gases, increases in greenhouse gas emissions would generate climate change that is deeply problematic for human society. The risks are greater for Australia than other developed economies. There will be little argument with these propositions from the overwhelming weight of specialist and authoritative opinion in climate science, or from the academies of science in any of the countries of large scientific achievement. If there were a case for reduction in greenhouse gas emissions in February 2009, there is a similar case in February 2010.

We may also need a reminder that, while the conference processes at Copenhagen were a fiasco, the international community moved closer than ever before to a strong agreement on mitigation of climate change.

There was widespread support in Copenhagen (not yet an agreement) for reducing the rate of growth of greenhouse gas emissions enough to create a reasonable chance of holding the increase in average temperatures to two degrees centigrade above pre-industrial levels. This would require global emissions to soon reach a peak and begin to fall, and then to be reduced by around 50% from 1990 levels by 2050. The world is a long way from agreeing on principles for allocating the required reduction in emissions entitlements across countries, and analysis and recent experience suggest that agreement is unlikely except around the principle of convergence towards equal per capita entitlements across the whole of humanity. If the world as a whole is to reduce emissions entitlements by 50 percent by 2050, developed countries will have to reduce them by nearly 90 percent. Australian emissions would have to fall by about 25percent by 2020 and by about 90 percent by 2050.

While the developing countries and in particular China did too little to support the emergence of international agreement at Copenhagen, they went much further in their commitments to domestic action than ever before. They actually committed themselves to domestic action that would, if implemented, meet their part of an ambitious global agreement. China went further in domestic commitments than the Garnaut Climate Change Review (2008) had calculated to be appropriate as China’s contribution by 2020 to a strong global agreement.

A binding international agreement on climate change mitigation would provide the framework for large emissions reductions at the lowest possible economic costs. It would allow international trade in emissions entitlements. This, in turn, would encourage the concentration of emissions reductions in countries in which they could be achieved at lowest cost, and the establishment of similar emissions entitlement prices in all countries. Similar emissions prices would be crucial to avoiding costly distortion of international trading patterns.

Not only would a binding international agreement provide the lowest cost path to lowering the risks of dangerous climate change to acceptable levels, but it would provide the framework for what is probably the only path. A succession of independent national measures in many countries, relying heavily on ad hoc regulatory interventions, growing larger as concern for climate change becomes more urgent, is likely in practice to be the main alternative to a global agreement on allocation of emissions entitlements. Such an alternative approach is much more likely than no intervention at all. This may turn out to be at once economically more costly, and inadequate to the mitigation task.

If the mainstream climate science is broadly right, the growing realisation of the realities, and then the manifestation of risks as damage from climate change, is likely to drive political responses and policy action. Not considered and ordered responses. Not economically rational responses. But policy responses that grow more in panic and disorder the longer they are delayed.

In the way of human political responses, in the absence of international agreement on principles for allocating emissions entitlements, most people in each country will judge other countries' efforts more than their own to be inadequate. This will be deeply corrosive of international cooperation in all spheres. It is likely to be associated with corrosion of open international trade in goods.

One way or another, Australia will come under pressure to make efforts in mitigation that others judge to be satisfactory. The pressure will be the greater because we are one of the developed countries; because we are the world's biggest exporter of coal; and because we start as the developed country with the highest per capita emissions.

Australia's distinctive place on top of the per capita emissions developed country league table derives partly from energy use generally and electricity generation in particular playing an exceptionally large part in the Australian economy. It derives to a considerable extent from coal, the most emissions-intensive energy source, playing an exceptionally large part in energy and especially electricity production. Australia will not get anywhere near its necessary place in an agreed global effort to reduce greenhouse gas emissions, nor anywhere near others' expectations of it in an ad hoc world of national mitigation policies, without radical reductions in emissions from energy use in general and electricity generation in particular..

To note the large role of energy emissions in a major Australian mitigation effort is not to talk down the importance of biological sources of emissions and bio-sequestration. The Garnaut Climate Change Review said that the change in biological processes was potentially transformational in Australia's mitigation effort. The 2009 report of the CSIRO for the Queensland Government underlined its potential importance.

