Submission No: 110

auswind
CLEAN POWER. CLEAN AIR.

House of Representatives Standing Committee on Industry and Resources

Inquiry into developing Australia's non fossil fuel energy industry

Case study into selected renewable energy sources

Australian Wind Energy Association Submission

June 2007

CONTENTS

Auswind

Auswind, (the Australian Wind Energy Association) represents the Australian Wind Energy Industry by working with all levels of government, community groups and interested organisations to raise awareness of the benefits of wind energy and promote its use.

Auswind's members include wind farm operators, some of whom produce electricity from coal, gas and hydro; wind farm developers; electricity retailers, manufacturers of wind turbines and associated hardware, engineers, lawyers and other consultants working with the Wind Energy Industry.

Our vision is for a robust Australian Wind Industry that makes a significant contribution to safe, reliable, economically and environmentally sustainable energy supply.

Summary

- Unlike other 'solutions' to clean energy and climate protection, wind power does not need to be invented, nor is there need to wait for any 'magical breakthrough'. Wind power is being implemented globally now. Modern wind farms that provide base load power equivalent to conventional power stations are already being built. In the future, the boundaries of technological progress will be pushed further to bring far greater benefits from wind power.

- Globally, the wind energy industry is experiencing particularly strong growth as government's recognise the need to assist new energy sector entrants meet GHG emission reduction, energy security and energy supply objectives. The wind energy industry has responded strongly to these measures because wind power is a mature, developed technology which is relatively easy and quick to construct, and the supply of zero emission electricity from wind turbines can be integrated in major transmission networks without significant change to the overall network structure. Of note, the IPCC in its 4th assessment report found that renewable technologies, including wind power, can meet 35% of the world's electricity needs by 2030.

- By the end of 2006, the capacity of wind energy installed globally had reached a level of 74,000 MW. The countries with the highest total installed capacity are Germany (20,621 MW), Spain (11,615 MW), the USA (11,603 MW), India (6,270 MW) and Denmark (3,136).

- Thirteen countries around the world can now be counted among those with over 1000 MW of wind capacity, with France and Canada reaching this threshold in 2006. In terms of new installed capacity in 2006, the US continued to lead with 2,454 MW, followed by Germany (2,233 MW), India (1,840 MW), Spain (1,587 MW), China (1,347 MW) and France (810MW). This development shows that new players such as France and China are gaining ground.

- A 2004 Report by the Australian Clean Energy Futures Group, which looks at scenarios in which Greenhouse Gas emissions from Australian stationary energy in 2040 are reduced to 50% of their level in 2001, found that wind power could have an installed capacity of 19,000 MW (19 Gigawatts) by 2040, representing <u>20%</u> of Australia's electricity generation.

- The Federal Government's *Mandatory Renewable Energy Target* (MRET) scheme achieved its target of 9,500 Giga Watt hour (GWh) of new renewable generation 4 years ahead of its original schedule (2010), leaving developers with no active incentive scheme. The Victorian State government has addressed this investment vacuum with the VRET of 10% by 2016 commencing in 2007. The NSW Government has also committed to a 15% NRET by 2020. Other State governments have also publicly announced an intention to implement renewable energy targets.

- Since electricity from wind (and from other clean energy types) is an essential service but is forced to compete unfairly against electricity produced from coal which does not contain many external costs of fossil fuel conversion, there is a strong public-good argument for providing targeted support for wind power. Not surprisingly, a great number of modern, developed and developing economies are using government targeted policies and programs to support the development of the wind energy industry and other renewables.

- The influence of carbon trading/taxes that Australia decides to adopt is likely to be far too slow to encourage the transition to cleaner electricity, particularly if a scheme does not commence until 2012. A much faster mechanism is required to rapidly 'push' the supply of zero emission electricity Australia needs to achieve a tougher Greenhouse Gas reduction target.

- Electricity supply from coal currently contributes significantly to Australia's emission profile and it is well recognised that a key challenge is the reduction of CO_2 emissions from this sector. To achieve this, restructuring of the electricity supply industry must occur to increase the contribution of wind power and other zero and low emission energy technologies. This restructuring requires targeted industry development measures. Carbon price signals will not drive the short term change that is necessary.

- The recommendation by the PM's Emission Task Group to delay the commencement of an Emission Trading System until 2012 and the fact that it is likely that the target and timeframe will result in a low carbon price means that this measure alone will be too slow to stimulate investment in clean energy technologies. Therefore it is essential that additional targeted support measures be provided to mature, proven clean energy technologies, like wind energy, to stimulate their expansion in Australia. These targeted support measures can then be phased out as the Trading System reaches a point where it can alone sustain investment in clean energy technology.

- As requested by Auswind, Frontier Economics has modeled a 20% by 2020 and 30% by 2030. This targeted measure will establish a market in which zero emission energy technologies can compete to ensure the most cost effective in installed. The modeling shows how implementing the measure would stablise emissions from the stationary energy sector. It is important that the State Governments continue with their targeted schemes (Renewable Energy Targets) until a co-incidence of the two policy measures can be arranged.

- Detractors of the wind energy industry frequently cite base-load incapability, variability (sometimes called intermittency) of wind power and the need for reserves as impediments to the economic value of the industry. The reality is that wind power can be a base-load source of electricity, while for variability and reserves, the issue is one of cost rather than a technical constraint

- Although a single wind turbine is variable, this is not generally true of a system of several wind farms, separated by several hundred kilometres and experiencing different wind regimes. The total output of such a system generally varies smoothly and only very rarely experiences a situation where there is no wind at any site. With short term forecasting of wind conditions now being quite accurate, wind power can be forecast for balancing electricity supply, especially when considering aggregate output and particularly for a large and meteorologically diverse country like Australia.

- No electricity plant has a capacity value of 100% and when determining reserve requirements, grid operators make an assessment of the needs of the electricity supply system as whole, rather than considering the needs of individual plant. Due to the variability of wind power, its capacity value to the grid is more limited than other conventional electricity generators. The capacity value decreases as more wind is installed on the system; at low penetrations it has been put at roughly equal to the capacity factor for wind (30-35%), but at higher supply penetrations the value decreases to around 20% at penetrations of 20%.

  This is because with low penetrations, wind output is hardly noticed on the system, but when this increases, the variability of wind becomes more noticeable and its ability to provide firm capacity is reduced.

- Since wind energy will provide an increasing amount of electricity in Australia, Auswind is leading two large initiatives to strengthen industry's adherence to environmental planning/legal requirements and community acceptance; and to recognise that the long-term sustainability of the wind energy industry in Australia depends on appropriately sited and environmentally sensitive wind energy projects.

1. Australian and overseas wind energy industry contributions to total energy supply

1.1 Introduction

Wind energy has come a long way since the prototypes of just 25 years ago. Two decades of technological progress has resulted in today's turbines being state-of-art modern technology - modular and rapid to install. A single wind turbine can produce 200 times more power than its equivalent two decades ago.

