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Wind Generation and the South Australian Economy

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Director's Note

Welcome to the fifteenth issue of *Economic Issues,* a series published by the South Australian Centre for Economic Studies as part of its Corporate Membership Program. The scope of *Economic Issues* is intended to be broad, limited only to topical, applied economic issues of relevance to South Australia and Australia. Within this scope, the intention is to focus on key economic issues — public policy issues, economic trends, economic events — and present an authoritative, expert analysis which contributes to both public understanding and public debate. Papers will be published on a continuing basis, as topics present themselves and as resources allow.

The author of this paper is Stephen Nelson, Senior Research Economist, SA Centre for Economic Studies.

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Michael O'Neil
Director
SA Centre for Economic Studies
April 2005

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Wind Generation and the South Australian Economy

Overview

The scope of *Economic Issues* is intended to be broad, limited only to topical, applied economic issues of relevance to South Australia and Australia. In this context the paper presents a discussion of issues arising in connection with wind farms, with particular reference made to the South Australian Economy.

Australia is a nation highly dependent on energy both domestically and for our international competitiveness. Australia has the third cheapest energy prices in the western world and is one of the largest carbon emitters despite our relatively small population.

Currently we are going through an energy transition similar to transitions of the past when steam drove the industrial revolution, and electricity and the internal combustion engine drove modern manufacturing practices. This time though the transition is as a result of environmental concerns stimulated by a growing realisation that real structural adjustments are needed in order to tackle our emission levels.

The recent interest in renewable and sustainable energy in Australia has come about for a number of reasons. One of the most significant is that electricity generation in Australia has doubled over the past two decades and now contributes 33.5 per cent of the Nation's total yearly greenhouse gas emissions.

With significant new investment in electricity infrastructure required to meet growing demand, renewable technologies such as wind, biomass and geo-thermal are seen as alternative methods of electricity generation with the added incentive of helping to reduce carbon emissions.

Currently these alternative methods are not commercially viable against fossil fuel generation. This is because the negative externality of carbon emission is not factored into the cost of generation through the use of carbon taxes or emission trading permits.

The Federal Government has publicly stated that they do not intend to use these policy instruments, but have instead implemented the Mandatory Renewable Energy Target (MRET), which is both a greenhouse gas abatement program and a renewable industry development initiative. The MRET equates to a total of 9,500 gigawatt hours (GWh) of Australia's energy needs to be generated using renewables technologies by 2010.

This scheme has seen the rapid growth of wind farm capacity in South Australia over the past 2 years. With an even great number of licenses waiting to be approved, South Australia is set to lead the nation in installed wind farm capacity by 2007. This is mainly a consequence of the large amount of recorded wind data available to potential investors.

Various studies espouse the benefits of wind farms to this State in terms of investment and jobs created. But South Australia is already one of the 'cleanest' States in Australia in terms of carbon emission because a large amount of our electricity is generated using gas as the source of fuel.

While it cannot be denied that wind farms will bring about a reduction in carbon emissions, this needs to be balanced off against other, potentially less beneficial consequences such as, the impact on our existing electricity infrastructure, the effect on future investment levels, and the potential impact of higher energy prices on our industrial sector.

To a degree the danger exists in believing that wind farms (and other renewable energy sources) offer the only solution to reducing emission levels. In parallel we need other measures to reduce carbon emissions. In this context other State and Federal Government programs that target demand management and educate consumers to the effects of energy consumption remain important.

1. Introduction

Australians spend over $50 billion on energy[1] every year with the demand for energy expected to increase by 50 per cent by the year 2020. This equates to an investment demand of $37 billion to meet future energy needs. Energy is also the single largest contributor to global emissions of greenhouse gases. Australia is one of the world's largest greenhouse gas emitter per capita nations with annual emissions of 1.6 per cent but with a population of only 0.32 per cent, of respective world totals. Australia produces more greenhouse emissions than both Mexico and Brazil with populations of 105 million and 184 million respectively.

... Australia produces more greenhouse emissions than both Brazil and Mexico ...

The recent interest in renewable and sustainable energy in Australia has come about for a number of reasons. One of the main reasons is that electricity generation in Australia has doubled over the past two decades, and coal, which accounts for 78 per cent of this generation, contributes 33.5 per cent of our total yearly greenhouse gas emissions. With electricity's share of emissions increasing, renewable technologies that help to reduce these emissions are of potentially great benefit to the Australia's economy and our environment.

Predicted strong growth in the demand for electricity, over the next decade implies that significant new investment will be needed. Generally, markets provide price signals relating to future investment opportunities. At present, for the majority of States in Australia, coal remains the cheapest fossil fuel for stable 'base load' electricity generation and gas the cheapest for intermittent 'peak load' generation. If, as is expected, this were to continue, then future electricity investment would be in technologies that rely on these cheap sources of fuel.

... the environmental costs of fossil fuels are rarely factored into their prices.

Because the attendant costs of fossil fuel generation are rarely factored into private investment decisions relating to generation capacity, there exists a role for Government to correct for this market failure. Fossil fuel, priced at levels that include greenhouse emissions, could result in renewable sources of energy such as wind, biomass, and geo-thermal approaching cost competitiveness. This may be achieved by the imposition of carbon taxes at levels that reflect the greenhouse gas costs or alternatively by restricting emissions and allowing tradable emission rights.

The Federal Government, however, is currently resisting the call for either carbon taxing or tradable emission permits. Instead, it has implemented "renewable energy initiatives" such as the Renewable Energy Strategy and the Mandated Renewable Energy Targets, with the intent of encouraging investment in alternative methods of electricity generation that, without assistance, would not be commercially viable.

Since the Renewable Energy (Electricity) Act was legislated in 2000 we have seen extensive Australia-wide investment in wind generation of electricity. In South Australia, over the next couple of years a potential

... Federal Government initiatives to reduce emissions include promoting wind farm investment.

of up to 1,000MW (or more if installed network capacity were capable) of electricity could be generated through the use of wind. This represents a significant investment cost and generation capacity when it is considered that South Australia currently has an average daily usage of 1,600MW. As well, with the maximum peak load estimation for summer 2004/05 of between 2,827MW and 3,294MW[2] and peak load demand currently growing at an average of 2.8 per cent per year, wind generation could go part way, at least, to meeting the States future energy demand requirements.