But the amount and the cost of reductions in emissions through land use change, agriculture and forestry are highly uncertain; the means of measurement of changes in emissions from biological processes in their early development stages; and the policy instruments that will promote efficient reduction of emissions under development. These processes are an appropriate focus of major research effort, partly supported by the public finances. Identifiable reductions in emissions through these processes should attract payments comparable to those attracted by other sources of emissions reductions.

Whatever the progress in biosequestration, effective Australian mitigation requires transformation of the energy sector. The required transformation is complex, and demands commitments of large amounts of capital over long periods of time.

Here I draw heavily on Chapter 20, Transforming Energy, from the Garnaut Climate Change Review (2008).

In a world of effective global mitigation, we would need to see over the next 40 years the emergence of something close to a zero-carbon energy sector in Australia and around the world—an energy transformation.

This would be part of a wider set of big changes for Australians. We have become accustomed to low and stable energy prices. These have underpinned aspects of our economic structure and lifestyles. The cheap energy is being challenged by rapidly rising capital costs as a result of the effects of the resources boom on capital costs in electricity generation and transmission; large increases for natural gas and black coal prices on world markets; less abundant and reliable water supply for thermal and hydro-electric power generation; and the likelihood of a big lift of gas prices in eastern Australia to international levels as export facilities are established. In a world of effective mitigation, a rising and eventually high carbon price would add to the transformational pressures—although they would contribute a small proportion of the pressures for higher energy prices.

The central role that the electricity sector is projected to play emerges from the 35 per cent contribution that electricity makes to greenhouse gas emissions today. It is magnified by the capacity for other sectors, notably other stationary energy and transport, to achieve lower emissions by changing from high-emissions fossil fuels to lower-emissions electricity. It is likely that the transition to the electric car supplemented by greater use of heavy and light rail transport would lead to a large upward shift in electricity demand, despite a rising electricity price.

The structures within which the Australian electricity industry operates are changing rapidly. The energy sector, driven by the reforms of national competition policy and progressive privatisation, is now a physically and financially sophisticated and increasingly but incompletely national sector, delivering security of supply, competitive prices and new investment. This evolution remains unfinished, with price and service regulation remaining in areas where competition should be capable of delivering greater consumer benefits. Weak interconnection between regions means that the populated southeastern crescent from Adelaide to Cairns and inland from the curve, although nominally connected in a national grid, largely comprise a series of separate state and regional markets.

Power generation based on black and brown coal for base-load supply, transmission interconnection for flexibility and additional security, and gas-fired plant to meet the growing demand for peak and intermediate capacity have all been important in this period of rapid change. Almost 5000 MW or approximately 12 per cent of net additional generation capacity was added between 1999 and 2006. Since the early stages of serious discussion of climate change mitigation, in 2007, there has been a shift in thinking about new generation capacity in Australia, from coal to natural gas and renewable energy. For gas, the focus has shifted from open cycle generators, with lower capital costs, to closed cycle, with their more efficient use of energy and lower emissions. Whereas in 2007 coal was being discussed as the likely fuel for new large-scale generators, discussion of the next three major investments to expand east coast capacity is now concentrated on combined cycle gas.

From the mid-1990s until around 2006, prices for both electricity and gas were generally stable.

Over the past two years, increases in electricity prices have been much larger than for any other substantial component of the Australian Consumer Price Index: 10.2 percent in 2008; and 15.7 percent in 2009. Notified electricity prices have been set at an increase of 20.2 percent in NSW and 11.8 percent in Queensland for 2009-10. (Victoria deregulated retail electricity prices in early 2009). So far, rising prices have reflected the need to justify considerable capital expenditure in transmission and generation. This has been compounded by the effect of drought on the availability of water for hydroelectric generation and power station cooling.