In 2005, 9,000 Megawatts (MW) were installed worldwide. This is equivalent to 18 coal fired power stations of equivalent capacity to each of the two 500 MW Victorian Loy Yang Power Stations.

The wind power sector includes some of the world's largest energy companies. In Australia large players such as AGL, Stanwell and Babcock and Brown are also involved in coal and gas electricity generation (the latter also having international investments). Pacific Hydro, has wind and hydro power projects in Australia, Chile, Canada and the Philippines. Another example of the mixed energy interests of Auswind's members is Hydro Tasmania which in a joint venture with China Light and Power, owns Roaring 40s, a Tasmanian wind farm company investing heavily in China.

Unlike other 'solutions' to clean energy and climate protection, wind power does not need to be invented, nor is there need to wait for any magical' breakthrough'; it is being implemented globally now. Modern wind farms are already being built that provide base load power equivalent to conventional power stations. In the future, the boundaries of technological progress will be pushed further to bring far greater benefits from wind power.

The following two Sections describe the current and potential capacity of wind power in the world and in Australia, set against prevailing views of the adequacy of global fossil fuel supplies.

However, in a survey of world fuel resources and their impact on the development of wind power, Renewable Energy System's Report "Plugging the Gap" (2006) concludes that the world's energy resources are diminishing at a rate faster than official estimates suggest, particularly for oil and gas. The Report describes huge opportunities for the gas gap to be filled with wind - a safe, carbon neutral, economic, free and indigenous resource that can help meet national environmental and energy security targets. Under this Report's scenario for the supply of fossil fuels, even faster growth in wind power can be expected than that described below.

1.2 World scene

By the end of 2006, the capacity of wind energy installed globally had reached a level of 74,000 MW. The countries with the highest total installed capacity are Germany (20,621 MW), Spain (11,615 MW), the USA (11,603 MW), India (6,270 MW) and Denmark (3,136).

Thirteen countries around the world can now be counted among those with over 1000 MW of wind capacity, with France and Canada reaching this threshold in 2006. In terms of new installed capacity in 2006, the US continued to lead with 2,454 MW, followed by Germany (2,233 MW), India (1,840 MW), Spain (1,587 MW), China (1,347 MW) and France (810MW). This development shows that new players such as France and China are gaining ground.

As this growth continues, Europe's market share has decreased from 72% in 2004 to 51% in 2006. This is due to the expansion of markets in other continents. Delays in the offshore market have pushed large scale offshore development towards the end of the decade.

The Global Wind Energy Council (GWEC) has forecast[i] the **North American market** to continue as the second largest regional market in terms of total installed capacity with an average annual growth rate of 24.6% to reach 31.6 GW by the end of 2010. The US market will be the most important national market in the world during the period 2007-2010 with a predicted average installation of 3.5 GW per year. The extension of the Federal Production Tax Credit seems likely due to the Bush Government's strong support for wind power. Together with high level support from an increasing number of State government's market growth will continue strongly. By 2010, the US will be on par with Germany in terms of cumulative installed capacity.

GWEC reports that strong growth of wind power in China has resulted in the **Asian market** growth estimates being overtaken and Asia will have the highest average annual growth rate (28.3%). The total installed capacity should reach 29 GW at the end of 2010, up from 10.7 GW in 2006. With a predicted installed capacity of 8,000 MW during the period 2007-2010, India will continue to be the continental leader and the fourth country globally. China will be a close second, with the highest growth rate and a predicted installed capacity also of 8,000 MW.

In 2006, there were encouraging developments in **Latin America and the Caribbean**, with new installations of 296 MW. During the period 2007-2010 the markets in Brazil, Mexico Argentian and Chile will expand. GWEC predicts despite its large potential, Latin America will remain a small market until the end of this decade, progressing towards significant development in the next decade.

Wind energy development in the **Pacific region** slowed considerably in 2006, with only 112 MW of new installations. However, despite some uncertainties regarding the political framework, the development is predicted to continue in Australia with 1,000 GW to be installed in the period 2007-2010. Although very little new capacity was added in New Zealand in 2006, many projects are in different phases of development indicating that 400 MW could be added by 2010.

Africa remains the continent with the smallest wind development. Two countries have emerged as leaders: Egypt and Morocco. Development in these two countries is expected to pick up, and some development is predicted in other North African and Middle East countries, adding a total of 900 MW during the period 2007-2010 for the whole continent.

In its business as usual scenario, the European Wind Energy Association forecasts that global installed capacity for wind power will reach 161,000 MW (or 161 Gigawatts) by 2012. If significant policy changes are made to include the external environmental costs of fossil fuel based electricity, not presently included in their prices, its "Wind Force 12" study demonstrates that 1,200 GW could be installed globally by 2020.[ii]

The American Wind Energy Association has recently committed to a vision of 20% of electricity supply from wind power by 2030.

The Intergovernmental Panel on Climate Change (IPCC) recently published the third part of its 4th Assessment Report. The Panel found that the climate change problem can be tackled with existing technologies at a very reasonable cost but that stronger political will is needed to deploy these technologies on a larger scale. The Panel also found that renewable technologies, including wind power, can meet 35% of the world's electricity needs by 2030.

1.3 Australia

Australia has some of the worlds best wind resources. This is due to the strong, consistent westerlies in the southern part of the continent (the Roaring 40s) and the easterly tradewinds in northern Australia, together with a relatively flat topography. Coastal sea breezes in the warm weather are another important wind resource; these correspond with the higher temperatures that result in increased electricity demand. As demonstrated by the CSIRO wind resource map below, there are numerous locations where wind speeds are greater than 6m per second and some locations averaging approximately 10m per second, making them world class wind sites. These characteristics provide Australia with significant clean energy advantages compared to other international locations.

In Australia, installed wind power capacity in 2006 was 817 MW situated mainly in NSW, Victoria, SA and Tasmania and representing only 1.3% of national electricity demand. The capital investment involved in these wind farms was $A1.9 billion with annual operation and management costs being $A22 million. Lease payments to landholders on which the wind farms are located were $A22 million.

Figures at January 2007 show the Australian wind energy industry offsetting 3.26 million tonnes of CO_2 per year, the equivalent of permanently taking 752,000 cars off the road or planting 4.86 million trees.