South Australia has advantages as a location for wind generation. The State has a substantial number of suitable sites and long data sets of wind patterns associated with these sites. Further we have an accommodating planning approval process where much of the responsibility lies with local councils. Questions remain however as to the impact of an extra 1,000MW of wind generated power on the future levels of investment in conventional generation, and transmission and distribution infrastructure, on the State's load shape and load factor and also on consumer prices.

This Issues Paper presents a discussion of issues arising in connection with wind farms. It looks at why so many wind farms have recently been built or are proposed. The paper looks at what impact wind farms will have on the national electricity market, on future levels of energy demand and supply, and on levels of carbon emissions. Throughout this paper particular reference is made to the South Australian context.

The paper purposely does not discuss in any detail the emotive environmental and aesthetic impact of wind farms.

2. What is Wind Energy?

A wind farm is the name given to a group of wind turbine generators that are connected together into a single point of delivery of energy. A wind farm consists of wind turbine generators, access tracks, underground cables, a switchyard, and connection to the existing grid.[3] The wind turbine generators come in a variety of tower and rotor blade sizes and with a range of outputs.

In simple terms, the wind flows over the rotor blades and due to their aerofoil shape and angle of blade, lift is generated which results in rotating force (torque) acting on the drive shaft. The drive shaft drives a generator, which generates electricity. As wind speed increases the drive shaft is turned faster with the relationship taking a cube effect. For example, a site with an average wind speed of 25km/hr can, all other things being equal, produces 50 per cent more electricity than another site with an average wind speed of 22km/hr. Generally wind farms only operate at wind speeds of between 10km/hr and 90km/hr.

The location of wind farms depends on three main factors:

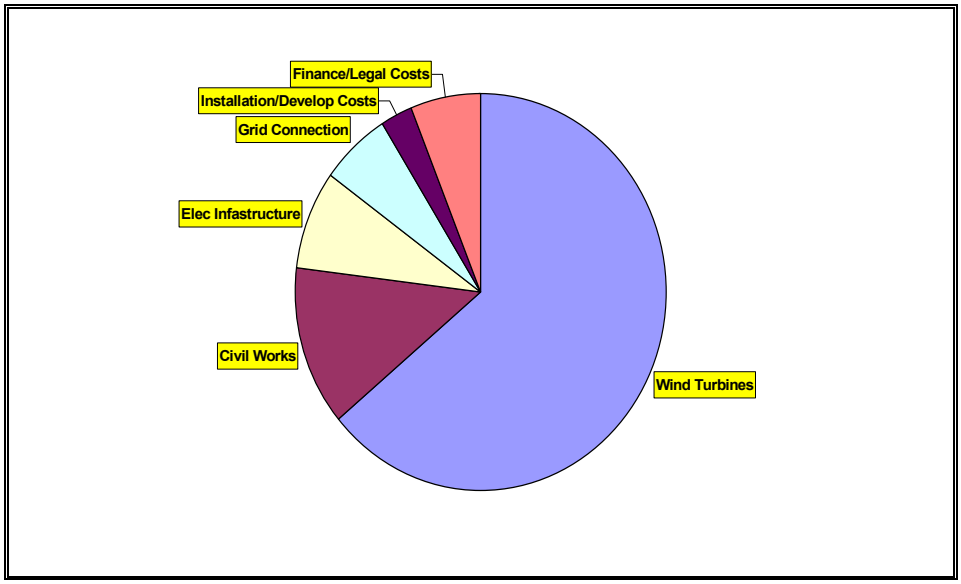
- availability of a constant and reliable wind source;
- availability of land; and
- accessibility to transmission or distribution network infrastructure to connect to the main grid.

3. The Cost of Wind Energy

... the main capital cost of a wind farm is the generators.

As wind generation has increased worldwide, scale economies and technology improvements have seen the cost of producing wind energy progressively decline over the past 3 decades, to the point that it is now one of the cheapest sources of renewable energy technologies. Today the capital cost of a wind farm is typically in the order of Aus$1,550/kilowatt (kW). Figure 1 indicates how this capital cost is broken down amongst the main components for a 5MW onshore wind farm.

Figure 1
Capital Cost Breakdown 5MW Onshore Wind Farm



Source: British Wind Energy Association.

... the long run cost of operation for wind are almost double that of fossil fuel.

On purely commercial criteria, wind farms are currently not able to compete with fossil fuel generation. The Federal Government in its recent report *Securing Australia's Energy Future* stated that at present, the long run marginal cost[4] (LRMC) of electricity generation using wind is between $75-$85/MWh. This compares with $30-$35MWh for coal generation and $40-$45MWh for gas generation. These costs do not factor in the environmental damage from greenhouse gas emissions.

This gap between fossil fuel and wind generation can be expected to narrow but the debate currently rages as too by how much. A recent report[5] by the Wind Energy Association of Australia (AusWEA) stated that:

> "It is expected that there will be a convergence between wind energy costs and gas generation costs in the period 2008 to 2015" p. 33.

The report went on further to state:

> "The wind cost ranges are expected to overlap with coal prices from 2016 onwards, with on-going reductions in wind increasing the competitive pressures thereafter" p. 33.

The Federal Government, in its report *Securing Australia's Energy Future* estimated the LRMC of wind generation may fall to as low as $55/MWh in 2010, while coal generation costs will remain at $35/MWh and gas generation prices at $45/MWh. They do not provide predictions post 2010.

In reality it is extremely difficult to accurately predict the future levels of LRMC for both fossil fuel and wind generation and particularly when, and if, they will converge. While there is some indication that capital costs associated with wind generation may fall further the eventual outcome of these generation costs will also be determined by other, unpredictable factors such as; the aggregate effect of connecting wind generators to the existing transmission network, levels of market penetration, future advances in generation technology and performance and impacts of renewable energy schemes. In turn, for fossil fuel generation, future cost levels are likely to be influenced by factors such as; levels of exploration, infrastructure investment needs, growth in electricity demand and impact of demand management programs.

... operating costs or wind farms are lower than fossil fuels if emission costs are included.

As mentioned above, the current LRMC estimates of between $35 to $45 MWh for coal and gas do not factor in the costs of treatment of carbon emissions associated with these generation technologies. If the negative externality associated with carbon emissions is included in the cost of fossil fuel generation, costs could reach as high as $300 MWh[6] depending on the abatement methodology[7] employed. Without including these abatement costs, there is a risk that markets will not receive the appropriate LRMC signals to accurately determine a mix of future investment levels that best meets long-term electricity needs and takes account of any environmental damage associated with these needs.