This is only the beginning of a new era of much higher and rising electricity prices, independently of climate change policies. The NSW Independent Pricing and Regulatory Tribunal (IPART) has looked ahead to the introduction of an Emissions Trading Scheme along the lines of the draft law passed by the Australian House of representatives, with an emissions price of $26 per tonne in 2012, and attributed more of large expected price increases to the need to recoup the costs of investment in strengthening the electricity distribution grid than to the ETS.

The large anticipated price increases arising from increased capital costs, and of coal prices to generators in NSW and of gas to all east coast users, as a result of the global and Australian resources booms, are ahead of us and not yet built into expectations.

Capital costs of new generation capacity have risen markedly with particular impact on capital-intensive industries. Industry advice to the Review indicated that there were increases of up to 60 per cent in construction costs per installed kilowatt of power plants since 2004, across all technologies. There was no reduction in Australian costs during the global financial crisis, and costs have now resumed their steep upward March with the restoration of the strength of the resources boom.

A major uplift in global coal prices—hundreds of percent over the past five years—will flow through to the costs of New South Wales power generation as long-term contracts mature and are replaced by contracts reflecting contemporary conditions. Eastern Australia has for many years enjoyed gas prices well below international levels, and has been insulated from the large recent increases in international prices by the absence of an export industry. The emergence of the gas export industry in the years immediately ahead will gradually push eastern Australian gas to international prices.

To put these various sources of potential price increases into perspective, a $20 per tonne price on carbon dioxide emissions could add $16–20 per MWh to the average wholesale electricity price. An increase of $3 per gigajoule in the gas price, to somewhere closer to but still short of export parity would add more than $20 per MWh to the price of gasfired electricity. An increase of $100 per tonne to black coal prices would add approximately $53 per MWh to the price of coal-fired electricity.

The most significant remaining step towards establishing competitive markets is the removal of retail price regulation. The experience of Victoria since deregulation seems to suggest that competitive pressures can maintain retail price discipline, at least in the main centres of population and economic activity. The retention of price controls can be seen as the main risk to supply security in the period of rapid cost increases ahead. Private generators can be relied upon to provide the necessary supply capacity whatever is happening to their costs if they expect market prices to embody the necessary incentives to investment. This is the way markets work. Continued price controls accompanied by politicization of the price adjustment processes introduce incalculable risks that can lead to underinvestment. This is the Californian problem that has risen to prominence over recent years.

So long as the potential problems of price regulation can be avoided, the established structures and processes generally will allow the private sector's assessment of supply and demand to determine the need for additional generation capacity and to deliver this capacity in a timely fashion, at something close to the lowest possible cost. Investment decisions will involve complex choices amongst a wide range of technologies, times and locations, affected by judgments about hundreds and thousands of future prices for goods and services.

There are mixed views across the industry as to whether established mechanisms are able to deliver the most efficient and timely investment in electricity transmission. My own assessment is that we have a problem, warranting major Commonwealth Government policy focus and public investment. A wide and deep national electricity market would allow expansion of capacity in the places where it can be provided at lowest cost; insurance against local failures of generation or transmission resulting from changing climatic or other conditions; easier accommodation of new sources of low-emissions energy; easier integration of intermittent renewable energy sources into the grid; and lower energy losses in transmission. The economics of network infrastructure would prevent private investment decisions from securing efficient outcomes, even if the grid were privately owned.

The Review examined the possible impact of nuclear power on Australian electricity costs. Nuclear power stations will have been disproportionately affected by the recent increases in capital costs on account of their exceptional capital intensity, although the latest nuclear technologies indicate potentially lower costs. Australia has better non-nuclear low-emissions options than other developed countries, especially (but not only) if carbon capture and storage is commercialized within the range of current cost expectations.

Australia is a major net exporter of a wide range of energy sources, notably coal, liquefied natural gas and uranium. Transport economics should favour local use of those fuels in which the gap between export parity and import parity price is greatest (first liquefied gas, then coal). As a consequence, Australia is not the logical first home of new nuclear capacity on economic grounds.