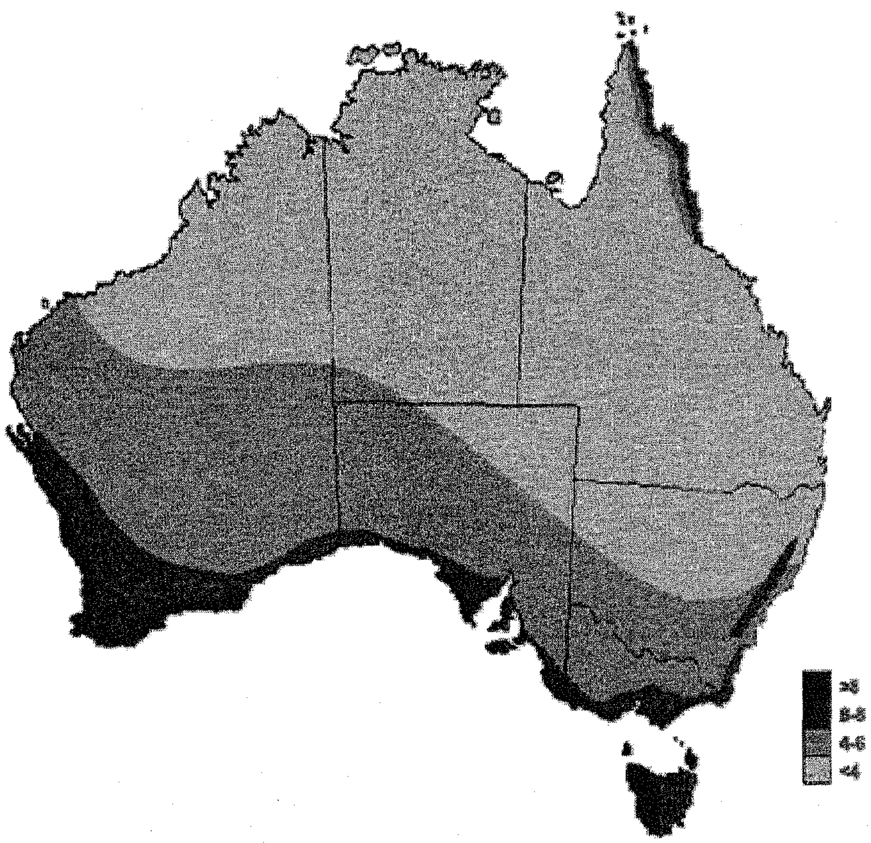
Projects totalling 521MW are currently under construction and 2100 MW of projects have received planning approval. Another 4000MW of projects are in the feasibility stage or seeking planning approval. Given this capacity, Auswind forecasts that the potential additional installed capacity in Australia could be at least 6000 MW. The capital investment involved in these wind farms would be valued at approximately $A15 billion with annual operation and management costs at $178 million and annual payment to landholders of $A22 million.

A report commissioned in 2003 by the Australian Greenhouse Office found that the national electricity market could readily accept an installed wind capacity of 8000 MW with appropriate siting, commercial wind output forecasting and the continual enhancement of interstate grid connectivity. This would equate to approximately 10% of Australia's electricity needs.

Given a stronger political commitment to a cleaner energy future for Australia and appropriate investment in electrical infrastructure, the future role for wind power in Australia can be even more substantial.

A 2004 Report by the Australian Clean Energy Futures Group, which looks at scenarios in which Greenhouse Gas emissions from Australian stationary energy in 2040 are reduced to 50% of their level in 2001, found that wind power could have an installed capacity of 19,000 MW by 2040, representing 20% of Australia's electricity generation.

WIND MAP OF AUSTRALIA



2. Current government policy and programs supporting wind power

2.1 Introduction

Both Federal and State Government support for industry development can be generally described as both targeted, (that is directed to specific industries), and as more broadly based policies. Most Western economies use a spread of targeted and broad based policies to encourage industry development. The following section describes the situation in Australia and then briefly the international situation.

2.2 Targeted Programs for wind power in Australia

2.2.1 Federal Incentive Programs

The major targeted scheme for the wind energy industry reached its effective conclusion in 2006. The Federal Government's *Mandatory Renewable Energy Target* (MRET) scheme achieved its target of 9,500 Giga Watt hours (GWh) of new renewable generation 4 years ahead of its original schedule (2010), leaving developers with no active incentive scheme until the States came to the rescue in the second half of 2006.

2.2.2 State-based Programs

The Victorian and NSW State governments have partly addressed the investment vacuum created by introducing state renewable energy targets. The Victorian Renewable Energy Target (VRET) 10% by 2016 commenced in 2007. The VRET (from Alcoa is excluded) will result in an additional $2billion of capital investment in wind power and is forecast to increase the average cost of electricity for household consumers by .23% per annum, commercial consumers by .27% per annum and industrial consumers by .45% per annum.

The NSW Government has also committed to a 15% NSW Renewable Energy Target (NRET) by 2020. Other State governments have also publicly announced an intention to implement renewable energy targets.

The major difference between VRET and NRET is that Victoria requires its quota of renewable electricity to be generated within the state, while New South Wales allows generation outside its borders as long as the electricity is consumed within NSW.

South Australia - which is already home to almost half of the nation's installed wind energy capacity – has a pledged to source 20% of its power from renewables by 2014. A specific measure to provide an incentive to solar has been implemented.

Both governments in WA and QLD have committed to the introduction of a state based renewable energy targets which grow to 20% by 2020.

2.2.3 International experience for targeted assistance

A large number modern, developed and developing economies use government targeted policies and programs to support the development of the wind energy industry and other renewables:[iii]

Europe

The most ambitious target has been set by the European Union. In 2001, the European Council and the European Parliament adopted a Renewable Energy Directive establishing national targets for each member country. Although these targets are indicative, they have served as a very important catalyst in initiating political initiatives throughout Europe to increase renewable energy's share of electricity supply. The Directive aims to double renewables' share of the energy mix from 6% to 12% by 2010, equal to 21% of EU electricity consumption.

The next step forward from the Directive is that the Commission should submit proposals to the European Parliament and Council for mandatory renewables energy targets. Furthermore, targets should be set for 2020 and the adoption of a legally binding target to achieve a minimum 20% renewable energy by 2020 in the EU25 should be set. A time-horizon of six years is not long in an electricity sector where the investment horizon is up to 40 years.

Canada

An important contributor to Canada's market has been the Federal government's Wind Power Production Incentive (WPPI). This was extended in the 2005 budget to provide a payment to wind power generators of 1 cent per kilowatt hour for ten years and to support the development of up to 4,000 MW of capacity over the period to 2010. The other factor has been policy commitments and targets adopted by Provincial governments which could see more than 5,000 MW in place by 2012.

USA

Federal Program

The United States was one of the pioneers in wind energy development, with hundreds of turbines erected across the mountain passes of California during the 1980s. First brought into force in 1992, the Production Tax Credit (PTC) currently provides a 1.9 cent per kilowatt hour credit for electricity produced commercially from a wind energy facility during the first ten years of its operation. In order to qualify, a wind farm must be completed and start generating power while the credit is in place. Justification for the credit is that it both recognises the environmental benefits of wind energy and helps to level the playing field with the subsidies available to other fuels used for power generation.

When the credit expires, however, as it has three times over the past six years, contracts are put on hold, investments trickle to a halt and jobs are lost. During the period from the PTC's last expiry in December 2003 until its extension in October 2004, for example, thousands of jobs were lost and over US$2 billion in investment put on hold. By the end of 2004, following the credit's renewal, the industry had brought into service only 389 MW of new capacity, well under what would otherwise have been installed. Renewal of the PTC is the main reason for the boom in construction activity during 2005. Because wind power in the USA is recognised as a in important source of domestic, zero emission energy, it is likely that the PTC will be extended for another 3 – 5 years.