4. Renewable Energy Targets: Australia and Overseas

On a worldwide scale, annual investment in renewable energy has risen substantially from US$6 billion in 1995 to US$20 billion in 2003.[8] Many countries are now in the process of setting national and regional renewable energy targets. For example:

- The United Kingdom has a renewable energy target of 10.4 per cent by 2010;

- The European Union has set a directive that the percentage of renewable electricity production be increased from 14 per cent in 1997 to 22.1 per cent in 2010;
- China has committed to a 10 per cent increase in renewable energy by 2010, and 12 per cent by 2020; and
- India has committed to a 10 per cent increase in capacity of new renewable energy by 2012.

... Australia currently generates 10.5 per cent of its electricity from clean sources.

Mainly as a consequence of hydro electricity generation, Australia currently generates about 10.5 per cent of its energy needs from renewable energy sources. However, with increased investment in coal and gas generation since the early 1960s, this 10.5 per cent figure represents a steady decline from peak levels of 24 per cent in 1964-65.

The Renewable Energy (Electricity) Act, legislated in 2000, sought to increase this 10.5 per cent figure to 12.5 per cent through investment in 'additional' renewable energy sources such as wind, solar, biomass, new hydro and geothermic rocks. Known as the Mandatory Renewable Energy Target (MRET), which is both a greenhouse gas abatement program and a renewable industry development initiative, the 2 per cent figure was replaced in 1999 by a target of 9,500 gigawatt hours (GWh) of Australia's energy needs to be generated using additional renewables by 2010.[9] In this context the MRET targets a reduction in greenhouse gas emission in 2010 by 10.4 million tonnes, which may seem only a small amount compared to predicted electricity sector emissions of 313m tonnes in the same period.[10]

... electricity generation from clean sources is expected to increase to 12.5 per cent by 2010.

There is continuing debate pertaining to the current MRET targets, with many State Governments and industry experts questioning the energy demand forecasts used to arrive at these targets as being too low.[11] AusWEA, for example, estimate that given current energy growth trends the 2 per cent figure will actually be diluted to only a 0.3 per cent growth in additional renewables by 2010, and the proportion of energy generated by renewable energy sources will fall to 8.5 per cent of total energy needs in 2010.

As part of a recent review of MRET[12] there were calls by these critics to increase the targets to around 5 per cent. However, the Review Panel recommended maintaining the 2 per cent or 9,500 GWh level. The reasons outlined in the review document for maintaining this level of MRET were that:

> "Any significant increase in the 2010 target would be difficult to achieve because of the time needed to obtain planning and environmental approvals, to undertake community consultations, and to complete the necessary financial due diligence processes". (Executive Summary)

The Federal Government is currently considering these recommendations.

5. Wind Farms in Australia and Overseas

Wind farms are being built in Australia at a rapid pace, which follows the trend overseas. Denmark, Germany, Spain, the UK and the US all have a large number of operating wind farms. Germany, Spain and Denmark together account for 60 per cent of the world's total installed wind generation capacity. Table 1 below lists the top 10 countries in the world for installed generation capacity.

Table 1
Installed Wind Generation Capacity for 10 Leading Nations, 2004 and 2005

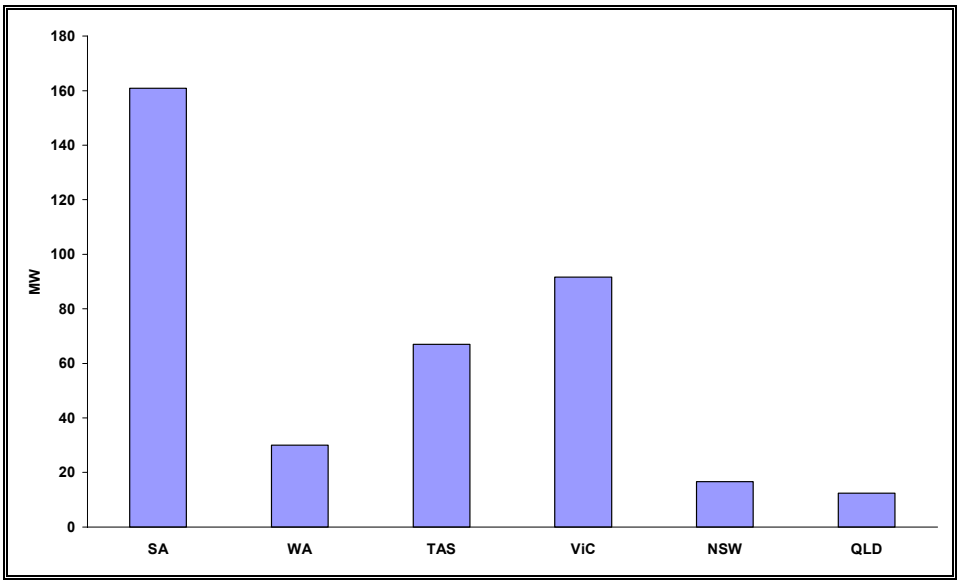
Rank	Country	Installed: Start 2004 (MW)	Installed: Start 2005 (MW)
1	Germany	14,609	16,626
2	Spain	6,202	8,263
3	North America	6,374	6,740
4	Denmark	3,110	3,117
5	India	2,110	2,800
6	Netherlands	912	1,078
7	UK	704	888
8	Japan	644	740
9	China	568	700
10	Austria	415	606
23	Australia	210	379
-	**World**	**39,294**	**46,853**

Source: New Zealand Wind Energy Association.

In Australia, the Australian Wind Energy Association lists Australia's installed capacity for wind generation at approximately 380 MW placing it about level with France and Ireland but below Portugal and Greece.

Figure 2 shows how much installed wind generation capacity exists by State and Territory as at March 2005.

Figure 2
Built Wind Farm Capacity - March 2005 by State



Source: Australian Wind Energy Association.

6. Wind Farms and the National Electricity Market

... wind farms are included in the National Electricity Market.

For the purpose of the National Electricity Market,[13] wind farm generators in Australia are classified as 'non-scheduled' generators in that they do not participate in the actual 'mechanics' of the market. Without going into excessive detail,[14] electricity is supplied to South Australia and the eastern States of Australia through this National Electricity Market or NEM. A wholesale market operates for the purchase and sale of electricity and the national grid consists of the connected transmission and distribution networks that deliver the electricity from the generators to the customers. The National Electricity Market Management Company (NEMMCO) manages the entire system.