In recent years, power generated from non-hydro renewable sources has increased as a result of MRET and, to a lesser extent, GreenPower demand. However, by 2007 it represented only around 3.3 per cent of capacity and 2.5 per cent of delivered electricity (ESAA 2008). Investment in renewable was increasing rapidly under the influence of a new MRET scheme, until the fall in certificate prices associated with the introduction into the scheme of roof-top solar energy production. This capacity has been dominated by wind, with contributions from solar hot water and biomass.

There is little likelihood of large net expansion in storage-based hydroelectric generation in Australia, although there is scope for much better use of existing storage capacity in the current environment, in which renewable power has greatly increased value. The anticipated growth in intermittent supply technologies (wind and solar) and ongoing, above-average growth in peak demand mean that existing hydroelectric infrastructure will play an enhanced role as a provider of flexible and readily available stored energy to meet short-term demand peaks. This role could be substantially expanded through judicious investment aimed at making the hydroelectricity assets important balancing components in the eastern Australian system. Australia's main hydroelectric assets—in the Snowy Mountains and Tasmania—will have increased value, far beyond that suggested by their installed capacities (3676 MW and 2278 MW respectively) alone. The value comes initially from their zero-emissions status and low underlying operating costs. This is enhanced by their potential for counteracting the intermittent supply from wind and solar power. If market conditions can be effectively exploited, power from intermittent sources at times of low demand and price could be used to pump water into hydroelectric storage for use at times of greater demand and value.

Climate change adds a major dimension to the future of the energy sector, with direct implications from the impacts of climate change and even greater implications as mitigation responses are adopted. Unmitigated climate change is predicted to cause greater storm, wind and bushfire damage and increased levels of materials degradation. This will mean additional transmission and distribution losses across the gas and electricity networks. The specific risk to electricity transmission and distribution networks that arises from the increased frequency of extreme weather events is illustrated by the power supply outages of January 2007, when a bushfire caused disruption to the transmission system between New South Wales and Victoria.

The most significant impact that will require adaptation planning in the energy sector is that on urban water supply. In 2007, the drought exposed the obvious dependence of part of the market, the hydro generators, on water supply. However, it also exposed the extent to which most fossil-fuel generators depend on water for cooling.

There will also be an impact on energy infrastructure demand through compounding growth in the peak summer period.

These challenges amplify the need for governments to maintain momentum towards a truly national energy market at the same time as they respond to the structural adjustment imposed by the mitigation task.

The implementation of a substantial price on carbon emissions would unleash far-reaching change, as the market responds to the emissions constraint and delivers an assessment of consequent pricing expectations. In the electricity market, the short-term price implications would cause a direct adjustment in marginal cost structures and asset values. This market response is also expected to be associated with a more certain framework to underpin contracting behaviour across the sector.

Expectations of steadily rising and eventually high emissions prices, as envisaged by the Garnaut Climate Change Review, would provide long-needed clarity to frame major investment decisions for new energy infrastructure, including base-load power generation. In addition to investment in technologies with known operating and cost characteristics, this longer-term perspective is expected to facilitate research, development and commercialisation of technologies assessed to have greater mitigation potential in the future. The Review's recommended support for research, development and commercialisation of low-emissions technologies, funded by sales of emissions permits, would have a powerful effect in accelerating innovation.

There would be three broad phases to the transformation to a low-emissions energy sector:

- an initial adjustment phase involving a transition from high-emissions growth to greater use of known lower-emissions technologies
- a technology transition phase as new technologies, some of which may be important through this phase only, emerge and then facilitate and accelerate the restructuring of the sector
- a long-term emergence phase to sustainable, low- and zero-emissions technologies.

From the perspective of 2010, the first phase could be expected to apply for 5–10 years, the second over the next 10–15 years and the third beyond that.