State-Level Renewables Portfolio Standards

The renewables portfolio standard (RPS) which applies to 21 States of the Union uses market mechanisms to ensure that a growing percentage of electricity is produced from renewable sources, like wind power. The RPS provides a predictable, competitive market, within which renewable generators will compete with each other to lower prices.

A few notable examples are:

California: The State target has been changed from 20% by 2017 to 20% by 2010. Currently, 12% of electricity in the State comes from renewables, primarily wind power.

Texas: The existing RPS in 2005 was expanded to 5,580 MW by 2015.

Colorado: In 2007, the existing RPS was changed to 20% by 2020, previously being 10% by 2015

Illinois: The State has a goal of 8% by 2013 in place. Under the Illinois Commerce Commission -approved RPS, 75% of the renewable energy generated to meet the state's goal should come from wind.

Other international measures

Many countries have implemented specific measures to support the expansion of the renewable energy sector. The wind energy industry has responded strongly to these measures because wind power is a mature, developed technology which is relatively easy and quick to construct, and the supply of zero emission electricity from wind turbines can be integrated in major transmission networks without significant change to the overall network structure.

The table below shows the various measures in place in IEA member countries.

Table 4 Incentive programs offered in IEA Wind Member Countries for 2005. NDA indicates no data available

		Australia	Canada	Denmark	Finland	Germany	Greece	Ireland	Italy	Japan	Korea	Mexico	Netherlands	Norway	Portugal	Spain	Sweden	Switzerland	United Kingdom	United States	TOTALS
Investment Support	Direct capital investment subsidies/ grants		X		X		X	NDA	X	X	X			X	X	X			X		10
	Capital investment write-offs		X					NDA				X	X								3
	Soft loans							NDA			X		X			X					3
	Others							NDA	X												1
Production Support	Premium price for generation		X	X		X	X	NDA	X		X		X		X	X		X			10
	Exemption from energy taxes				X			NDA									X		X		3
	Production tax credits							NDA												X	1
	Others							NDA	X		X	X								X	4
Demand Creation	Obligation for production from renewables on suppliers	X	X					NDA	X										X	X	5
	Free market for green electricity				X			NDA	X				X		X	X	X	X		X	8
	Others					X	X	NDA			X										3

Note: see country chapters for more detail

2.3 General Federal Government programs for renewables and low emission technology

2.3.1 National Greenhouse Strategy

The development and growth of the renewable energy industry in Australia is primarily supported by the strategic initiatives that flowed from the Federal Government's 1998 National Greenhouse Strategy (NGS), the strategic framework for advancing Australia's domestic greenhouse response.

The Australian government, through the Australian Greenhouse Office (AGO), delivers the majority of these initiatives under the $A1.8 billion climate change strategy. The initiatives include a wide range of measures focusing on the energy, transport, and agricultural sectors. The most significant NGS initiative for the renewable energy sector has been the MRET scheme, discussed below. Other NGS initiatives are outlined below.

- The $A 26.5m Renewable Energy Equity Fund, which provides venture capital to high-growth and emerging companies commercialising direct or enabling renewable energy technology services.
- The $A54m Renewable Energy Commercialisation Program (RECP), which provides the potential for a strong commercial contribution to the renewable energy industry, with a focus on greenhouse gas emission reductions.
- The Renewable Energy Showcase, which provides funding and/or promotion of leading edge technologies that are approaching commercialisation.

2.3.2 White Paper on Energy and the Environment

The Federal Government's most recent comprehensive response to energy and environmental issues was released in June 2004, and framed within the White Paper on Energy and the Environment, "*Securing Australia's Energy Future*". The existing MRET (9,500 GWh by 2010 through to 2020) (see Section 2.2.1) was retained, although there was some refining of the processes associated with its administration and operation.

The White Paper included funding for the following support incentives:

- A renewable energy development initiative - $A100m over seven years
- Low emissions technology and abatement - $A27m over four years
- Advanced electricity storage technologies - $A 20m over four years
- Wind forecasting capability - $A 14m
- Improved electricity grid accessibility – through Federal and State government relations.

The White Paper also included a $A500m Low Emissions Technology Demonstration Fund to support industry-led projects that can reduce the cost of large-scale, low-emission technologies with significant long-term abatement potential. However, it is anticipated that this fund will be predominantly focused on the fossil-fuel industry.

3. Priorities for the further development of the wind energy industry in Australia

3.1 Introduction

Auswind has identified a number of key priorities to significantly expand the wind energy industry in Australia and to reduce the substantial growth in emissions forecast from the stationary energy sector. The emission reduction trajectory influence of carbon trading/taxes that Australia decides to adopt is likely to be far too slow to encourage the transition to cleaner electricity, particularly if a scheme does not commence until 2012. A much faster mechanism is required to rapidly 'push' the supply of zero emission electricity Australia needs to meet its Greenhouse Gas reduction targets.

As well as the economic priority, Auswind is advancing a number of other initiatives to address grid integration issues and market categorisation in the Australian National Electricity Market (NEM).

Projects are also under way to address community concerns about the regional expansion of wind energy; to ensure industry compliance with best environmental practice; and to increase national support for future wind energy projects (see Section 6).

3.2 Economic

3.2.1 Cost competitiveness of wind power

Although the diagram below shows the reducing cost of wind power, until an Emissions Trading Scheme (ETS) fully reflects the external costs of greenhouse gas emissions from fossil fuel generation, wind will continue to be undercut by higher emission sources. A targeted deployment measure such as an extended clean energy target is essential to sustain the level of investment in the industry created under MRET. (See Section 4.2.2).

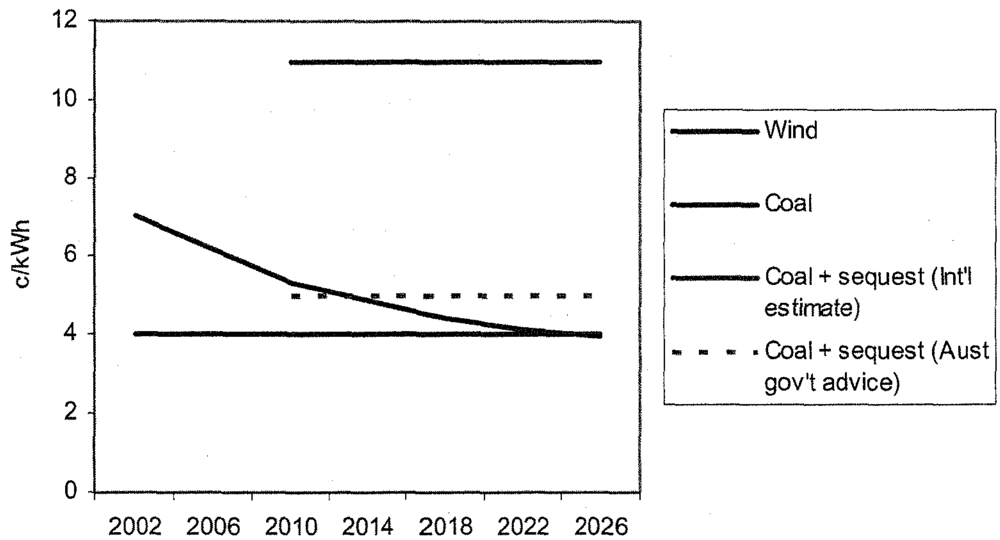
As the industry expands, the cost of wind energy will continue to decline and to become cost competitive with energy produced from fossil fuel generation.