The wholesale electricity market is a spot price clearing market where 'scheduled' generators offer to the market, in half-hourly intervals, the amount of electricity they can generate and at what price. The market then selects the cheapest generation offered that meets customer demand while maintaining the security of the national power system. The spot price payable to all participating generators is equal to the offer of the marginal supplying generator in the region.

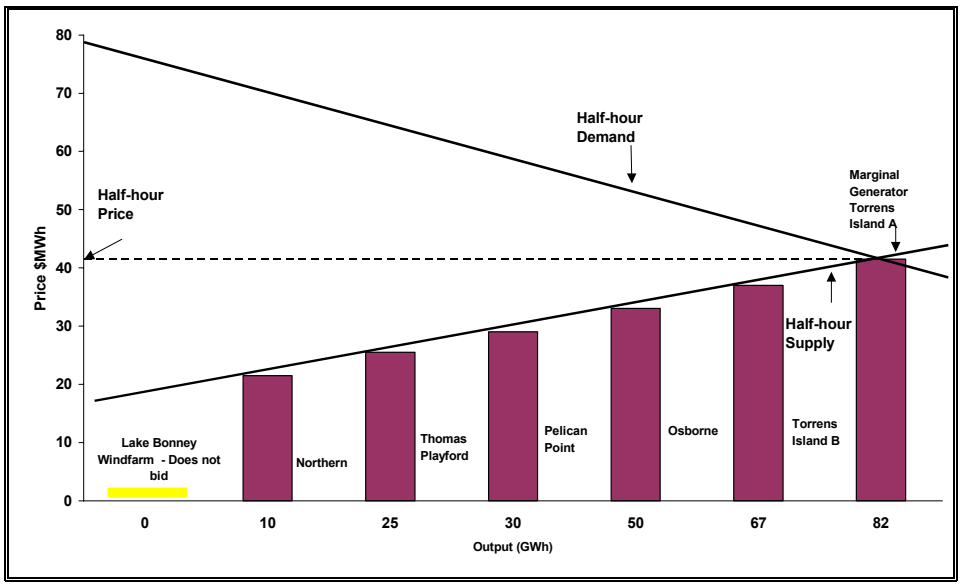
A simplified model of electricity generation in South Australia is shown in Figure 3A. Based on Table 2, which shows the short run marginal costs of National Electricity Market Generators in South Australia, for a half-hour demand of 82GWh, scheduled generators Northern to Torrens Island B would be fully employed and Torrens Island A, the marginal generator, only employed to meet the remainder of required demand. The price of $42MWh that all generators receive is the half-hour price where supply equals demand, which also equals that price offered by the marginal generator.

Table 2
Short Run Marginal Costs of National Electricity Market Generators in South Australia

Power Station	Type/Fuel	SRMC 2004-05 ($MWh)
Northern	Steam/Brown Coal	16.33
Thomas Playford	Steam/Brown Coal	23.71
Pelican Point	CCGT/Gas	30.53
Osborne	Cogen/Gas	33.52
Torrens Island B	Steam/Gas	41.19
Torrens Island A	Steam/Gas	44.70

Source: Report on NEM generator costs (Part 2), ACIL Tasman, February 2005.

Figure 3A
Generation: Electricity Price for a Half-Hour Interval: Without Wind Farm Bid



Source: SACES based on ACIL (2005).

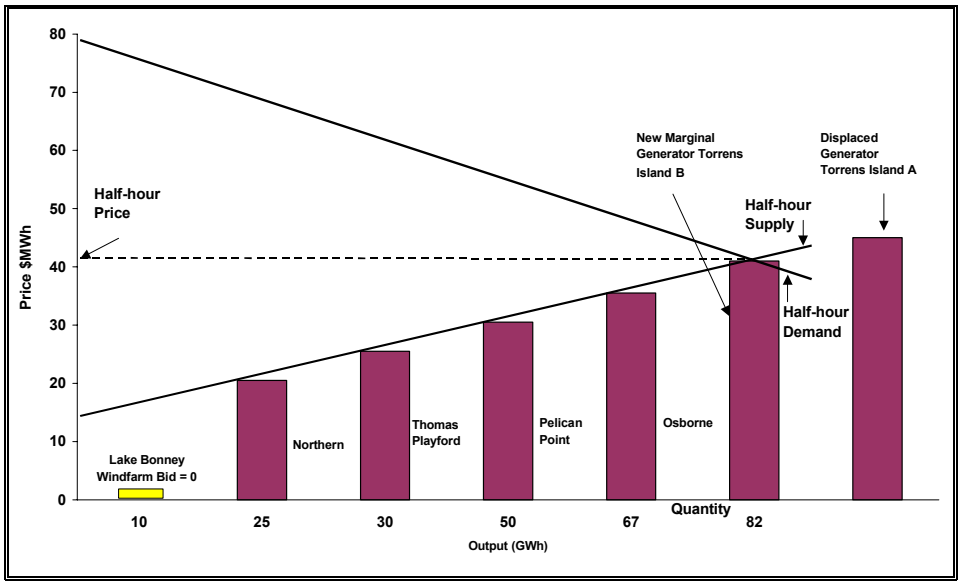
... when operating, a wind farm may displace a fossil fuel generator.

In this situation Northern and Thomas Playford are both coal generators, which have cheaper short-run costs compared to the other generators, which are gas and are more expensive to operate due to their higher price of fuel. Lake Bonney wind generator in Figure 3A has the lowest short run cost of all generators, at close to zero as it requires no fuel to operate.

The open access regime associated with the National Electricity Market ensures that fuel sources cannot be discriminated against. When the Lake Bonney Wind Farm is generating, as a consequence of its zero (or very low) short run marginal cost, it enters the market at the bottom of the pricing stack ensuring that it is always dispatched in any half-hour period. As Figure 3B indicates, this has the effect of displacing the marginal generator from Torrens Island A to Torrens Island B.

The displacement of Torrens Island A for wind generation will reduce carbon emissions, with estimates of between 0.49 – 0.52 million tonnes per annum for every 1MW reduction in gas generation. However, decreased fossil fuel outputs and the resultant increased variability of operation of gas generators in this State may affect the predicability and hence transport costs of gas deliveries through introduced complexities in scheduling of production and transport. Variability in generator operation may also have an effect on generator efficiency, which will negatively impact on the overall level of carbon emission savings.

Figure 3B
Generation: Electricity Price for a Half-Hour Interval
With Wind Farm Bid



Source: SACES based on ACIL (2005).