Australia is ideally placed for this transformation, with its abundant coal, gas, uranium, geothermal, solar and other renewable resources, and exceptional opportunities for geosequestration and biosequestration of carbon dioxide. Therefore, while major structural change always presents challenges, energy supply security need not be one of them. Furthermore, Australia has a strong recent history of supporting its resources and engineering industries with appropriately skilled people. However, that skills base may be challenged as the transformation accelerates.

Within Australia and through the application of a general price on emissions, the size, structure, greenhouse gas emissions and, ultimately, the cost of the electricity sector in the first phase will be determined by:

• the adoption of supply-side energy efficiency, retrofitting of CO2 capture, brown coal drying, gas injection into coal-based generators and other in-plant abatement opportunities

• rebalancing the use of current generation plant in favour of plant with lower emissions

• demand reduction through demand-side energy efficiency and price elasticity

• adoption of new and replacement plant with lower emissions, driven by post–permit price economics and leading to progressive retirement of existing higher emissions plant.

As the trajectory diverges from the business-as-usual path under the influence of a rising carbon price, the next set of responses is likely to involve some fuel switching. Constraints will include transmission interconnection for new (and possibly remote) capacity, and gas availability and cost, involving existing gas-fired open-cycle plants being operated more intensively. Competitive tensions will arise from the relative emissions intensities of existing coal-fired plants as the permit price is incorporated into short-run marginal costs. Increased price volatility is likely to be a feature of this period—around a tendency for prices to be driven by factors outside but augmented by the emissions price.

The fuel mix and cost implications will be strongly influenced by the extent to which new black coal contracts in the domestic electricity sector are negotiated at higher prices and the speed with which domestic gas prices move towards global price parity. The implications for brown coal generators will, in the short term, be dominated by the effect of these factors on their competitors and east coast electricity prices, and therefore their capacity to recover lost volume in prices.

It is likely that some coal-fired generators with captive coal supply will stand to reap significant increases in profits from the higher price environment driven by increases in capital costs and gas and black coal prices. There will be a vigorous search for in-plant mitigation including partial fuel substitution (injection of some gas into coal-fired plants). Beyond the commercial limits of in-plant emissions reduction, it is likely that it will be economical for some time for such generators to maintain substantial production despite their high emissions intensity, in an environment in which high gas and black coal prices are underpinning higher electricity prices.

In this phase, new base-load generation capacity is likely to be based on established, combined-cycle gas turbine technology, ideally designed for post-combustion capture of carbon dioxide. This period would generate acute pressures for owners and operators of existing coal-fired plants to operate them in new ways; some of the plants have been optimised to run efficiently in a mode that will be challenged in this new world. Some coal-fired generators would be adjusted for more flexible operations, as in older days, with production concentrated at times of higher price.

• There will be opportunities for some relatively low-cost reductions in emissions.

• There will be capacity to recover volume loss through price. The strong upward pressure on competitors' costs for reasons beyond the mitigation regime will strongly favour established producers with sources of non-tradable coal including some of these generators most affected by the emissions trading scheme. Some of these generators will not see a loss in cash flows for several years, and may well see opportunities for increasing profit in the current circumstances.

The second phase of the transformation would see resolution of the tension between the pull of global gas prices and successful deployment of the first coal-fired power stations with carbon capture and storage. Either way, this scenario plays out to Australia's advantage due to its diversity of fuels, its favourable sites for geosequestration and biosequestration, and its wide range of relatively low-cost renewable generation opportunities.

This phase is likely to be dominated by technology shifts as the investment in research, development and commercialisation delivers the commercial-scale models of new generation capacity across several technologies. New base-load fossil fuel generation plant is likely to incorporate coal drying and coal gasification technologies. It is expected that retrofitting of oxy-firing and carbon dioxide capture will be added to existing coal and gas-fired plants, accompanied by carbon dioxide pipelines and commercial-scale geosequestration operations.

For other coal-fired plant, where such changes are not economically feasible, this phase will see increasing cost pressure as the permit price rises. This phase will be characterised by investment in technologies for which the electricity costs have been demonstrated at commercial scale through the investments in research, development and commercialisation of the first phase. Victoria’s brown coal resource, unsuitable in its natural state for export, and therefore with low opportunity cost, could be expected to have a strong future in this scenario.