With the introduction of an ETS in the correct form and/or a clean energy target, and with cost of wind energy continuing to decline, Auswind believes that wind energy will become cost competitive with traditional fossil fuel generation.

Australia wind energy industry is internationally competitive. Both the US and the UK cite that at wind speeds of 7m per second wind energy can be generated for (equivalent) AUD$75 MWh. With such a large number of world class sites and higher than average wind speeds, Australian wind power can be even more competitive.

Due to the significant increase in demand and installed capacity globally (see section 1.2) supply chain constraints (particularly in components such as gears and bearings), increased steel and copper prices, and competition for heavy engineering manufacturing capacity from the mining industry globally, there has been upward pressure on turbine prices. However given the long term demand growth in many countries around the world substantial building of manufacturing capacity is currently taking place (eg China and India) and in fact supply capacity is forecast to exceed demand within a couple of years. In Australia, these factors are not inhibiting the supply of turbines. Australia's excellent wind regime means that manufacturers view Australia's market very positively. The price increases experienced over the past 12-24 months have not stopped wind farms proceeding in Australia, and our membership feedback is that the recently announced State renewable energy mandated targets will see numerous wind farms proceed in coming months, despite price rises.

Cost Convergence of Wind Power and Conventional Generation



Within 10-15 years time wind energy can be cost-competitive with fossil fuels[iv]

3.2.2 Water as a cost impediment

Directly linked to the cost curve scenario, the issue of access to reliable water and at what cost is already becoming a matter of significance for traditional fossil fuel generators. Currently, both Tarong and CS Energy have thermal power stations off-line due to limited access to the large amounts of water required in the generation cycle. As many capital cities in Australia head towards stage 4 and 5 water restrictions, traditional generators will be increasingly faced with the very real possibility of limited access to water, or a significant increase in the price paid to gain access to the required volumes of water. This additional cost will, ultimately, be passed on to the consumer.

With approximately 1000 MW of new generation required in Australia each year to meet growth in demand, it is simply not feasible to suggest that this requirement can be met via traditional thermal generation requiring large volumes of water. Wind energy does not require water in the generation phase, instead relying on the completely renewable and predictable resource of the wind. The significance of this cannot be underestimated as we move towards a water-restrained future

3.2.3 Carbon trading/taxes

Electricity supply from coal currently contributes significantly to Australia's emission profile and it is well recognised that a key challenge is the reduction of CO_2 emissions from this sector. To achieve this, restructuring of the electricity supply industry must occur to increase the contribution of wind power and other zero and low emission energy technologies. This restructuring requires targeted industry development measures. Carbon price signals such as from carbon trading will not drive the short term change that is necessary.

Wind power is a mature, proven, clean energy technology. Most notably, it is the most important clean energy technology currently available to supply electricity for Australia's growing economy whilst reducing the increase in CO_2 emissions. As described in Section 1.3, the significant expansion of the Australian wind energy industry is achievable and is fundamental to this restructuring.

Auswind supports a global Emissions Trading System (ETS) in which Australia could participate. However, in the absence of a global scheme, it is important that Australia introduce a domestic emissions trading scheme quickly to commence the restructuring process discussed above. Any cap to limit carbon emissions must be set so that the effective carbon price makes up the difference between the current electricity price from coal and that from wind power.

The recommendation by the PM's Emission Task Group to delay the commencement of an Emission Trading System until 2012 and the fact that the target and timeframe is likely to result in a low carbon price means that this measure alone will be too slow to stimulate investment in clean energy technologies. Therefore it is essential that additional targeted support measures be provided to mature, proven clean energy technologies, like wind energy, to stimulate their expansion in Australia. These targeted support measures can then be phased out as the ETS reaches a point where it can alone sustain investment in clean energy technology.

3.2.4 Targeted industry support

The most urgent requirement to reduce emissions from the stationary energy sector and to help prepare Australia's economy for a carbon constrained future is a larger market for zero emission electricity projects.

Auswind recognises that there is a role for a broad range of zero emission clean energy technologies to help overcome Australia's dependence on electricity sourced from coal and it has been working extensively with related organisations, such as the Business Council for Sustainable Energy (BCSE), to develop a clean energy policy proposal for the consideration of the Federal Government. Importantly though, there is sufficient technology already developed to commence significant emission reduction today.

Auswind contracted Frontier Economics to model the cost to the economy of setting a single, national target that will meet 20% of Australia's electricity demand with zero emission energy sources by 2020 and 30% by 2030. The modeling, which included solar, wind, hydro, geothermal, carbon capture and storage coal technology and clean gas, showed that by enabling these technologies to compete on a level playing field, with no capital subsidies, the most cost effective will be built to meet demand. The measure would also halt the exponential growth that is inevitable under a Business as Usual approach. Effectively, the measure would see new demand for electricity met by zero emission infrastructure. Frontier has calculated that the additional cost to the economy of the measure is between $5 and 7 billion dollars which equates to approximately $0.45 per person pre week[v]. Extrapolating the results shows that this new generation would result in $60 billion in investment and 40,000 jobs.

Because the State Government renewable energy targets continue to underpin the growth of the renewable energy sector, it is important that the State Governments continue with their targeted schemes (Renewable Energy Targets) until a co-incidence of the two policy measures can be arranged.

Auswind understands that in a market economy there is philosophical/political opposition to targeted industry support mechanisms. However, it must be recognised that the wind energy industry (and other renewable industries) are unequally competing with the long-established coal power generation utilities, which were State monopolies that financed their investments through low interest funds and subsidies. It must also be recognised that many of these utilities have fully or partially depreciated assets allowing them to compete at a lower cost compared with new investments in clean energy production.

Another serious competitive disadvantage is that the 'external' costs of electricity generation are not fully reflected in the prices of fossil fuel based electricity particularly that based on coal. The European Commission – through a project called "ExternE" – has tried to quantify the true costs, including the environmental costs of electricity generation.

"ExternE" estimates that the cost of producing electricity from coal or oil would double and the cost of electricity production from gas would increase by 30%, if external costs, in the form of damage to the environment and health, are taken into account. The study further estimates that these costs amount to 1-2% of the European GDP or between €85 billion and €170 billion/annum, not including the additional costs of the impacts of human-induced climate change on human health, agriculture and ecosystems.