Because in South Australia, base-load coal generation is largely unaffected by the introduction of wind generation, due to its much lower short run marginal costs, any reduction in capacity is always likely to come from more marginal gas generators.[15] While greenhouse gasses are still reduced, because the marginal generator are not coal fired there is a limit to this amount of greenhouse gas reduction.[16] This trade-off needs to be taken into consideration when considering the capital and other costs associated with wind farms and the levels of carbon reductions expected.

In Figure 3B, the Lake Bonney wind farm, like the fossil fuel generators receives the *short run* marginal clearing price of $42MWh for any energy they dispatch, although as with other market generators such as coal and gas, the actual revenue they receive is more likely to be established through their long-term contracts with retailers. However, investment decisions are normally based on *long run* cost structures and while a short run marginal price would cover short run costs, wind farms have very large capital costs which may not be recovered through this pricing structure.

7. Renewable Electricity Certificates and the Mandated Renewable Energy Targets

Government policy has stimulated investment in wind farms.

To stimulate investment in renewable energy projects that would otherwise lack commercial viability due to high long run cost structures, Australian electricity retailers like Origin and AGL are required by the Commonwealth *Renewable Energy Act 2000* to source a percentage of their electricity demands per annum from additional renewable sources such as wind, new hydro and biomass.

This is achieved through the use of Renewable Energy Certificates or RECs. When an additional renewable energy source such as a wind generator produces a unit of electricity (1 MWh) it also creates with it a REC. Electricity retailers then purchase or trade these certificates to an amount equal to their renewable energy obligations. A penalty, currently $40 per MWh, is imposed on any obligations retailers do not meet.

To date all electricity generated by wind farms has been bought by retailers in the form of fixed price contracts over extended periods of time. This has been a consequence of the need to fulfil quotas under the MRET legislation. These fixed price contracts for wind generators would incorporate not only the value of the energy wind farms produce and sell on the national market, but also the value of the REC (or 'subsidy' - which is dependent on the level of trading in the REC market on any given day). For example, the $42MWh short run marginal cost from Figure 3B that the Lake Bonney wind farm receives, plus the $40 MWh REC certificates would now allow it to fully recover its long run marginal costs.

... electricity prices may increase as more wind farm output is used.

Expectations are that by 2010 the MRET scheme will result in a price increase for South Australian consumers of between 1 to 3 per cent of the average electricity bill.[17] However, predicting any changes to electricity prices is highly dependent on the bidding behaviour of participant generators in the NEM and past evidence has shown that changes in wholesale electricity prices are not always reflected in changes in final consumer prices. It would be expected, however that given the large amount of capital investment associated with wind farms in this State that must be recovered, their higher generating costs and possible fuel price increases due to changes in the utilisation of the gas pipeline, that final consumer prices will rise.

The REC scheme should not be confused with the "Green Power" scheme where customers voluntary chose to buy renewable energy, at premium, above the legislated MRET requirement. These Green Power products are usually accredited under other schemes. While no figures are available for price increases due to the voluntary Green Power Scheme, a recent Newspoll (commissioned by Greenpeace) found that 83 per cent of Australians would be willing to pay more on their monthly energy bills for new renewable sources. In reality though around 1 per cent have taken the Green Power option.

8. Wind Farms and Carbon Emissions

The Kyoto Protocol is the only international agreement that commits nations to control their greenhouse pollution. To date more than 140 nations have ratified. Only 2 developed countries - Australia and the USA have not. Australia has not signed the Kyoto Protocol due to the absence of emission commitments for developing countries under the Protocol which means that countries such as India and China, with almost half of the world's population are not required to reduce emission levels by 2012. Further, no internationally agreed global regime to contain emissions exists for the period after 2012, or is currently in prospect. Therefore the Federal Government has stated that it may be premature to commit to specific long-term targets that would affect our international competitiveness given our high dependence on coal as a source of generation, and would not greatly contribute to the reduction in global greenhouse gas levels.

Disagreement exists whether Australia is on target to meet its Kyoto protocols.

While Australia has not ratified the protocol it has declared its intention to meet Kyoto targets of 2008-2012 emission levels that are 8 per cent *higher* than 1990 levels.[18] This will still require a cut of more than 30 per cent in our emissions growth from a 'business-as-usual' case.

In terms of current progress towards these emission targets, the Australian Greenhouse Office states:

> "Australia is on track to achieve its target of limiting greenhouse emissions to 108 per cent of 1990 emissions over the period 2008-12, as agreed to at Kyoto"[19] (p. 1).

In contrast, some academics and environmental groups have claimed that that it is only the so-called 'Australia Clause', (which allows Australia to claim pollution reductions from stopping land clearing) that is allowing us to meet these target levels and the actual outcome may be an increase of up to 33 per cent in our level of emissions by 2012.

While not supporting these claims, the Australian Greenhouse Office has also stated:

> "Substantial net emissions reductions from land based sectors are contributing to reducing Australia's overall emissions growth to 2012. These reductions help offset underlying emissions growth from the energy sector (covering Stationary Energy, Transport and Fugitive emissions). Emissions from the energy sector are driven by Australia's relatively high rates of economic growth and international demand for Australia's resources". (Australia's Greenhouse Emissions Trends, p. 1).

... calls have been made for environmental policy instruments to help reduce emissions.

Economics theory generally suggests that the most sensible way to tackle any problem is as close as possible to its source. Carbon taxes are one example of an environmental policy instrument designed to do this. They are simply direct payments to government, based on the carbon content of the fuel being consumed, with a portion of the tax falling on both producers and consumers depending on their respective elasticities of

supply and demand. They can make sense economically and environmentally because they tax the carbon externality directly depending on the level of emissions. Coal generates the greatest amount of carbon emissions and would therefore be taxed in greater proportion than oil and natural gas, which have lower carbon concentrations.

However, because Australia is an economy highly dependent on coal as a source of energy, there are many groups, including the Federal Government and the Coal Industry (a powerful Federal lobby group), opposed to carbon taxes. Critics of a carbon tax point to its potential negative impact on GDP with estimated reductions of about 0.8 per cent of GDP[20] and its regressive nature, with the longer-term burden likely to fall disproportionally on low-income households.[21]

Despite domestic opposition to a coal tax, we are also one of the world's largest coal exporting countries and as a consequence of the Kyoto Protocol becoming international law on February 16th 2005 attitudes towards Australia's energy exports, especially coal exports, may now change as other countries strive to *reduce* their emission levels *below* 1990 levels. In this case we may then see a form of carbon tax imposed on Australian coal exports by importing countries.