At the same time, it is expected that various factors—the rising permit price, the results of programs directed at commercialization of large-scale solar energy, and funding for research, development and innovation in renewable technologies such as geothermal, solar thermal and solar photovoltaic—will be delivering favourable trends in the deployment of such technologies at a commercial scale.

Wind power may struggle to remain competitive due to site availability, wind quality and community restrictions. Energy storage technologies, including through effective use of the stored hydroelectric potential in the Snowy Mountains and Tasmania, can be expected to be available on a commercial basis to support the intermittent nature of solar and wind, so that these sources could act as base-load sources. The marrying of such technologies to demand that matches their availability will enable a more comprehensive approach to infrastructure planning. This phase may see the validation of the potential for biological technologies such as algal conversion of carbon dioxide.

The combined impacts of rising energy prices, capital replacement cycles and complementary measures to deploy cost-effective energy efficiency changes will contribute in this phase, driven primarily by the increasing emissions prices.

In the third phase of the transformation, the energy sector will move close to a position of zero carbon emissions. The balance of technologies cannot be forecast with certainty. The transport sector, both public and private, is also likely to be based largely on this zero-emissions electricity generation supply.

The success of near-zero emissions coal technologies would lead to the retention of coal as the main fossil fuel energy source, while Australia continues to gain as an exporter from the ongoing high global gas prices. Gas is likely to be most valuable to countries without local coal resources and for which near-zero emissions coal technologies are neither physically nor economically feasible. Inceasingly effective solar technologies are expected to combine with geothermal energy to begin to replace fossil fuels as the long-term solution to our energy needs. Near-zero emissions coal technology will have carried out its primary role and remain a significant energy source for some time. An alternative possibility could be the successful development of biosequestration technologies, for example through running generator exhausts through water as feed for rapid algae growth. Such a development could deliver a more favourable long-term future for coal in the energy sector, allowing it to compete with renewable energy technologies as resources and geography dictate.

As in the earlier phases, Australia will be in the fortunate position of being able to monitor the global competitive dynamics of coal, gas, nuclear and renewable technologies and to apply economically superior options flexibly as they emerge.

The implications of the above for the aluminium sector are significant. Australia is currently the world's largest exporter of aluminium metal, based on its indigenous bauxite resources and the availability of relatively low-cost energy from coal. It has enjoyed this position since Japan instituted strong measures to improve the local environment and to reduce energy use in the late 1979s and 1980s. Through 2007, in the early stages of my work on the Climate Change Review, Australian states were actively canvassing prospects for expansion of coal-based aluminium smelting. In a major development for Australian and international climate change mitigation, the main resource companies now attribute a shadow price to carbon emissions in alumina and aluminium (and other) investment decisions. This means that there is unlikely to be any substantial expansion of Australian aluminium production in the period ahead. There may be contraction if state government subsidies to some uneconomic production were removed. New investment in global aluminium smelting capacity will gravitate towards countries with low-cost, low-emissions energy sources, notably hydro-electric and geo-thermal capacity and natural gas in locations isolated from major urban and industrial demand. However, currently economic Australian plants are likely to remain in production for most of the remainder of their current economic lives because of the high costs of capital in new capacity. These outcomes are unlikely to be greatly affected by payments to trade-exposed, emissions-intensive industries. However, Australia's exceptional endowment of a range of low-emissions energy sources and opportunities, including its sites for biosequestration and geosequestration, combined with the local bauxite resource endowment, could again make this country a major focus of international investment interest after the full utilization of favourable renewable energy potential in developing countries.

After the initial price response, residential electricity demand on a per capita basis grows steadily, until this growth is strongly augmented by the switching to electricity for private transport.

Over the longer term, the critical factor that is likely to determine the structure of the electricity supply sector and the future of fossil fuels, both in Australia and internationally, is achieving near-zero emissions carbon capture and storage.