If these environmental costs are levied on electricity generation according to their impact, many renewables, including wind power, would not need any support to successfully compete in the marketplace. In the EU alone, wind power in 2005 avoided external cost of electricity production of approximately €5 billion, according to the report.[vi][vii]

Finally, there is increasing political pressure from some quarters for Australia to adopt nuclear based electricity generation and it is widely expected that such an initiative would require targeted Federal Government support to allow it become commercially attractive for investors.

Since electricity from wind (and from other clean energy types) is an essential service but is forced to compete unfairly against electricity produced from coal, there is a strong public-good argument for providing targeted support for wind power to overcome the external (non-costed) costs of fossil fuel based electricity.

3.3 Grid integration and market categorisation

The Australian energy market is one of the most flexible in the world and could easily adapt to incorporate larger amounts of wind energy. However, some Australian regulatory authorities are requiring wind energy projects to be subject to the same market rules that govern fossil-fuelled power stations. To enforce these rules without altering the mechanics of the National Electricity Market (NEM) will unnecessarily reduce the amount of energy that can be delivered from clean energy projects.

Additionally, any cost associated with changes to the energy market can be off-set through consolidation of balancing areas or the use of dynamic scheduling to improve system reliability and reduce the cost of integration of additional wind generation into electric system operation. Studies have shown that greater than 10% wind penetration into the market can be achieved without special measures, and can reduce system operating costs largely due to fuel savings (New York State Energy Research and Development Authority, 2006).

4. The issues of base-load, variability and reserves

Detractors of the wind energy industry frequently cite base-load incapability, variability (sometimes called intermittency) of wind power and need for reserves as impediments to the economic value of the industry. In the case of base-load, the reality is that wind power can be a base-load source of electricity while, for variability and reserves, the issue is one of cost rather than a technical constraint.

4.1 Wind Energy - another source of base-load power

The key point for consideration when addressing the base-load issue is that perceived problems associated with increased wind generation in the Australian market context will not apply until levels greater than 20% penetration are reached. Currently, wind generation in Australia accounts for less than 2% of overall market supply and research in 2006 by the Business Council for Sustainable Energy (BCSE) highlights that Australia could have up to 20% of wind energy penetration in the market before issues of variability might become significant.

4.1.1 Base-load power stations

A base-load power source is one that is in theory available 24 hours a day, seven days a week and operates most of the time at full power. In mainland Australia, base-load power stations are mostly coal-fired – a few are gas-fired. (Coal-fired power stations are by far the most environmentally unsustainable of all power stations, both in terms of fossil fuel and water use, greenhouse gas emissions and local air pollution). However in practice, even base-load power stations can break down and drop large amounts of MW at any one time.

Overseas, some base-load power stations are nuclear. They produce little pollution during normal operation, but cause significant pollution (including carbon dioxide emissions) from mining, enrichment, plant construction and decommissioning, reprocessing and waste management.

4.1.2 Optimal mix of base-load and peak-load

An electricity supply system cannot be built out of base-load power stations alone. These stations take a long time to start up from cold and, in general, their output cannot be changed up or down quickly enough to handle the peaks and other variations in demand. Base-load power stations, especially coal-fired and nuclear, are generally cheap to operate, but their capital costs are high, so they cannot be used only to handle peaks in demand. To pay back their high capital costs, base-load power stations must be operated as continuously as possible. A faster, cheaper, more flexible type of power station is needed to complement base-load and handle the peaks.

Peak-load power stations are designed to be run for short periods of time each day to supply the peaks in demand and to handle unpredictable fluctuations in demand on timescales ranging from a few minutes to an hour or so. They can be started rapidly from cold and their output can be changed rapidly. Some peak-load stations are gas turbines, similar to jumbo jet engines, fuelled by gas or (rarely) by oil. They have low capital costs but high operating costs (mostly fuel costs).

Hydro-electricity with dams is also used to provide peak-load power. Because the amount of water available is limited to that stored in the dam, the 'fuel' of a hydro power station is a scarce resource and therefore a valuable fuel that is best used when its value is highest, that is, during the peaks.

A third type of power station, intermediate-load, runs during the daytime, filling the gap in supply between base- and peak-load power. Its output is more readily changed than base-load, but less than peak-load. Its operating cost lies between those of base and peak load.

Sometimes intermediate load is supplied by gas-fired power stations and sometimes by older, smaller, coal-fired stations.

Clearly, if an electricity generating system has too much peak-load plant, it will become very expensive to operate, but if it has too much base-load plant, it will be very expensive to buy. For a particular pattern of demand there is a mix of base-load, intermediate-load and peak-load plant that gives the minimum annual cost. This is known as the *optimal mix* of generating plant.

Looking to the future, Australia's *optimal mix* of generating plant will include a mixture of generating technologies, including wind, solar photo voltaic and thermal, geothermal, biomass, gas and clean coal. This range of technologies will ensure diversity and security of supply, and reduce the need for traditional large-scale base load generators. Ultimately this will change how the market manages risk and will result in a market unrestricted by contingency forecasting and the need for large amounts of spinning reserve, delivering large fuel savings and associated environmental benefits.

4.1.3 Reliability of generating systems

Even an optimal mix of fossil-fuelled power stations is not 100% reliable. To achieve this would require an infinite amount of back-up and hence an infinite cost. In practice, a generating system has a limited amount of back-up and a specified reliability. This can be measured in terms of the average number of hours per year that supply fails to meet demand or by the frequency and duration of failures to meet demand.

Many sources of electricity considered highly reliable, suffer from unexpected outages. For instance, nuclear reactors and coal plants that shut down, often at short notice, for safety repairs or maintenance. Yet there are no proposals to back up a coal or nuclear power plant with a similar amount of dedicated generation from another plant. The reality is that wind energy is naturally variable, but not unreliable. Wind farms are built in windy areas and seasonal and daily wind generation patterns can be anticipated. Denmark and utility systems in regional areas elsewhere in Europe operate with 20% or more of their power coming from wind without increased reliability problems or the need for additional back-up power plants. And in contrast to conventional power plants, wind farms need not shut down altogether for maintenance and repairs

4.1.4 Wind power as base-load

To replace the electricity generated by a 1000 MW coal-fired power station, with annual average power output of about 850 MW, a group of wind farms with capacity (rated power) of about 2600 MW is required. The higher wind capacity allows for the variations in wind power and is taken into account in the economics of wind power.

Although this substitution involves a large number of wind turbines (for example 1300 turbines, each rated at 2 MW), the area of land actually occupied by the wind turbines and access roads is only 5–19 square km, depending upon wind speed. Farming continues between the wind turbines. By comparison, a coal-fired power station and its open-cut coal-mine typically occupies 50–100 square km.

Although a single wind turbine is variable, this is not generally true of a system of several wind farms, separated by several hundred kilometres and experiencing different wind regimes. The total output of such a system generally varies smoothly and only very rarely experiences a situation where there is no wind at any site.

Computer simulations and modelling show that the integration of wind power into an electricity grid changes the optimal mix of conventional base-load and peak-load power stations but wind power replaces base-load with the same annual average power output.