Commonly seen as a competing policy instrument to reduce greenhouse gases is emissions trading. Whereas carbon taxes are "price-based", emissions trading or tradable permits as they are more commonly known are a "quantity-based" environmental policy instrument as they fix the *total amount* of carbon emitted and allow price levels to fluctuate according to market forces.

Under an emissions trading system, a cap fixes the quantity of emissions, for example 10,000 tons of carbon per year. A fixed number of 'permits to emit' are issued, and the right to emit becomes a tradable commodity. To be in compliance, firms (or countries) must hold a number of permits greater or equal to their actual emissions level. High carbon emitters may purchase (by auction, direct sale or a 'stock market' type arrangements) permits from low emitters at the market rate.

The incentive to lower carbon emissions is two-fold; low emitting firms can actually profit by selling their excess greenhouse gas allowances and high emitting firms can reduce costs by reducing carbon emissions to equal the quantity of permits they hold. Tradable permits are allowed under the Kyoto Protocols and on January 1st 2005 carbon trading began in Europe.[22]

In Australia, while some State Governments have expressed their support for the introduction of tradable emission permits, the Federal Government in its report *Securing Australia's Energy Future* have stated:

> "Australia will not impose significant new economy wide costs such as emission trading in its green house response at this stage. Such action is premature in the absence of effective longer-term global action on climate change" (p. 25).

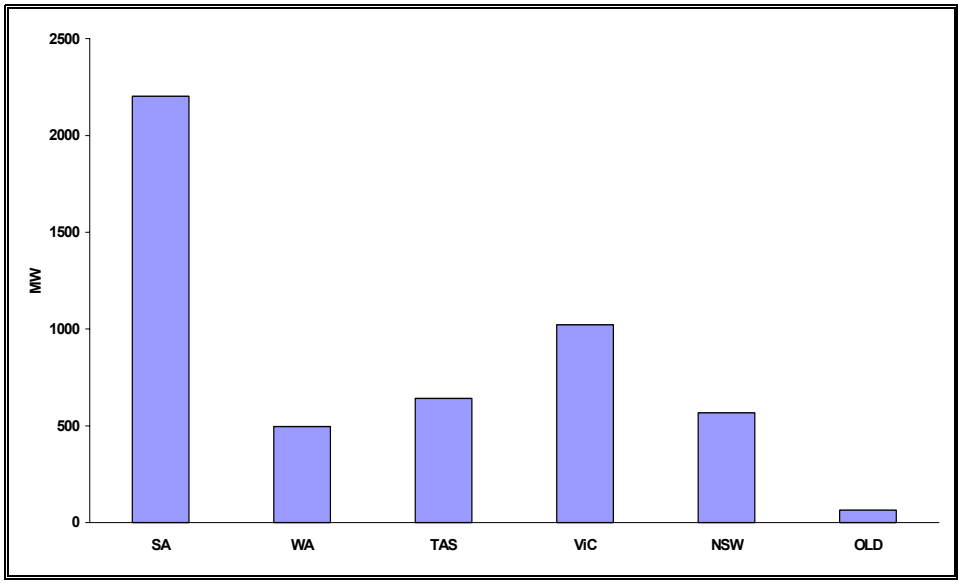
9. Outlook for Wind Farm Investment in South Australia

The Australian Wind Energy Association (AusWEA) and the Australian Business Council for Sustainable Energy estimate that the MRET target of 9,500 GWh requires a total of 1,400 MW of wind generation, Australia wide, by 2010.

Over the next couple of years, as the South Australia Government strives to meet is own 15 per cent renewable energy target, we are likely to see a large increase in the amount of installed wind farm capacity approaching that required to fulfill the current MRETs targets. However, we can expect this rapid growth phase to be exhausted by 2007, and future capacity to then be dependent on higher levels of policy support.

Indeed, as Figure 4 below shows, if all wind farms Australia-wide currently being 'proposed' or undertaking a 'feasibility study' were added to already installed capacity over the remainder of this decade, South Australia would have double the wind farm capacity by 2010 than any other State in Australia.

Figure 4
Installed 2004, plus Proposed: Wind Farm Capacity in Australia in 2001



Source: AusWea and SACES.

South Australia has the largest wind farm investment of any State.

Wind Farm capacity in South Australia of between 2,000 MW and 2,500 MW is unlikely to emerge, as it would not be supported by the current MRET targets, and the cost of connecting that level of capacity to the network would be prohibitive. Despite this, wind farms are still the 'flavour of the month' and with close to 400MW in place or under

construction, predictions from informed bodies such as, ElectraNet, and Energy SA see a potential of 800MW - 1,000MW of installed wind generation capacity within the next 2 years. In support of these estimates, Table 3, below, shows the number of licences issued for wind farms in South Australia and those under consideration by the Essential Services Commission (ESCOSA). Together they equate to a wind farm investment of 1,190MW.

Table 3
Wind Farm Generation Licenses Issued and Under Consideration in South Australia

Electricity Licences Issued	**Owners**	**Location**	**No. of Generators**	**Capacity (MW)**
Canunda	International Power Plc	Lake Bonney	23	46
Lake Bonney Wind Power Pty Ltd (Stage 1)	Babcock and Brown	Lake Bonney	46	80.5
Cathedral Rocks Wind Farms Pty Ltd	Hydro Tasmania	Eyre Peninsula	37	66
Wattle Point Wind Farm Pty Ltd	Meridian Energy	Yorke Peninsula	59	90
Tarong Energy Corporation Ltd	Tarong Energy (Starfish Hill)	Yankalilla	23	34.5
Mt Millar Wind Farm Pty Ltd	Tarong Energy	Eyre Peninsula	35	70
		Total		**387**
Electricity Licences under consideration	**Owners**	**Location**	**No. of Generators**	**Capacity (MW)**
Ausker Energies	Ausker Energies & ANZ Infrastructure Services	Elliston	n.a.	49.5
Lake Bonney Wind Power (Stage 2)	Babcock and Brown	Lake Bonney	n.a.	128
Pacific Hydro Clements Gap Pty Ltd	Energy Pacific Pty Ltd	Port Pirie region	35	57.8
Sellicks Hill Wind Farm Pty Ltd	TrustPower Australia Ltd	Myponga	n.a.	40
Snowtown Wind Farm Pty Ltd	TrustPower Australia Ltd	Port Pirie region	35	57.8
Wind Prospect Pty Ltd	Wind Prospect Group Ltd	Port Pirie region	85	200
Willogoleche Power Pty Ltd	International Power Plc	Port Pirie region	35	57.8
AGL Power generation	Hallet Power Station	Hallet (Mid North)	n.a.	90 – 135
		Total		**803**
		Overall Total		**1,190**

Note: n.a. = not available.
Source: ESCOSA and AusWea.