It is clear that whatever specific technology mix emerges, it is likely to deliver a progressive decarbonisation of electricity generation by mid-century to an extent that is strongly influenced by the cost of near-zero and zero emissions coal technologies.

The structure of the energy sector and the future for specific technologies as projected in the modelling are critically dependent on the assumptions of future technology developments. While many of these could be subject to sensitivity analysis, the Review focused on three of these for assessment.

If there were no community or policy constraints on the use of nuclear energy in Australia, it the review's modeling suggests that there would be progressive investment in nuclear capacity from about 2030, with nuclear supplying about a quarter of total electricity demand by 2050, and primarily replacing coal combined with carbon capture and storage. This outcome is particularly sensitive to relative technology cost assumptions. Within this framework, the impact of the availability of nuclear power on electricity costs is modest.

If the coal industry is to have a long-term future in a low-emissions economy, then it will have to be transformed to near-zero emissions, from source to end use, by mid-century. A range of technical, environmental and economic challenges must be addressed effectively to achieve this objective.

Priority should be given to resolving whether a near-zero coal future is feasible. If it is not, then Australia needs to know as soon as possible, so that all who depend on the coal industry can begin the process of adjustment, and so that adequate and timely investments are made in other industries. This makes a strong case for large and early public investment in research, development and commercialization of carbon capture and storage technologies.

As described above, the introduction of a rising and eventually high emissions price is projected by the Review to lead to an increasing role for gas in power generation, reaching around one quarter of the total by 2020. Gas's role becomes constrained in later years as coal with carbon capture and storage and renewable sources become more competitive under the rising permit price, even when combining carbon capture and storage with gas is included. As with coal, this outcome can be strongly influenced by relative movements in future technology costs and global commodity prices.

The Review showed that the required energy transformation could be achieved at non-trivial but manageable cost within stable and well-designed policies: a supportive international framework; a high price on emissions, rising at an appropriate interest rate; public support for research, development and especially commercialisation of new, low-emissions technologies; major investment in network infrastructure for electricity distribution.

The long term and capital intensive nature of investments in future energy supply make certainty in policy settings especially important in this sector, and uncertainty's effects especially costly.

Australia currently faces a more uncertain environment for investment in the energy sector than at any time since early 2007. In the absence of the early introduction of a price on carbon emissions, there is a danger that the progress that has been made within business towards forward-looking structural change—the avoidance of new investment in high-emissions, coal-based electricity generation and aluminium smelting, the commitment to investment in combined cycle gas plants, and investment in commercialisation of renewable energy power generation technologies—will go into reverse. That would greatly increase the ultimate cost of Australian adjustment.

The current political barriers facing market-based approaches to the reduction of emissions (through an ETS or a carbon tax, with part of the revenue supporting research, development and commercialisation of new technologies) have caused some participants in the policy discussion to grasp for regulatory approaches—such as selecting certain high-emissions activities for closure, with compensation from the public finances. The complexity of energy sector choices discussed in this paper rules out any possibility that such an approach could generate an efficient outcome. There is no way that the decisions of bureaucrats or politicians, supported with whatever clever devices they may invent, could bring to account all of the rapidly changing information that markets would assimilate in decisions in response to an appropriately calibrated ETS or carbon tax. The superiority of market over regulatory approaches to complex resource allocation issues is the ultimate source of the West's victory over the former Soviet Union in the Cold War. The whole world learned an important lesson from that episode, at great cost. It would be a pity if Australians were asked to pay a high price to learn the same lesson again.