However, to maintain the reliability of the generating system at the same level as before the substitution, some additional peak-load plant (say, gas turbines) will be needed. This back-up does not have to have the same capacity as the group of wind farms. For widely dispersed wind farms, the back-up capacity only has to be one fifth to one-third of the wind capacity and does *not* have to be run continuously.[viii]

Additionally, because of the grid's inherent design, there is no need to back up every megawatt of wind energy with a megawatt of fossil fuel or other dispatchable power. The electricity grid is designed to have more generation sources than are needed at any one time because no power plant is 100% reliable. It is an integrated system designed to absorb many impacts, from generation sources going out of service unexpectedly to industrial customers starting up energy intensive equipment. The grid operator matches electricity generation to electricity use and wind energy's variability is just one variable in the mix.

4.2 Variability and Reserves

4.2.1 The need for reserves

It is commonly assumed that adding significant wind power capacity to the electricity system will lead to a large expansion in the need for balancing services, particularly reserves. This is due to an implicit assumption that the variable output of wind power results in the need for large amounts of reserves devoted entirely to providing standby power for wind output – this is often referred to as 'backup plant'. Therefore, it is argued, that if the average output of wind plant is 35% of its rated output (its capacity factor), the remaining 65% must be provided as reserve, or backup capacity.

This reasoning is seriously flawed, for three key reasons:

- No generating plant is 100% reliable. Therefore, reserves are required to cover for unexpected outages on all plants.
- The rated capacity of the total installed wind plant is of minor interest to grid operators, who make supply security assessments based on estimates of overall statistical probabilities for the complete generating mix. This leads to the concept of 'capacity values', described below.
- Wind power is sometimes described as 'intermittent', which implies a high level uncertainty as to its actual output, but it can be quite accurately forecast in the appropriate timeframes for balancing electricity supply. A more precise term is 'variable', especially when considering aggregate output, which benefits from the wide distribution of wind turbines across a country, particular a large and meteorologically diverse country like Australia.

Additionally, the level of the costs of managing impacts resulting from wind's variable output will depend on factors that are inherent in the markets in which it operates, such as size of territory, functionality of power markets, and the mix of resources on the grid. It is important to note that some of the very factors that make for smoother integration of wind, such as more efficient use and expansion of physical transmission capacity, also make for a more resilient, efficient electricity market for all.

Grid operators assign to all generating plant a 'capacity value' (often called 'capacity credit'), which refers to the ability of that plant to contribute firm capacity to the overall system.

High availability plant, such as combined cycle gas turbines (CCGT) can have a capacity value of up to 90%, meaning 10 GW of gas plant would be treated as providing the system with 9 GW of firm capacity – the remaining 1 GW allows for outages, both scheduled and unscheduled.

No plant has a capacity value of 100%, because there will always be some statistical probability that it will not be available when required. When determining reserve requirements, grid operators make an assessment of the needs of the system as a statistical whole rather than considering the needs of each individual plant.

This leads to a treatment of wind output that is different than if it were the only generating source available.

Capacity value of wind

Due to the variability of wind power, its capacity value is more limited, as it will not be possible to displace conventional generation capacity on a 'megawatt for megawatt' basis. The capacity value decreases as more wind is installed on the system; at low penetrations it has been put at roughly equal to the capacity factor for wind (30-35%), but at higher penetrations the value decreases.

This is because with low penetrations, wind output is hardly noticed on the system, but when this increases, the variability of wind becomes more noticeable and its ability to provide firm capacity is reduced. The National Grid Company (UK) has stated that 8,000 MW of wind capacity would displace 3,000 MW of conventional plant; with 25,000 MW displacing the need for 5,000 MW. This means that wind power has a capacity value of around 35% at penetrations of around 6%, declining to around 20% at penetrations of 20%. (These figures, along with other corroborating evidence, were accepted by the House of Lords Science & Technology Select Committee in their 2004 report into renewable energy.)

Wind forecasting and distribution

Wind conditions can be predicted over the course of days or weeks and forecasting for the next few hours has become quite accurate. The total output of all wind capacity will be less variable, as it will be made up of a large number of wind farms spread throughout the country. It therefore follows that greater geographic diversity in wind farm locations is beneficial to the combined output profile of wind power. Australia is rapidly developing this diversity.

The accuracy of wind forecasting will continue to improve as more sites are developed and forecasting models are refined.

Accommodating wind power

Accommodating significant amounts of wind capacity on the electricity system has been confirmed by Great Britain grid operator, the National Grid Company. It is also the conclusion of a comprehensive report on this issue commissioned by the Carbon Trust and DTI. At higher wind penetrations, the capacity value of wind is indeed reduced, and this does lead to additional balancing requirements. However, this represents a cost rather than a barrier, as additional reserve requirements will lead to an increase in systems costs. (See Section 5.2.2)

Further supporting this, findings of the Utility Wind Interest Group (an organisation of some 55 United States based energy utilities that have wind power on their systems) in November 2003 noted that:

> "The results to date also lay to rest one of the major concerns often expressed about wind power: that a wind plant would need to be backed up with an equal amount of dispatchable generation. It is now clear that, even at moderate wind penetrations, the need for additional generation to compensate for wind variations are substantially less than one-for-one and is often closer to zero."

Further, on an operational level, wind power has a distinct advantage when compared to large centralised plant. Faults at conventional plant can cause a large instantaneous loss of supply that must be dealt with using a full range of balancing services. In contrast, combined wind output does not drop from the system in the same way, even under extreme weather conditions (too much, or no wind). Variations in wind output are smoother, making it easier for the grid operator to manage changes in supply as they appear within the overall system.

4.2.2 Cost of wind power integration

This Section describes a summary contained in the IEA Report, "Variability of Wind Power and other renewables: Management Options and Strategies" [ix]. This Report contains a number of studies from Europe and the USA that attempted to quantify the additional system costs that wind power might impose on electricity systems:

Assessing the added costs of integrating renewables into electricity grids involves four main parameters: Balancing; operating reserve; capacity reserve; and extension of transmission and distribution lines.

Operating reserve is likely to be limited relative to the other two items. As wind power expands, the issues of additional capacity reserve and new transmission and distribution lines will grow in importance. The studies presented below use slightly different methodologies to assess the various cost items. Thus, while some aim to quantify all of the above-listed system integration costs, others focus specifically on the operating and capacity reserves. Also, it has to be borne in mind that the precise numbers are country-specific and there is no one cost figure that is universally applicable. In this sense, the studies below present an overview of different country experiences and expectations on the costs of system integration of renewables.

Strbac et al. (2002) were commissioned by the UK Department of Trade and Industry (DTI) to carry out a study "Quantifying the System Costs of Additional renewables" to the UK electricity grid in 2020 (also known as the SCAR report). A variety of scenarios, using different combinations of technologies were considered, and OCGT and CCGT power plants were used as benchmarks to quantify the additional system costs of operational and capacity reserve respectively. A comprehensive methodology was developed to assess all relevant aspects of system adaptation due to renewables.