There are a number of reasons for such a large amount of wind generation investment in this State. Much of it is a consequence of our 'first-mover advantage' associated with having a long history of publicly available data relating to some of the windiest areas on mainland Australia. Other reasons such as: plentiful amounts of cheap and vacant land; ease of access to the electricity grid (and in South Australia's case the national grid); and a supportive local council planning system, have also contributed to investment decisions by wind farm operators.

10. The Costs and Benefits of Wind Farm Investment in South Australia

... the benefits of wind farms are quantifiable.

The investment benefit to an area associated with the installation of wind farms has been estimated in various State Governments' and Wind Energy Association sponsored reports at approximately $1.8m per MW. With 160MW installed so far in South Australia this equates to an investment of $288 million, and a potential for over $1 billion worth of investment, should installation of 1,000MW of wind capacity be achieved.

Further, estimates of employment benefits for the State of between 0.5-0.8 persons per MW[23] equates to between 500-800 extra jobs in the construction, operation and maintenance phases of wind generation, with overseas experience suggesting that wind farms generate as much as 6.6 times more manufacturing and installation jobs than coal-fired power stations.[24]

With forty per cent of capital expenditure sourced from overseas, these figures could increase further if more local manufacturing is undertaken. A recent business manufacturing and trade report[25] which described a 'medium scenario' of 260 MW of wind farm generation on the Eyre Peninsula and 235MW in other South Australian regions concluded a benefit to the State of $562m during construction and an annual $85m operating benefit.

... the benefits of wind farms do not factor in the potential displacement of conventional generation technologies.

Any net benefit to the State must, however, factor in potential displacement of investment associated with conventional generation technologies. Gas is one of the cleanest forms of generating electricity and Government policy to stimulate investment in gas powered generation would equally bring benefits to this State without some of the security of supply problems associated with wind generation. As well, potential for higher energy prices associated with wind generation could impact negatively on our manufacturing sectors, especially those that are export orientated. A truly accurate picture of the benefits of large-scale wind investment in this State must net out the transfer away from consumers towards wind farm operators to sustain their technologies. This is an area where little previous research has been undertaken.

Apart from any monetary benefits claimed, other potential benefits do exist to the State from the investment in wind farms. South Australia is heavily dependent on natural gas as a fuel, generating 60 per cent of power from low-carbon emitting gas generation. Although gas is a relatively clean source of emissions the remaining 40 per cent of electricity generation capacity in this State comes from coal, oil and diesel, which are high carbon emitters. Therefore, with 1,000MW of wind capacity equating to approximately 4 million tonnes of greenhouse gas abatement per year,[26] this will not only help enhance the State Government's desire to brand South Australia as the 'clean green' State,

but also diversify our heavy reliance on gas which makes our State vulnerable to supply interruptions.

Critics of wind farms have pointed to the intermittent nature of wind and the need to have back up fuel generators. Although wind energy forecasting is never an exact science, forecasting has improved in recent years and the Federal Government is now providing $14m to develop and install systems to provide accurate long term forecasts for wind output. As well, with wind farms being spread throughout the State the impact of reduced wind in one area has the potential to be offset by other areas. Finally, many local communities are still divided on the visual and environmental impact of the towers as highlighted by recent debates in State and local newspapers.

11. Impact of Wind Farms on South Australia's Existing Electricity Infrastructure

... the aggregate impact of wind farms is currently being investigated.

The Essential Services Commission of South Australia (ESCOSA) and the Electricity Supply Industry Planning Council (ESIPC) are currently investigating the aggregate impact of current wind farms and future applications on South Australia's electricity infrastructure. With a report due in March/April 2005 relating to maximum wind farm capacity the State's electricity infrastructure can handle, ESCOSA is currently delaying decisions on new licence application detailed in Table 3.

Perhaps as a precursor to this forthcoming report, in its Annual Planning Report of June 2004 ESIPC stated

> "If the level of wind penetration was to increase [above 600MW] than the resultant change in market share between scheduled and non-scheduled generation could delay the development of more conventional new generation in the state" (p. 43).

Currently there are no new scheduled power station projects committed to go ahead in South Australia.

... wind farms may help ease the growth in peak-load demand in South Australia.

In this State, we have 3,450MW of 'name plate' electricity generation from fossil fuels of which about 3,140MW[27] can be made available on a hot summers day. With peak load demand currently growing at an average of 2.8 per cent per year (peak load under extreme conditions drives the need for future capacity) without additional investment, demand may outstrip supply by 2007-08.[28]

In this context the sustainable level of wind farm capacity in South Australia becomes critical. While modelling on 3 levels (low, medium and high) of wind generation capacity by ESPIC[29] found that for all levels the:

> "volumes of installed wind power ... were able to be accommodated [by the States' electricity infrastructure] without significant operational impact" (p. 4).

It also went further to say that:

> "there appears to be a practical limit to the level of wind generation above which the operational viability of some of the incumbent [fossil fuel] generators is uncertain" (p. 4).

Although no figures have been published by either ESIPC or ESCOSA, various other (unsubstantiated) reports place the practical limit of wind farm capacity in this State at somewhere between 600MW and 800MW. Further, portability estimates by ESIPC indicate that levels of wind farm such as this could be relied upon to contribute only 8 per cent of total capacity to meet peak loads with absolute certainty.

In reality, as a consequence of South Australia's coastal sea breeze effect, the average output from wind farms during summer peak hours may be higher. However, because on very hot days, security of supply in this State is essential, and wind generation cannot be simply 'turned on' to absorb extra demand in a way peaking generators such as Dry Creek can, absolute certainty of wind farm scheduling becomes critical. With this in mind, ESIPC have reported that wind generation in South does not appear to flatten the State's 'needle point' (top 30 per cent of our electricity demand occurs for only 10 per cent of the year) load shape curve or load factor of 0.51 (average load divided by peak load).