The Review's first recommendations on an Emissions Trading Scheme to put a price on the external costs of carbon emissions, and to generate revenue for support for research, development and commercialization of low-emissions technologies, have been overtaken by events in Copenhagen and in Canberra. In the aftermath of Copenhagen, we are in what the Review called "The Waiting Game"—awaiting the international agreement that would allocate emissions entitlements across countries and provide a sound basis for international trade in entitlements. In the "Waiting Game", the Review recommended that the emissions trading scheme be introduced, but that emissions permits be issued at a price of $20 per tonne (2005 prices), and rise at 4 per cent per annum in real terms. Permits sold at the fixed price would need to be used in the period of issue, and could not be banked for use after the introduction of a floating price. The proposed price is roughly what the Garnaut–Treasury modelling indicates would be generated by a global agreement around stabilisation of greenhouse gas concentrations at 550 ppm CO2-e. In The Waiting Game, the rising fixed price would continue until there were an effective global agreement on emissions reductions. From the time of international agreement, the emissions permit price would be determined within an Australian Emissions Trading Scheme embedded in a system of international trade in emissions permits. Tighter global trajectories, for example those implied by the Copenhagen discussion of holding temperature increases to two degrees, could be expected to generate a higher price through market processes.

At the time of international agreement, the appropriate targets for Australia would be a weighted average of those for other countries—with weightings reflecting the modified conversion towards equal per capita entitlements favoured in the Garnaut Climate Change Review.

In the meantime, Australia would maintain its current position: it would commit to reduce emissions by 5 percent by 2020 in the absence of global agreement, and up to 25 percent depending on the commitments of other countries in the context of an agreement.

Incidentally, the 5 percent reduction from 2000 levels will require about one quarter reduction from business as usual levels, and its achievement would require the application of strong and well designed policies. It is unlikely to be achieved except at extraordinarily high cost in the absence of a general carbon price.

I have said elsewhere (Garnaut, 2010) that if other countries confirmed in an agreement the targets that they indicated as matters of domestic policy in Copenhagen, Australia's proportionate share would be in the vicinity of 17-18 percent. Participation in an international agreement, and the associated opportunities for international trade in entitlements, would substantially reduce the costs of achieving strong emissions reduction targets.

Within The Waiting Game, the ETS structures would be legislated in readiness for uninhibited trade upon the completion of a satisfactory international agreement.

I have spent much of this paper describing the nature of the adjustment through which the Australian energy sector would pass in the process of achievement of Australia's part of an effective international agreement. The main message so far is that the transition is feasible and the costs manageable in the context of market-based policies—a price on emissions to allow for the costs that they place on others; and the use of part of the proceeds from sale of emissions permits or a carbon tax to support research, development and commercialisation of new, low-emissions technologies.

It must be said that the allocation of all--more than the total—of the potential permit value of an ETS to "compensation" of various interests, and the associated incapacity to fund from this source major investment in research, development and commercialisation of new technologies from this source, is a substantial weakness of policies for which the Government has sought legislative support. The Garnaut Climate Change Review said that there was no economic case for any "compensation" of generators in advance of operation of an ETS for loss of market value. It is impossible to tell in advance whether a particular generator will become unprofitable as a result of the introduction of an ETS, or even whether there is a loss of market value; the outcome depends amongst much else on the quality of management responses to the new circumstances. And even if we could know in advance, the new idea of compensating business owners for government's charging to cover the cost a firm's activities imposes on others is an abomination. Many citizens may think that the payments buy lower electricity prices; they do not. Others may be persuaded that the payments may contribute to greater supply security: they are mistaken; energy security is determined by other things, most importantly confidence in market-based electricity pricing. The provision of some assistance to some emissions-intensive, trade-exposed industries is justified in principle, but the proposed arrangements lack economic principle, and in many cases greatly exceed what would be warranted by informed analysis.

The current stalemate provides an opportunity to review the "compensation" arrangements. Part of the budget savings from moving towards the application of economically principled approaches could be applied to support for investment in the new technologies.

The availability of a feasible path with manageable costs does not guarantee that it will be followed by the Australian community and polity. There is serious risk to the Australian standard of living and to the integrity of our political processes if we do go down the path of ad hoc intervention in response to growing domestic and external pressures. The greatest dislocation from such an approach, and the greatest unnecessary cost, would be felt through confusion, instability, underinvestment and wasteful investment in the energy sector.

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