This included the reinforcement and management of the transmission system, the impact on transmission losses, the reinforcement and management of the distribution networks and balancing energy generation and demand.

In the scenario using a mix of biomass and wind, it was found that the total additional system costs per year for a 20% renewables share of total electricity supply were €205m (£143m) in 2020, translating into total additional system costs of €4.9 per MWh of renewable electricity compared to current wholesale electricity prices in the UK of about €47 (£32).

The highest additional system costs were found for a scenario where the renewables share would come predominantly from wind, mostly located in Scotland and off-shore, far away from load centres. Here the per annum additional system costs would be €570m (£398m) in 2020, translating into total additional system costs of approximately €14 per MWh of renewable electricity, in this case almost entirely from wind. An extensive sensitivity analysis of a variety of parameters can be found in the study. As expected, costs for upgrades in the transmission and distribution system were highest in the scenario with a high share of renewables far away from load centres, contributing about one quarter of the additional costs. In all scenarios, costs for operational and capacity reserves dominated, taking a share between 67% and 100% of the total costs. In the break down between operational and capacity reserve, costs for the latter dominated in all scenarios, typically at a ration of 2/3 to 1/3.

A second comprehensive study, which examined reserve as well as transmission and distribution requirements, is presented in Auer (et al. 2004) from the "GreenNet" research project. In reviewing and modelling their results in a number of European electricity markets, they establish a cost range for system integration costs specifically for wind power at different levels of market penetration and for different climatic conditions. For a 20% market share of wind power, they establish a cost range for operational and capacity reserves between €4.5 and €6 per MWh, while transmission and distribution upgrades are modelled to lie between €2.5 and €3 per MWh. Thus, total costs range from €7 to €9 at that level of market penetration.

It should be noted that these figures, even in the most pessimistic case, represent about 8% of current wholesale market prices in the UK (€47/MWh or £32/MWh), noting that these include only balancing costs.

For Western Denmark, the Transmission System Operator (TSO) Eltra (2004a) reports that for the 3,368 GWh of wind power that they were mandated to purchase in 2003, the total balancing costs were €8.7m (65m DKK). This corresponds to about €2.6 per MWh of wind energy.

5. Strengthening industry's adherence to environmental planning/legal requirements and community acceptance

5.1 Introduction

Auswind's initiatives to strengthen industry's adherence to environmental planning/legal requirements and community acceptance recognise that the long-term sustainability of the wind energy industry in Australia depends on appropriately sited and environmentally sensitive wind energy projects.

Like many other countries around the world, wind energy projects in Australia have attracted considerable media attention and vocal community debate. Auswind has completed a number of initiatives which address some of the most common concerns and more are underway.

In Australia, wind energy projects come under the jurisdiction of State or local authorities. Most States are now moving towards state government approval for the larger wind energy projects, while involving local governments in the consultation process. Victoria, South Australia and NSW have developed extensive planning approval guidelines for wind energy projects.

5.2 Auswind Best Practice Guidelines

In 2002, Auswind, with funding from the Commonwealth Department of Environment and Heritage, developed best practice guidelines for wind farm developments in Australia. These Auswind Best Practice Guidelines document best practice processes, particularly for environmental and amenity values, for site selection, the preparation of the development application, through to construction, operation and decommissioning operations (at the end of the wind farm's life).

A review of the Guidelines was undertaken in the second half of 2006 to ensure that they continued to reflect best practice (by benchmarking them against international and national standards), and could be used in the Auswind Accreditation Scheme (see following).

5.3 Auswind Accreditation Scheme

In June 2006 Auswind received funding from the Department of Environment and Heritage, Australian Greenhouse Office, to develop an Accreditation Scheme for the wind energy industry in Australia.

This Scheme requires participating organisations to show, by independent auditors, that they are meeting:

- Relevant statutory environmental and amenity planning requirements

- Relevant Federal and State environmental laws, policies and regulations
- The Auswind Best Practice Guidelines.

The Accreditation Scheme covers the planning phase as required by statutory requirements and the site operations phase, including the design, construction, operations and de-commissioning processes.

The Scheme will commence in June/July 2007 and Auswind has appointed certification bodies to carry out independent auditing of participating organisations. Certification is open to any organisation who is a wind energy developer and/or operator and their contractors.

5.4 Wind Farms and Landscape Values Project

The Wind Farms and Landscape Values - National Assessment Methodology project is a joint project between the Australian Council of National Trusts (ACNT) and Auswind funded by the Department of the Environment and Heritage under the Low Emission Technology and Abatement Program.

The objective of the project is to provide a sound and transparent, nationally applicable framework for identifying and assessing landscape values, assessing the potential impacts of wind farms on landscape values with site impact assessment and mitigation, and community consultation procedures.

Stage one of the three-stage *Wind Farms and Landscape Values Project,* the issues paper, was released in June 2005. It effectively addresses the complexities associated with wind farm siting issues, largely because it is the result of an extensive consultation process, which has given all stakeholders the opportunity to assist in formulating an agreed set of national landscape issues for the Australian wind energy industry. Over 50 organisations and many more individuals were consulted in the first stage of the project.

This set the scene for Stage two, which is involving a series of public meetings and forums throughout Australia during 2007, seeking the views of the public and relevant organisations as to how a landscape assessment methodology should work.

Funding from the Australian Greenhouse Office will see this process repeated in every State of Australia, seeking input to the final goal of an agreed set of national landscape methodologies to be adopted by the Australian wind energy industry and promoted by the ACNT.

The requirements of the methodology will be included in the Best Practice Guidelines, the meeting of which is one of the requirements of the Auswind Accreditation Scheme (see above).

[i] Global Wind Power Report 2006
[ii] Acknowledgement to the Global Wind Energy Council's document "Wind Force 12, 2005 for parts of Sections 1.1 and 1.2
[iii] [iii] Global Wind Energy Council's document "Wind Force 12, 2005
[iv] Wind generation cost estimates from EWEA http://www.ewea.org/doc/WF12.pdf, exchange rate based on A$1 = €0.55
Baseline coal costs assumed at ($40/MWh).
International sequestration estimates ($70/t CO2-e) from IPPC, USDoE, IEA: Iain Macgill and Hugh Outhred, UNSW, April 2003. http://www.ergo.ee.unsw.edu.au
Australian sequestration estimates ($10/t/CO2-e) from PMSEIC Working Group paper *Beyond Kyoto – Innovation and Adaptation*, pp26, 31
[v] Frontier Economics, June 2007 Clean Energy Target modeling results
[vi] Global Wind Energy Council's document "Wind Force 12, 2005, Page 15
[vii] "Uranium mining, Processing and nuclear energy opportunities for Australia" Section 4.4.3 - Zwitkowski Report 2007
[viii] Taken from The Base-Load Fallacy" by Mark Diesendorf, the Institute of Environmental Studies, University of New south Wales
[ix] "Variability of Wind Power and other Renewables: Management Options and Strategies", Pages 33 and 34. International Energy Agency 2005