12. Conclusion

South Australia's image as the clean, green state is promoted by its production of electricity using mainly gas-fired generators. This is in contrast with New South Wales and Victoria, where over 90 per cent of the generation comes from high greenhouse gas emitting coal generators. Yet it is South Australia where the majority of wind farm investment in Australia is likely to occur over the next couple of years. This will bring monetary benefit to the State in the manufacturing and construction phase (which would also occur with an increased investment in fossil fuel generation) and some additional benefits in the operational phase. These additional benefits include reductions in greenhouse gas emissions, mitigated by the unlikely displacement of either Playford or Northern coal generators and diversification of our heavy reliance on gas as the primary source of fuel for electricity generation.

Studies into the true impact of wind farms on our existing electricity network infrastructure are currently being completed. Without pre empting these studies, there is a belief that a maximum level of installed capacity exists beyond which some degree of network augmentation will be required and investment decisions in new fossil fuel generation plant will be affected. The current number of license applications may currently exceed this maximum level.

Critics of wind farms point to their intermittent nature of operation, as wind is never guaranteed. In reality, with diversification of sites throughout the state, large amount of available wind forecasting data and increased accuracy in wind pattern predictions, the level of intermittency of wind farm input into the network is likely to be reduced. With the level of capacity of wind farms likely to be anywhere up to 1000Mw there is potential to have a substantial impact on South Australia's average daily usage of 1600Mw.

Wind generation will not replace fossil fuel generation, however, if we can balance the number of installed wind farms with the level the network infrastructure can support, without requiring large-scale upgrades or reducing the required level of conventional investment to meet expanding demand, then the State will have an electricity generation technology that has the potential to reduce our emissions and smooth our 'needle point' peak-load profile.

Over the past year, descriptions of wind farms have contrasted between the only solution to reducing our carbon emissions to environmental and ecological disasters. In reality the balance falls somewhere in between. Notwithstanding, it is important that South Australia continues to promote other measures aimed at reducing electricity demand and more efficiently managing our network infrastructure.

End Notes

1 Australia's energy sector includes the production and supply of stationary energy (such as electricity and gas), transport energy (petroleum bases fuels) and energy for exports.

2 South Australia currently has 3,454MW of installed "name-plate" generation capacity excluding wind farms.

3 The idea of this paper is not to go into detail pertaining to the structure and operation of a wind farm. If the reader is interested plenty of information relating to this topic is available on the internet, for example, an excellent paper by the AusWEA entitled *Windfarm Basics* can be found at http://www.auswea.com.au/WIDP/assets/BP1_Basics.pdf

4 Includes capital costs, operating and maintenance costs and common (or head office) costs.

5 Mallon K (2004) '*Cost Conversion of Wind Power and Conventional Generation In Australia'*

6 Australian Federal Government, *Securing Australia's Energy Future*, 2004

7 For example, unsubstantiated estimates have indicated that the cost of black coal generation, with disposal of carbon emissions by geosequesteration disposal (deep burial) varies from $64/MWh to $130/MWh, The Advertiser, *Letters to the Editor*, November 29th 2004.

8 Dr Eric Martinot, Renewable Energy Knowledge Base: Global Markets, Investments and Policies, Presentation to World Council for Renewable Energy Forum, Bonn June 2004 at http://www.martinot.info/Martinot_WCRE2.pdf

9 Studies from various consultants were incorporated in assessing the options for the finals level of the MRET target. These included:

a). McLennan Magasanik Associates: *Projections of Price of Renewable Energy Certificates to Meet the 2 per cent Renewable Energy Target* (November 1999);

b) Redding Energy Management Report: 2 *per cent Renewables Target in Power Supplies* (January 1999);

c) Econtech Report: Macroeconomic and Industry Effects of the 2 per cent Renewables target (April 1999); and

d) Tony Beck Consulting Report: Sectoral Impacts of the 2 per cent Renewables Target (April 1999).

10 Australian Greenhouse Office.

11 ABARE 1996-97 data was used to determine the baseline figure with growth projections undertaken by the reports outlined in Footnote 8.

12 Renewable Opportunities, A Review of the Operation of the Renewable Energy (Electricity) Act 2000.

13 Currently only WA and NT are not supplied by the NEM and Tasmania will be supplied when Basslink comes on line in April 2006.

14 There are numerous papers on this topic such as "*Wind Farming and the Australian Electricity Market*" available on the Internet at the Australian Wind Energy Association's homepage.

15 This may not be the case in NSW and Victoria where the marginal generators will likely be coal as a consequence of the vast majority of electricity in these States being generated by coal rather than gas.

16 The reader should consider this, as often figures associated with greenhouse gas savings due to wind generation are quoted with much higher carbon emitting coal as the marginal generator.

17 Australian Federal Government *"Securing Australia's Energy Future",2004.*

18 All except 2 other developed countries (Norway and Iceland) have agreed to a collective target of a 5.2 per cent *reduction* in greenhouse gas emissions below 1990 levels by between 2008 and 2012.

19 Australia's Greenhouse Emissions Trends - 1990 to 2008-2012 and 2020 at http://www.greenhouse.gov.au/projections/tracking/pubs/tracking2004.pdf

20 Repetto and Austin (1997) *The Cost of Climate Protection: A Guide for the Perplexed* (World Resources Institute)

[21] Most models of carbon tax incidence show that in the short run the burden of the tax will fall on capital stocks such as coal-fired power stations. In the longer run capital is mobile and distributional effects will result in a move out of these high taxed industries and a shift of the incidence of the tax onto consumers.

[22] It may be significant that carbon prices fell by 25 per cent in the first 10 days of operating of the tradable permits market in Europe. This has been suggested as being a consequence of emission quotas being set too high.

[23] Sustainable Energy Authority of Victoria*, Policy and Planning Guidelines for Development of Wind Energy Facilities in Victoria*, Sept. 2002, pg 8.

[24] Does not take into account jobs generated through coal mining.

[25] Deloitte Touche Tohmatsu, *"Wind Generation Developments on the Eyre Peninsula: Economic Impact Analysis", 2002*

[26] KPMG, *The Emerging Wind Energy Industry in Australia and Some of the Key Policy Challenges,* Sept 2003

[27] On average 16 per cent of SA's energy requirement is imported. We have about 700MW of imported energy available through South Australia's interconnection with the National Grid and expectations of a further 600MW when the Basslink interconnector between Tasmania and Victoria is completed in April 2006.

[28] Electricity Supply Industry Planning Council.

[29] ESPIC, *South Australian Wind power Study*, March 2003 - Low wind penetration of 165MW, medium wind penetration of 488MW – 548MW, and high wind penetration of 1,018.5MW